



Economie a Management Economics & Management

scientific journal

www.ekonomie-management.cz

The journal E&M Economics and Management (E&M) publishes high quality original research articles and scientific studies based on theoretical and empirical analyses. E&M encourages new intriguing ideas and new perspectives on existing state of knowledge. Among the key topics covered are Economics, Business Administration, Finance, Management, Information Management, and Marketing & Trade. The journal features theoretical articles as well as application-oriented papers. Occasionally published review articles summarising existing knowledge are accepted only if they are based on a systematic literature review. The journal is published quarterly and all articles are double-blind peer reviewed. Editorial board consistently pays attention to compliance with the rules of publishing ethics. Therefore, among other things, articles received are checked by the Crossref's service Similarity Check.



The journal is licensed in accordance with Creative Commons BY-NC 4.0 International. License terms are available at <https://creativecommons.org/licenses/by-nc/4.0>.

The journal is covered in the Social Sciences Citation Index, Social Scisearch and Journal Citation Reports/Social Sciences Edition (<https://clarivate.com>). It is also monitored by the electronic EconLit index (<https://www.aeaweb.org/econlit/>), International Bibliography of the Social Sciences (<http://www.proquest.com/products-services/ibss-set-c.html>) and by Inspec (<https://www.theiet.org/resources/inspec/>), SCOPUS (<https://www.elsevier.com/solutions/scopus>), ABI/INFORM (http://www.proquest.com/products-services/abi_inform_complete.html), EBSCO Information Services (<https://www.ebsco.com>) and GALE (<https://support.gale.com/tlist/products>) databases. It is listed in the 11th Edition of Cabell's Directory of Publishing Opportunities in Economics and Finance/Management (www.cabells.com).

Contents

Economics

- 4 | **Complementing Data Gaps on Wages in the Labour Force Survey Data Set: Evidence from Poland**
Wojciech Grabowski, Karol Korczak

- 23 | **Health-related Quality of Life and Socio-economic Status of the Unemployed**
Daniel Puciato, Michał Rozpara, Marek Bugdol, Piotr Oleśniewicz, Helena Jáčová

- 38 | **Youth Unemployment and Self-employment: Trends and Perspectives**
Rita Remeikienė, Jan Žufan, Ligita Gasparėnienė, Romualdas Ginevičius

- 49 | **Competitiveness of Mutual Agrarian Foreign Trade of the Post-Soviet Countries**
Irena Benešová, Luboš Smutka, Jana Hinke, Adriana Laputková

Business Administration and Management

- 67 | **Technological and Organizational Innovation in Warehousing Process – Research over Workload of Staff and Efficiency of Picking Stations**
Izabela Kudelska, Rafał Niedbał

- 82 | **Relationship between Impersonal Trust and Innovative Culture: An Empirical Study**
Katarzyna Krot, Dagmara Lewicka

- 101 | **Alter Ego Only Four Times? The Case Study of Business Profits in the Visegrad Group**
Katarína Valášková, Beáta Gavurová, Pavol Ďurana, Mária Kováčová

Finance

- 120 | **Methodology of Industry Statistics: Averages, Quantiles and Responses to Atypical Value**
Martin Boďa, Vladimír Úradníček

- 138 | **Impact of Stock Markets on the Economy in V4 Countries**
Radmila Krkošková

Marketing and Trade

- 155** | **Face-to-face and Electronic Communication with Customers in Retailing and Company Performance: A Case Study in the Electronics and Communication Equipment Retail Industry in the Czech Republic**
Ludvík Eger, Petr Suchánek
- 173** | **DEA Approach for Performance Assessment of Call Centre Agents**
Viera Mendelová, Petra Strnádoá

Information Management

- 191** | **Assessment of Logistics Platform Efficiency Using an Integrated Delphi Analytic Hierarchy Process – Data Envelopment Analysis Approach: A Novel Methodological Approach Including a Case Study in Slovenia**
Patricija Bajec, Monika Kontelj, Aleš Groznik
- 208** | **Prospective MADM and Sensitivity Analysis of the Experts Based on Causal Layered Analysis (CLA)**
Sarfaraz Hashemkhani Zolfani, Morteza Yazdani, Edmundas Kazimieras Zavadskas, Hamidreza Hasheminasab

Others

- 224** | **Notices and Instructions for the Authors of the Articles**

COMPLEMENTING DATA GAPS ON WAGES IN THE LABOUR FORCE SURVEY DATA SET: EVIDENCE FROM POLAND

Wojciech Grabowski¹, Karol Korczak²

¹ University of Łódź, Faculty of Economics and Sociology, Department of Econometric Models and Forecasts (Institute of Econometrics), Poland, ORCID: 0000-0002-6707-3736, wojciech.grabowski@uni.lodz.pl;

² University of Łódź, Faculty of Economics and Sociology, Department of Computer Science in Economics (Institute of Applied Economics and Informatics), Poland, ORCID: 0000-0003-1936-1423, karol.korczak@uni.lodz.pl.

Abstract: Due to the low level of quality of the Labour Force Survey (LFS) data set, studies devoted to matching the LFS data with data from alternative sources are frequent. In this paper, we propose a novel method of complementing data gaps on wages in the Labour Force Survey data set. The method is based on estimating the parameters of the multilevel model explaining wages on the basis of the Structure of Earnings Survey (SES) data set. In such a way, we identify the impact of individual characteristics and enterprise-level features on wages. We also find evidence of random differences between the wages of workers from different professional groups. The relative importance of consecutive groups of variables is evaluated on the basis of the estimates of the parameters of the full model and reduced models. The results of the estimation of the parameters are in line with expectations. The estimates of parameters and predictions of random effects are used in order to calculate the theoretical wages of individuals who do not report wages in the Labour Force Survey. When the predicted wages are compared with the observed ones, some discrepancies are observed. Rationales for these discrepancies are provided. Therefore, the use of a correction factor is proposed. Correction factors are provided for different features of workers and different features of enterprises. The use of the microeconomic multilevel model, as well as the correction factor, leads to reasonable wage estimates of workers not reporting them in the Labour Force Survey. The proposed method may be used in order to complement data gaps on wages for other EU countries.

Keywords: LFS, SES, microeconometrics, mixed-effects model, data gaps.

JEL Classification: C50, J01, C21.

APA Style Citation: Grabowski, W., & Korczak, K. (2020). Complementing Data Gaps on Wages in the Labour Force Survey Data Set: Evidence from Poland. *E&M Economics and Management*, 23(3), 4–22. <https://doi.org/10.15240/tul/001/2020-3-001>

Introduction

The European Union Labour Force Survey (EU LFS) is a widely used source of information on the participation in the labour force of citizens from the countries of the European Union. The LFS data set contains quarterly collected, anonymized data on individuals representing various industries and occupations. The data are collected using common classifications, concepts and definitions. In each country, the same set of characteristics is collected.

Despite common standards for data collection, the use of the unified LFS data set may sometimes encounter various difficulties. First of all, from the very beginning of the LFS, there have been numerous methodological changes in sampling (Kerr & Wittenberg, 2015), definitions and classifications (European Commission, 2018). These changes make it difficult to compare data with previous years. Secondly, different cross-national classification rules may produce various problems. Cross-national

differences in coding data (regarding parental leave beneficiaries) can be a source of bias in international comparisons (Mikucka & Valentova, 2013). Another problem which limits the use of the LFS data is related to the data gaps. Research studies devoted to the analysis of the LFS data point out the problem of non-response (see, e.g., Pastore & Socha, 2006; ADB, 2012). The problem of non-response may introduce sample-selection bias when characteristics for the population are analysed. In some countries, in the presence of a non-response, the designated households that cannot be interviewed are replaced with other households in the vicinity. However, such a practice may lead to the disadvantages far outweighing the benefits (Vehovar, 1999).

The low quality of the data is reflected when it is compared with data from other sources (ADB, 2012). The lack of coherence of data from various sources is likely to surprise the user when faced with different figures referring to similar concepts. Therefore, studies devoted to matching the LFS data with data from alternative sources are commonly used (see, e.g., Ormerod & Ritchie, 2007; O'Mahony & Timmer, 2009; Orche Galindo & Bueno Maroto, 2011). Moreover, researchers also propose alternative measurement methods, which prove to be more accurate compared with those based on LFS estimates (see, e.g., Skinner et al., 2002).

In the LFS data set for Poland, significant data gaps occur, especially in relation to wages. Our analysis shows that in the LFS data set for people employed in Poland in the years 2010–2016, data gaps regarding wages varied from 47 to 71%. This is due to the fact that the purpose of the LFS is to describe the situation on the labour market in Poland (economic activity of the population, characteristic of employed and unemployed persons, economically inactive population), and all other data, including data on wages, are treated as additional (see, e.g., Central Statistical Office, 2018). In general, citizens are not willing to provide information concerning their wages. They willingly provide information concerning their level of education, type of education, marital status, etc, while fields with information about wages are often not filled in. Therefore, in Poland (as in other countries), the LFS data set is not treated as a reliable source of data regarding wages (see, e.g., Ormerod & Ritchie, 2007; Pastore & Socha, 2006; ADB, 2012).

The main goal of our research study is to propose a novel method for complementing the LFS data on wages. It is based on the use of estimates of parameters of a microeconomic model, estimated on the basis of the European Union Structure of Earnings Survey (SES) data set. The SES data set is a source of complete information on individuals' wages. For all individuals, reliable information about wages is provided. The reliability of this source of data is due to the fact that all information concerning wages is provided by employers. Therefore, the problem of individuals being ashamed of their wages is avoided. Moreover, the paper contributes to the economic literature in several other ways. A secondary aim of the study is to analyse the factors determining wage levels. We propose the original specification of the econometric model, which takes into account random differences among the wages of workers from different occupational groups. Since workers are classified according to 1-digit, 2-digit, 3-digit and 4-digit codes, the use of the multilevel model is justified. Therefore, our specification extends specifications from other studies devoted to the determinants of wages (see, e.g., Skinner et al., 2002; Majchrowska & Strawiński, 2018). The use of data covering the period 2010–2016 allows us to point out the variability of the results of the estimation for different years. Finally, we compare the characteristics of empirical wages of individuals who declare them with the theoretical wages for workers who do not. We learn about the reasons for not declaring, overestimating and underestimating wages.

Despite the fact that the SES data set is complete, there are still good reasons to complement the LFS data set. The SES data set is narrower as it includes only data on wages, professions and basic characteristics of employment. The LFS data set, in turn, gathers additional information concerning, participation in training courses, doing extra work, commuting to work etc. Therefore, completing the LFS data set appears to be useful for purposes of conducting more in-depth analyses of labour market.

The paper has the following structure. In the first section, a literature review on the microeconomic determinants of wages is provided. In the second section, the data preparation and research method are described. The results and their discussion are

provided in section 3. The final section offers concluding remarks.

1. Literature Review on Microeconomic Determinants of Wages

In this paper, we propose a novel method for complementing data on wages when the Labour Force Survey does not provide such information. Since data from the Structure of Earnings Survey are used, the microeconomic model explaining wages should be specified. Therefore, the parameters of the econometric model are estimated in this paper. This specification is based on similar studies devoted to the determinants of wages.

Firstly, the analysis of individual wages should be based on the classical theoretical framework proposed by Mincer (1974) and Mincer and Polachek (1974). These authors argued that individual wages grow as the number of years of schooling and the level of experience increases. As a result, variables associated with experience (general experience, experience in an enterprise a worker had worked in before the poll was conducted) are included as explanatory variables. Since the rate of return of different types of education may not be constant, binary variables associated with the level of education are taken into account (Psacharopoulos & Ng, 1994).

In order to take into account the problem of the gender wage gap, a variable associated with gender should be included (see, e.g., Blau & Kahn, 2007; Peter & Drobnič, 2013; Ahn & Sanchez-Macros, 2017; Gallen et al., 2018; Hara, 2018; Artz & Taengnoi, 2018). Moreover, inter-industry disparities in wages make the inclusion of sectoral dummies reasonable (Gannon et al., 2007). Wages in the private and public sectors should differ (Melly, 2005), the size of an enterprise should have a positive impact on wages (Zimmermanová, 2010), and workers employed for an indefinite period are expected to earn more than employees with other types of contracts. Therefore appropriate dummy variables are included in the specification.

According to the New Economic Geography approach, there is a correlation between wages and the economic potential of the region (agglomeration patterns, market access, migration processes) (see, e.g., Ciešlik & Rokicki, 2016). The results of other studies

indicate that spatial differentiation of wages is an especially important problem in emerging and transition economies (Majchrowska & Strawiński, 2016). Therefore, dummy variables associated with regions are taken into account. Though variables associated with marital status and town size are also included as regressors in the microeconomic model of wages (see, e.g., Ahituv & Lerman, 2007; Grabowski, 2019), unfortunately, the SES by Occupations data does not enable identification of these categories. Therefore these variables are not included in the specification.

Labour markets in developed but also in developing countries have been experiencing significant multidimensional changes in recent years, reflected in the occupational-wages structure affecting the distribution of income between various groups of employees. These processes have been examined within the framework of the theory of Skill-Biased Technical Change (SBTC) (see, e.g., Freeman & Katz, 1994; Katz & Autor, 1999) and the concept of Routinization-Biased Technical Change (RBTC), leading to labour market polarization (Autor et al., 2003). According to this first concept, changes in demand for workers with different skill levels result in an increase in the gap between the wages of skilled and unskilled employees. The RBTC hypothesis is rooted in the model proposed by Autor et al. (2003), which assumes that different types of tasks are defined, and the wages of workers from the same task group depend on whether performed activities are routine or non-routine.

All in all, both theories (RBTC and SBTC) assume that wages strongly depend on occupations. Using data from the SES by Occupations, theoretically, workers belonging to the same 4-digit code occupational group should have similar wages, *ceteris paribus*. If large differences between wages of workers from the same group exist, workers with lower wages may quit and start working for enterprises offering higher wages. Workers belonging to the same 3-digit code occupational group should have similar wages, but within group variation, they may be larger than in the case of workers from the same 4-digit code occupational group. Changes of enterprises for workers from the same 3-digit code occupational group and different 4-digit code occupational groups are easy but more difficult than in the case of workers from the same 4-digit code occupational

group. Analogously, changes of enterprises for workers from the same 2-digit code occupational group and different 3-digit code occupational groups seem to be more difficult than in the case of workers from the same 3-digit code occupational group. Changes of enterprises for workers from the same 1-digit code occupational group are easier than in the case of workers from different 1-digit code occupational groups but more difficult than in the case of workers from the same 2-digit code occupational group. Therefore, the largest differences among wages should be observed for employees from different 1-digit code occupational groups.

2. Data and Method

2.1 Data Description

We use data on Polish individuals from the Labour Force Survey and the Structure of Earnings Survey. The LFS as well as the

SES are conducted in the 28 Member States of the European Union, candidate countries and countries of the European Free Trade Association (EFTA). The LFS data set contains data reported from employees while the SES data set contains data reported from employers. The LFS data are published annually (quarterly data sets) while data from the SES are published at two-year intervals (annual data sets). The SES data set contains a complete set of data on individuals' wages. We use annual data from the SES and data (only for employed people) from the fourth quarter from the LFS. It should be mentioned that in the SES, wages from October are reported. Therefore, we take wages from the fourth quarter in the case of the LFS. Finally, our analysis covers the years 2010, 2012, 2014 and 2016. Tab. 1 presents the number of observations in our research process, including the number of missing data on wages in the LFS.

Tab. 1: Number of individual observations

Data set	2010	2012	2014	2016
The LFS	19,215 (9,097)	28,471 (20,197)	24,785 (14,408)	22,345 (13,824)
The SES	688,383	725,239	730,498	795,879

Source: own

Note: Numbers in brackets show missing data on wages.

A novel method of complementing the LFS data on wages has been developed on the basis of the advantage of the SES. Since there is no gap in data concerning wages in the case of the SES, this data set is used in order to identify the relationship between wages and the features of the workers and the enterprises they represent. Since data has a hierarchical structure, the parameters of the hierarchical model should be estimated. Among the variables affecting the level of wages, the following groups are distinguished: features of workers (gender, experience, education), locations of enterprises (all 16 regions in Poland), NACE sections (statistical classification of economic activities in the European Community) represented by enterprises, other features of enterprises (size, sector). All variables representing the mentioned groups are listed in Tab. 2.

2.2 Method

The procedure of complementing the individual LFS data on wages can be implemented in a few steps. In the first step, we define vector **SES**, which consists of all variables listed in Tab. 2. Apart from this vector, we define vector **LFS**, which consists of the same variables, but their values concern individuals analysed in the Labour Force Survey. For example, the variable *LFS_GENDER* has the same definition as the variable *SES_GENDER*, but its values are observed for individuals from the Labour Force Survey. It should be mentioned that for some variables, there were differences in the LFS and SES data structure. For example, in the SES, gross wage is reported by the employer, while in the LFS, net wage is reported by the employee. In addition, the education and size of the enterprise were divided by some other

Tab. 2: Independent variables used in the model

Variable	Definition of variable
SES_GENDER	Dummy variable taking a value of 1 for females and 0 for males
SES_EXP_GEN	Experience of worker (number of years) in all enterprises he/she had worked before the poll was conducted
SES_EDU[1–5]	Dummy variables taking a value of 1 for workers with: a basic level of education (<i>SES_EDU1</i>); vocational education (<i>SES_EDU2</i>); secondary general education (<i>SES_EDU3</i>); secondary technical education (<i>SES_EDU4</i>); tertiary education (<i>SES_EDU5</i>)
SES_IND	Dummy variable taking a value of 1 if a respondent is employed for an indefinite period and 0 otherwise
SES_LOC_[DLN-ZACH]	Dummy variables taking a value of 1 for workers from the region: Dolnośląskie (<i>SES_LOC_DLN</i>); Kujawsko-Pomorskie (<i>SES_LOC_KP</i>); Lubelskie (<i>SES_LOC_LUBE</i>); Lubuskie (<i>SES_LOC_LUBU</i>); Łódzkie (<i>SES_LOC_LODZ</i>); Małopolskie (<i>SES_LOC_MAL</i>); Mazowieckie (<i>SES_LOC_MAZ</i>); Opolskie (<i>SES_LOC_OPOL</i>); Podkarpackie (<i>SES_LOC_PODK</i>); Podlaskie (<i>SES_LOC_PODL</i>); Pomorskie (<i>SES_LOC_POM</i>); Śląskie (<i>SES_LOC_SL</i>); Świętokrzyskie (<i>SES_LOC_SW</i>); Warmińsko-Mazurskie (<i>SES_LOC_WM</i>); Wielkopolskie (<i>SES_LOC_WIEL</i>); Zachodniopomorskie (<i>SES_LOC_ZACH</i>)
SES_SECTION_[A-S]	Dummy variables taking a value of 1 in the case of enterprises from section: Agriculture, forestry and fishing (<i>SES_SECTION_A</i>); Mining and quarrying (<i>SES_SECTION_B</i>); Manufacturing (<i>SES_SECTION_C</i>); Electricity, gas, steam and air conditioning supply (<i>SES_SECTION_D</i>); Water supply; sewerage, waste management and remediation activities (<i>SES_SECTION_E</i>); Construction (<i>SES_SECTION_F</i>); Trade; repair of motor vehicles (<i>SES_SECTION_G</i>); Transportation and storage (<i>SES_SECTION_H</i>); Accommodation and catering (<i>SES_SECTION_I</i>); Information and communication (<i>SES_SECTION_J</i>); Financial and insurance activities (<i>SES_SECTION_K</i>); Real estate activities (<i>SES_SECTION_L</i>); Professional, scientific and technical activities (<i>SES_SECTION_M</i>); Administrative and support service activities (<i>SES_SECTION_N</i>); Public administration and defense; compulsory social security (<i>SES_SECTION_O</i>); Education (<i>SES_SECTION_P</i>); Human health and social work activities (<i>SES_SECTION_Q</i>); Arts, entertainment and recreation (<i>SES_SECTION_R</i>); Other service activities (<i>SES_SECTION_S</i>)
SES_SIZE_[1–4]	Dummy variables taking a value of 1 for individuals employed in enterprises with: 1–9 workers (microenterprises) (<i>SES_SIZE1</i>); 10–49 workers (<i>SES_SIZE2</i>); 50–249 workers (<i>SES_SIZE3</i>); more than 250 workers (<i>SES_SIZE4</i>)
SES_SECTOR	Dummy variable taking on a value of 1 for individuals employed in enterprises from the public sector and 0 for enterprises from the private sector

Source: own

categories. In order to compare the results, we use appropriate methods of transforming their values (see, e.g., Strawiński, 2015).

In the second step, we estimate the parameters of the following multilevel model (McCulloch, 1997) explaining individuals' wages:

$$\log(wage_i) = \mathbf{SES}_i \boldsymbol{\beta}^{SES} + \sum_j z_i^j u^j + \sum_k z_i^k u^k + \sum_l z_i^l u^l + \sum_m z_i^m u^m + \varepsilon_i \quad (1)$$

where $\log(wage_i)$ is the logarithm of wage of an i -th individual. \mathbf{SES}_i is the vector of explanatory

variables which are listed in Tab. 2. β^{SES} consists of consecutive parameters for explanatory variables. ε_i denotes error term following normal distribution with average equal to zero and constant variance. $u1^j$, $u2^k$, $u3^l$ and $u4^m$ denote random effects associated with the 1-digit code, 2-digit-code, 3-digit code and 4-digit code occupational groups respectively. The letters j , k , l , and m index 1-, 2-, 3- and 4-digit occupational groups. It is also assumed that random effects follow normal distribution with means $E(u1^j)$, $E(u2^k)$, $E(u3^l)$ and $E(u4^m)$ and standard deviations $\sqrt{Var(u1^j)}$, $\sqrt{Var(u2^k)}$, $\sqrt{Var(u3^l)}$, $\sqrt{Var(u4^m)}$. The variable $z1^j_i$ equals unity, if the i -th worker belongs to the j -th 1-digit code occupational group and 0 if he/she belongs to another group. Variables $z2^k_i$, $z3^l_i$ and $z4^m_i$ are defined analogously. The proposed approach assumes that each worker is assigned to one of 4-digit code occupational groups, each 4-digit code group belongs to one of the 3-digit code groups, each 3-digit code occupational group is included in one of the 2-digit code groups etc. Therefore, the data set has a hierarchical structure and the use of a hierarchical model is justified. Arendt and Grabowski (2019) suggest that individuals assigned to the same 4-digit code occupational group should have similar wage levels, *ceteris paribus*. If large differences between workers' wages from the same 4-digit code occupational group exist, workers with lower wages may quit and start working for enterprises offering higher wages. The wages of workers from the same 3-digit code occupational group may differ slightly more, but we expect that between-group variation exceeds the within-group variation etc. Therefore, a multilevel model seems to be appropriate. We were unable to take into consideration the problem of endogeneity of education level due to missing data on the workers' family members in the SES data set.

After estimating the parameters of model (Formula 1), we receive estimates of β^{SES} parameters, the expected values of random effects ($E(u1^j)$, $E(u2^k)$, $E(u3^l)$, $E(u4^m)$) with their standard deviations ($\sqrt{Var(u1^j)}$, $\sqrt{Var(u2^k)}$, $\sqrt{Var(u3^l)}$, $\sqrt{Var(u4^m)}$). These results are used further in the third step of the analysis in which we complement the LFS data on earnings on the basis of estimates of structural parameters, means and standard deviations for predicted random effects. We

use the following Formula for the wage of an individual from the LFS data set:

$$W_{theor_LFS_i} = \begin{cases} W_LFS_i & \text{if } AV_LFS_i = 1, \\ \exp(\hat{f}_i) & \text{if } AV_LFS_i = 0, \end{cases} \quad (2)$$

where AV_LFS_i is a dummy variable taking on the value 1 if data concerning workers' wages (W_LFS_i) is available in the LFS data set, and \hat{f}_i is defined as follows:

$$\hat{f}_i = LFS_i \hat{\beta}^{SES} + \sum_j z1^j_i w1^j + \sum_k z2^k_i w2^k + \sum_l z3^l_i w3^l + \sum_m z4^m_i w4^m, \quad (3)$$

and variables $w1^j$, $w2^k$, $w3^l$ and $w4^m$ are defined as follows:

$w1^j$ – random number generated from the normal distribution with mean $E(u1^j)$ and standard deviation $\sqrt{Var(u1^j)}$,

$w2^k$ – random number generated from the normal distribution with mean $E(u2^k)$ and standard deviation $\sqrt{Var(u2^k)}$,

$w3^l$ – random number generated from the normal distribution with mean $E(u3^l)$ and standard deviation $\sqrt{Var(u3^l)}$,

$w4^m$ – random number generated from the normal distribution with mean $E(u4^m)$ and standard deviation $\sqrt{Var(u4^m)}$.

The algorithm of complementing the individual data on wages in the LFS source file is presented in the Appendix (Fig. 1).

3. Results and Discussion

Firstly, we identified factors which turned out to be statistically significant in the equation explaining the logarithm of wages (Formula 1). Tab. 3–5 present the results of the estimation of the parameters of the multilevel model for the analysed years (2010–2016).

Results of the estimation indicate that the wages of females in the Polish economy are significantly lower than the wages of males. This result is in line with the results of investigations conducted by, among others, Majchrowska and Strawiński (2016; 2018), who analysed this phenomenon in the Polish labour market. Moreover, the positive relationship between the level of education and wages is in line with the Mincerian framework and confirms the results of other studies for the Polish economy (see, among others, Florczak & Grabowski, 2018). However, the decreasing role of tertiary

Tab. 3: Estimates of parameters for variables associated with features of workers and features of enterprises

Variable	2010	2012	2014	2016
<i>SES_GENDER</i>	-0.106***	-0.112***	-0.110***	-0.106***
<i>SES_EDU5</i>	0.194***	0.184***	0.188***	0.185***
<i>SES_EDU4</i>	0.009***	0.012***	0.011***	-0.005***
<i>SES_EDU2</i>	-0.059***	-0.052***	-0.045***	-0.065***
<i>SES_EDU1</i>	-0.069***	-0.061***	-0.045***	-0.048***
<i>SES_IND</i>	0.159***	0.171***	0.169***	0.132***
<i>SES_EXP_GEN</i>	0.007***	0.007***	0.006***	0.004***
<i>SES_SIZE2</i>	0.079***	0.058***	0.088***	0.074***
<i>SES_SIZE3</i>	0.176***	0.158***	0.184***	0.186***
<i>SES_SIZE4</i>	0.318***	0.277***	0.304***	0.304***
<i>cons</i>	7.598***	7.748***	7.782***	7.909***

Source: own

Note: *, **, *** denote significant at the 10%, 5% and 1% level respectively.

Reference categories:

- workers with secondary general education (*SES_EDU3*);
- microenterprises with 1 to 9 workers (*SES_SIZE1*).

Tab. 4: Estimates of parameters for variables associated with the location of an enterprise

Variable	2010	2012	2014	2016
<i>SES_LOC_KP</i>	-0.067***	-0.066***	-0.084***	-0.098***
<i>SES_LOC_LUBE</i>	-0.090***	-0.103***	-0.089***	-0.117***
<i>SES_LOC_LUBU</i>	-0.048***	-0.044***	-0.045***	-0.031***
<i>SES_LOC_LODZ</i>	-0.039***	-0.048***	-0.045***	-0.067***
<i>SES_LOC_MAL</i>	-0.031***	-0.035***	-0.031***	-0.047***
<i>SES_LOC_MAZ</i>	0.111***	0.085***	0.069***	0.059***
<i>SES_LOC_OPOL</i>	-0.035***	-0.048***	-0.054***	-0.066***
<i>SES_LOC_PODK</i>	-0.105***	-0.111***	-0.109***	-0.122***
<i>SES_LOC_PODL</i>	-0.037***	-0.100***	-0.068***	-0.087***
<i>SES_LOC_POM</i>	0.012***	0.010***	-0.008***	-0.024***
<i>SES_LOC_SL</i>	-0.014***	-0.009***	-0.025***	-0.044***
<i>SES_LOC_SW</i>	-0.066***	-0.089***	-0.078***	-0.108***
<i>SES_LOC_WM</i>	-0.061***	-0.052***	-0.076***	-0.063***
<i>SES_LOC_WIEL</i>	-0.030***	-0.032***	-0.025***	-0.036***
<i>SES_LOC_ZACH</i>	-0.034***	-0.009***	-0.026***	-0.024***

Source: own

Note: *, **, *** denote significant at the 10%, 5% and 1% level respectively. Dolnośląskie region (*SES_LOC_DLN*) is treated as reference category.

education attainment and the increasing role of vocational education attainment is in line with the results obtained by Strawiński et al. (2018) as well as Parteka (2018). Some changes in patterns are also observable. For example, in the years 2010–2014, workers with secondary technical education had an advantage over workers with secondary general education, but in 2016, the latter earned more. The findings of these papers confirm that due to the very low supply of workers with vocational education and the high demand for labour-intensive jobs in the Polish economy, the relative wages of physical workers are increasing compared to the wages of cognitive workers. The phenomenon of the positive relationship between experience and wages was positively verified. In order to avoid the problem of multicollinearity, only one variable associated with experience was taken into account (*SES_EXP_GEN*). In order to check the stability of the results, a variant with the second variable *SES_EXP_ENTERP* was

also considered. This variable is defined as the number of years a worker had worked for an enterprise (in the year of the poll). The results of the estimation were very similar.

Analysis of wage differences in the regional dimension points to the dominant position of the Mazowieckie region (Tab. 4). This result confirms the leading role of the capital city, cumulating the social and economic potential of the country. Regions such as Pomorskie and Dolnośląskie also offer higher than median wages. The lowest level of wages is observed in such regions as Lubelskie, Podkarpackie, Podlaskie and Świętokrzyskie, which are classified as the least developed Polish regions with low innovation potential, thus creating relatively low-wage jobs. The obtained results are in line with the new economic geography approach, arguing that there exists a strong correlation between wages and the economic potential of the region (agglomeration patterns, market access, migration processes) (see,

Tab. 5: Estimates of parameters for variables associated with the NACE section of an enterprise

Variable	2010	2012	2014	2016
<i>SES_SECTION_A</i>	0.034***	0.098***	0.062***	0.105***
<i>SES_SECTION_B</i>	0.317***	0.283***	0.220***	0.163***
<i>SES_SECTION_D</i>	0.178***	0.170***	0.172***	0.185***
<i>SES_SECTION_E</i>	0.047***	0.002	0.002	-0.005
<i>SES_SECTION_F</i>	-0.039***	-0.057***	-0.068***	-0.057***
<i>SES_SECTION_G</i>	-0.018***	-0.052***	-0.032***	-0.031***
<i>SES_SECTION_H</i>	-0.034***	-0.058***	-0.044***	-0.053***
<i>SES_SECTION_I</i>	-0.036***	-0.112***	-0.100***	-0.091***
<i>SES_SECTION_J</i>	0.148***	0.107***	0.081***	0.094***
<i>SES_SECTION_K</i>	0.194***	0.125***	0.084***	0.136***
<i>SES_SECTION_L</i>	0.025***	-0.039***	-0.021***	-0.027***
<i>SES_SECTION_M</i>	0.045***	0.054***	0.045***	0.043***
<i>SES_SECTION_N</i>	-0.216***	-0.173***	-0.147***	-0.140***
<i>SES_SECTION_O</i>	-0.024***	-0.097***	-0.124***	-0.135***
<i>SES_SECTION_P</i>	-0.116***	-0.187***	-0.148***	-0.163***
<i>SES_SECTION_Q</i>	-0.093***	-0.160***	-0.169***	-0.188***
<i>SES_SECTION_R</i>	-0.036***	-0.133***	-0.119***	-0.103***
<i>SES_SECTION_S</i>	-0.157***	-0.048***	-0.041***	-0.061***

Source: own

Note: *, **, *** denote significant at the 10%, 5% and 1% level respectively. Section C (Manufacturing) (*SES_SECTION_C*) is treated as the reference category.

Tab. 6: Predictions of random effects for selected 4-digit professional groups

	2010	2012	2014	2016
Professions with very low predicted random effects (lower than -0.4)	2642, 6223, 7113, 7536, 7537, 9334, 9510	2642, 5242, 6114, 6221, 6222, 9334, 9510	2642, 2656, 4213, 6129, 6221, 6222, 7113, 9123, 9334	2642, 2656, 4213, 6222
Professions with very high predicted random effects (higher than 0.8)	1111, 1112, 1120, 2330, 2341, 2352, 2612, 3153, 3154	1111, 1112, 1120, 2333, 2341, 2352, 2612	1111, 1112, 1120, 2612	1111, 1120, 2352, 2612

Source: own

e.g., Cieřlik & Rokicki, 2016). However, it should be stressed that information concerning regions is very limited. Regions in Poland are characterized by a high variance of the intra-regional level of development. For example, in the Mazowieckie region, although Warsaw is rich and the enterprises located there offer high wages, the peripheral counties of the region are much poorer.

The results from Tab. 5 reveal significant inter-industry differences in wages. The highest wages were recorded in Mining and Quarrying (section B), Professional, Scientific and Technical Activities (section J), as well as the Information and Communication industries (section K). The high level of wages in the IT and Scientific industries is due to the very high demand for jobs related to these NACE sections in the labour market. The strong historical position of trade unions in the Mining and Quarrying industry determined the very high level of wages in this NACE section. However, some changes in patterns are observable. Differences between wages in this section and wages in other industries decreased substantially from 2010 to 2016. As a consequence of the trade unions' strategy in the wage bargaining process, the observed levels of wages do not take into account market conditions and may be above productivity levels (see Jonek-Kowalska, 2014). On the other hand, substantial increases in wages between 2010 and 2016 can also be observed (e.g. in section N – *Administrative and support service activities*). Estimates of the parameters for the remaining variables are in line with expectations and the results of other similar studies. Workers employed in larger enterprises, private enterprises (the positive relationship between

membership of an enterprise in the public sector and wages for emerging countries was found by Seshan, 2013, among others), or on permanent contracts (the impact of the type of contract on wages was verified by, among others, Dias da Silva and Turini (2015)) earn more.

Tab. 6 provides predictions of random effects for selected 4-digit professional groups. Groups with predicted random effects below -0.4 and above 0.8 are taken into account. The lower (in absolute value) negative threshold is due to the fact that wages are generally right-skewed.

The predictions of random effects indicate that, for some professions, wages are higher than expected (on the basis of a microeconomic model without random effects) in the whole analysed period (2010–2016). In particular, this concerns members of public authorities (1111), senior public administration officials (1112), general and executive directors, and judges (2612). High (in absolute value) and negative predictions of random effects are found in the case of professions requiring a lower quality of worker and are characterized by a decreasing demand for them (for example workers stacking shelves (9334), employees of pawnshops and loan institutions (4213), or inland fishermen (6222)). The results from Tab. 6 are in line with expectations and indicate that it is not only the level of education but also the task content of a job that affects wages (see Hardy et al., 2018).

After the estimation of the parameters of multilevel models, the validity of the assumptions concerning random effects should be verified. The presence of random effect for all 4-digit code occupational groups is verified on the basis of testing the validity of the following hypothesis:

$$\begin{aligned} H_0: \forall_m u4^m &= 0, \\ H_1: \sim H_0. \end{aligned} \quad (4)$$

If H_0 hypothesis is not rejected, the presence of random effects for 3-digit code occupational groups should be verified on the basis of testing the validity of the following hypothesis:

$$\begin{aligned} H_0: \forall_l u3^l &= 0, \\ H_1: \sim H_0. \end{aligned} \quad (5)$$

If random effects are not present for 4-digit nor for 3-digit code occupational groups, the presence of random effects for 2-digit code occupational groups should be verified on the basis of testing validity of the following hypothesis:

$$\begin{aligned} H_0: \forall_k u2^k &= 0, \\ H_1: \sim H_0. \end{aligned} \quad (6)$$

If H_0 hypothesis is not rejected in all three cases (Formulas 4, 5 and 6), the presence of random effects for 1-digit code occupational groups should be verified on the basis of testing the validity of the following hypothesis:

$$\begin{aligned} H_0: \forall_j u1^j &= 0, \\ H_1: \sim H_0. \end{aligned} \quad (7)$$

Tab. 7 summarises the results of the verification of the hypothesis concerning the presence of random effects for 4-digit code occupational groups for all analyzed years.

The results from Tab. 7 indicate that in all analysed years random effects were present for

Tab. 7: The verification of the hypothesis concerning presence of random effects for 4-digit code occupational groups

Year	2008	2010	2012	2014	2016
P-value	0.000	0.000	0.000	0.000	0.000

Source: own

Tab. 8: Maximum values of the Cramer's V statistic for pairs of binary explanatory variables

	SES_GENDER	SES_EDU5	SES_EDU4	SES_EDU2	SES_EDU1	SES_IND	SES_SIZE2	SES_SIZE3	SES_SIZE4
SES_GENDER	–	0.18	0.05	0.17	0.04	0.01	0.07	0.02	0.08
SES_EDU5		–	–	–	–	0.10	0.03	0.04	0.06
SES_EDU4			–	–	–	0.00	0.02	0.04	0.05
SES_EDU2				–	–	0.05	0.02	0.01	0.02
SES_EDU1					–	0.07	0.02	0.00	0.03
SES_IND						–	0.01	0.01	0.01
SES_SIZE2							–	–	–
SES_SIZE3								–	–
SES_SIZE4									–

Source: own

4-digit code occupational groups. It indicates that the use of the multilevel mode was justified.

In order to measure the scale of the dependence of binary variables, the Cramer's V statistic was calculated for all pairs and every time periods. Tab. 8 presents maximal values of the Cramer's V statistic for all (excluding regional and sectional dummy variables) pairs of two dichotomic variables. To save space, the Cramer's V statistic for pairs including regional and sectional dummies were not enclosed, however it should be pointed here that these values remained at a low level.

The results from Tab. 8 indicate that the problem of strong dependence among explanatory variables does not exist (as indicated by low values of the Cramer's V statistic).

In order to evaluate the relative importance of consecutive groups of variables, we compared the sum of squared residuals for the full model with the sum of squared residuals for models without specific variables or groups of variables. We considered reduced models without the following variables/groups of variables, associated with: gender; experience; employment for an indefinite period; regions; NACE sections; size of enterprise; level of education. For each variant of the reduced model we calculated the following quantity:

$$S_j = \frac{e_j^T e_j - e^T e}{e^T e}, \quad (8)$$

where $e^T e$ denotes the sum of squared residuals for the full model, while $e_j^T e_j$ is the sum of squared residuals for a model without the j -th group of variables.

Next, we calculated the relative importance of each group of variables on the basis of the following Formula:

$$RI_j = \frac{S_j}{\sum_k S_k}. \quad (9)$$

Tab. 9 presents the relative importance of consecutive groups of variables for all years.

The results of the estimation of the parameters of the full and reduced models indicate that the unexplained part of the variation of the dependent variable increases substantially if the variables associated with the size of an enterprise are excluded from the basic specification. It means that the relative importance of the size of an enterprise contributes the most in explaining workers' wages. Though the importance of some variables which reflect individuals' features in explaining wages turned out to be large (experience, level of education), the role of the variable reflecting type of employment contract as well as most of the company-related characteristics (region, NACE section, size) turned out to be important as well. This result is in line with Ryczkowski and Maksim (2018), who have evidenced that the impact of company-related characteristics is not weaker than the impact of personal characteristics. The relative importance of groups of variables seems to be stable across the whole period 2010–2016. However, it should be stressed that the role of gender in explaining wages decreased in 2016 compared with 2010–2014. In fact, the gender pay gap has decreased in Poland in recent years (see OECD, 2017).

Tab. 9: Relative importance of consecutive groups of variables

Variable/group of variables	2010	2012	2014	2016
Gender	0.055	0.063	0.068	0.017
Experience	0.151	0.157	0.151	0.137
Regions	0.129	0.105	0.098	0.113
NACE sections	0.161	0.174	0.143	0.156
Size	0.244	0.213	0.232	0.276
Level of education	0.130	0.133	0.143	0.151
Indefinite employment period	0.129	0.153	0.163	0.146
Public sector	0.000	0.002	0.002	0.003

Source: own

Tab. 10: Actual and predicted average wages for workers from the Labour Force Survey (in PLN)

Group created on the basis of features of workers and features of enterprises	2010		2012		2014		2016	
	<u>Pred.</u> (1)	<u>True</u> (2)	<u>Pred.</u> (3)	<u>True</u> (4)	<u>Pred.</u> (5)	<u>True</u> (6)	<u>Pred.</u> (7)	<u>True</u> (8)
All workers	2,912	2,646	3,189	2,872	3,549	3,091	3,877	3,471
Males	3,124	2,747	3,278	3,099	3,612	3,252	3,954	3,721
Females	2,586	2,533	3,078	2,703	3,476	2,919	3,793	3,213
Private sector	2,560	2,434	2,750	2,532	3,170	2,903	3,479	3,307
Public sector	3,931	3,056	4,138	3,278	4,364	3,485	4,767	3,808
1–9 workers	1,894	2,138	2,135	2,301	2,448	2,492	2,726	2,704
10–49 workers	2,654	2,558	2,987	2,783	3,409	2,955	3,700	3,310
50–249 workers	3,143	2,777	3,489	3,021	3,840	3,273	4,274	3,649
More than 250 workers	3,960	3,108	4,012	3,378	4,266	3,536	4,625	4,076
Basic education	2,071	1,883	2,123	2,011	2,317	2,188	2,569	2,369
Vocational education	2,319	2,219	2,456	2,389	2,609	2,588	2,870	2,801
Secondary general education	2,379	2,294	2,503	2,489	2,676	2,685	2,946	3,116
Secondary technical education	2,697	2,514	2,878	2,756	3,087	2,923	3,328	3,195
Tertiary education	4,121	3,838	4,457	3,975	4,895	4,161	5,306	4,509

Source: own

In order to evaluate the quality of our novel method for complementing data on the wages of workers who did not provide any information about their wages in the LFS, descriptive statistics both for workers who gave information about their wages as well as for workers who did not provide any information have been calculated. The mean values for all workers, as well as for members of consecutive groups, are presented in Tab. 10.

According to the results from Tab. 10, the higher predicted wages correspond to actual wage levels. This tendency is optimistic, since it seems that the microeconomic model correctly predicts the distribution of wages. For workers who have completed tertiary education and who are employed in large enterprises or the public sector, predicted wages are higher, which is in line with reality. On the other hand, the theoretical wages of women with basic or vocational education in microenterprises belonging to the private sector are low, which corresponds with reality. However, the differences between the predicted wages and the observed ones in some groups are not

negligible. Therefore, an in-depth analysis of these differences should be conducted.

Analysis of the ratios of predicted wages to observed ones indicates that they are not equal in all groups. The analysed ratio is much higher in the case of workers from public sector enterprises than for employees representing private enterprises. Moreover, the ratio strongly depends on the size of the enterprise (the larger a company, the higher the analysed ratio) and the level of the workers' education (positive correlation). The results are in line with expectations and common knowledge concerning discrepancies between wages obtained from the LFS and the SES data sets. As Strawiński (2015) found, wages from the two data sets are almost equal in the case of employees with below median wages. When wages exceed the median, the difference between SES wages and LFS wages is an increasing quantile function of the wage distribution.

Large differences between predicted and observed wages in the public sector and the largest enterprises may be due to the fact that

employees do not take into account perks or other additional benefits when they report their net wages. A similar tendency may be observed in the case of employees with higher education. Additional benefits and perks are more often provided in larger enterprises, the public sector and departments with a high ratio of well-educated workers. Moreover, in large and public enterprises, a quarterly or yearly bonus is very often provided to workers. This bonus is taken into account by Human Resources (HR) departments when they provide information about the wages of employees, but may not be included by individual employees when they reveal their net wage. It should be stressed that high earning workers may be less aware of their wages than low earning workers. Suppose that there is one worker with a constant wage of 2,247 PLN and a second worker with a wage of 6,247 PLN. The second one may report 6,200 since 47 is not a large part of his/her wage. For the first worker, the difference between 2,247 and 2,200 is large, so this employee will probably give his/her exact wage. A positive correlation between the quantile of the wage distribution and the discrepancy between the predicted and observed wages may be due to changes in wages as well as polarization and the SBTC phenomenon (see, e.g., Goos & Manning, 2007). The increasing gap between high and low earners results from the fact that the wages of professionals change more often. When workers report the level of their wages in the Labour Force Survey, they may mention wages earned a few months before. In the case of highly-qualified employees, the difference between wages observed a few months previously and the current level may be much larger than in the case of low earning workers.

In the case of workers from some groups (low level of education, the private sector, microenterprises), the predicted wages are higher than the observed ones. This tendency may be due to the envelope wage phenomenon, which is popular in transition economies (see, e.g., Williams, 2015; Kukk & Staehr, 2014;

2017; Williams & Hordonic, 2015). Employees with a low level of education, working for poor enterprises in transition countries, very often agree to receive a so-called envelope wage. Employers decide to provide an envelope wage in order to reduce costs. Officially, they are given very low wages, which is reported by the HR departments of the enterprises. In reality, they are given this minimum low wage plus an envelope wage. They report their true income in the Labour Force Survey. This may result in higher actual wages than predicted ones for particular groups of workers.

All in all, discrepancies between the predicted wages and the actual ones indicate that additional steps are required when the predicted data on wages are combined with the empirical data. The results of the ANOVA analysis (available upon request) indicate that four factors explain more than 95% of the variation of the predicted to observed ratio. They are: sector, employee's level of education, employee's gender, and size of the enterprise. Therefore, for each year (2010, 2012, 2014, 2016) we define the following variables:

- $pre_{se,e,g,si}^t$ – average predicted wage of an employee from sector se , employed in an enterprise from size class si with the level of education e and gender g in year t ,
- $obs_{se,e,g,si}^t$ – the average observed wage of an employee from sector se , employed in an enterprise from size class si with the level of education e and gender g in year t .

On the basis of these variables, the correction factor is calculated according to the following Formula:

$$corr_{se,e,g,si}^t = \frac{obs_{se,e,g,si}^t}{pre_{se,e,g,si}^t} \tag{10}$$

As a result, a modified Formula for calculating wage for the i -th individual from the LFS who works in an enterprise belonging to sector se and size class si is as follows:

$$W_{theor_LFS_CORR}_i = \begin{cases} W_{LFS}_i & \text{if } AV_{LFS}_i = 1, \\ W_{theor_LFS}_i * corr_{se,e,g,si}^t & \text{if } AV_{LFS}_i = 0. \end{cases} \tag{11}$$

Formula 11 indicates that when the wage of an individual in the LFS is given, its prediction is redundant. When it is not given, a theoretical value should be calculated on the basis of the SES and microeconomic model estimates. Moreover, after comparing the wages of individuals' reporting their wages with workers not reporting them, a correction factor should be

calculated for all groups. This correction factor should next be used to calculate corrected theoretical wages. After using Formula 11, we obtain the improved LFS data set with wages for all individuals (even those not reporting them).

The correction factors turned out to be similar in all analysed years (2010, 2012,

Tab. 11: Geometric mean of a correction factor calculated according to the Formula 10

Size of an enterprise and educational attainment of workers	Females, Public sector	Females, Private sector	Males, Public sector	Males, Private sector
Microenterprises, Basic education	–	1.07	–	1.08
10–49 workers, Basic education	0.87	0.94	1.03	0.99
50–249 workers, Basic education	0.80	0.92	0.93	0.93
At least 250 workers, Basic education	0.73	0.90	0.75	0.89
Microenterprises, Vocational education	–	1.07	–	1.12
10–49 workers, Vocational education	0.85	1.05	0.99	1.03
50–249 workers, Vocational education	0.87	0.99	0.93	0.94
At least 250 workers, Vocational education	0.83	0.96	0.83	0.87
Microenterprises, Secondary general education	–	1.06	–	1.15
10–49 workers, Secondary general education	0.98	1.06	0.90	1.06
50–249 workers, Secondary general education	0.86	1.09	0.86	0.95
At least 250 workers, Secondary general education	0.77	1.00	0.95	0.89
Microenterprises, Secondary technical education	–	1.08	–	1.13
10–49 workers, Secondary technical education	0.96	1.00	0.93	1.00
50–249 workers, Secondary technical education	0.93	0.93	0.90	0.90
At least 250 workers, Secondary technical education	0.79	0.91	0.85	0.85
Microenterprises, Tertiary education	–	0.96	–	1.01
10–49 workers, Tertiary education	0.79	0.97	0.85	0.95
50–249 workers, Tertiary education	0.85	0.91	0.82	1.00
At least 250 workers, Tertiary education	0.84	0.94	0.84	0.87

Source: own

Note: – denotes microenterprises that are very rare in the public sector. Therefore means for these groups are omitted.

2014, 2016). To save space in the article, only the geometric means of the ratio for different sectors, size groups, genders and levels of educational attainments are reported. These geometric means are presented in Tab. 11.

The results from Tab. 11 comply with the results from Tab. 10. After predicting the wages (according to Formula 2) of employees with tertiary education working in larger public enterprises, they are multiplied by a correction factor lower than 1. After predicting the wages (according to Formula 2) of employees with a lower level of educational attainment, working for smaller, private enterprises, a correction factor higher than 1 is used. After using the correction factor according to Formula 11, the predicted and actual data can be combined, and a researcher may use a larger data set in order to analyse the level of wages.

Conclusions

To sum up, the presented study highlights the problem of the large data gaps in wages in the Polish Labour Force Survey data set. However, this problem is universal and also appears in data sets from other EU countries. We propose a novel method to complement the LFS data on wages on the basis of the SES data set and microeconomic model estimates. The proposed method can be adapted and implemented on the LFS data sets of other countries. The use of this method makes it possible to get a more complete profile of respondents from the LFS. Moreover, the completed data on wages can be used in further LFS data analyses without having to skip a large number of incomplete observations.

As a result of using our method of complementing missing data, we found some discrepancies between the predicted and observed wages. However, these discrepancies turned out to depend mainly on two features of the enterprises (size class and sector) and two features of the workers (level of education and gender). Therefore, on the basis of these features, we created correction factors which are used in order to adjust wages. The analysis of correction factors provided information about the mechanism of not declaring, underestimating and overestimating wages. Well-educated employees from large and public enterprises may not include additional benefits when providing information about wages. Workers with a low level of educational

attainment who are employed in small, private enterprises may agree to receive a so-called envelope wage and report higher earnings in the LFS than is reported in the SES.

The results of the estimation of the parameters of the multilevel model show the impact of features of employees on wages. Generally, they are in line with expectations. However, some changes in patterns are observable. For example, workers with secondary technical education had an advantage over workers with secondary general education in the years 2010–2014. However, in 2016, the latter earned more, *ceteris paribus*. Differences between wages in the mining and quarrying industry and wages in other industries decreased substantially from 2010 to 2016. Predictions of random effects indicate that there are professions with very high (e.g. members of public authorities) and very low (e.g. workers stacking shelves) wages in the whole analysed period. When random effects are not included, the explanatory power of the econometric model decreases substantially.

We should also emphasize that our research could have some limitations. Not all variables affecting wages are included in the SES data set. For example, variables associated with the class of town/village and marital status are not available. Therefore, some variables that are traditionally used in models explaining wages cannot be included in the specification. Moreover, information concerning the location of an enterprise is very limited. Regions may be characterized by a high-variance of the intra-regional level of development. Therefore, information that an enterprise is located in a specific region does not reflect the full picture of conditions in the local labour market.

In the future, we will use completed data on wages in further LFS data analyses, related to, for example, the polarization hypothesis, the skill-biased technical change phenomenon, the gender wage gap, and inter-regional and section differences in wages. On the basis of newer LFS and SES questionnaires, we will develop the proposed method in order to obtain more accurate estimates. Moreover, we will try to conduct similar estimations for other EU countries. After that, we will compare the differences between Poland and other countries.

Acknowledgement: *This paper was prepared within the framework of the research project*

entitled "The polarization of the Polish Labour Market in the context of technical change," financed by the National Science Centre, Poland (contract number 2016/23/B/HS4/00334).

We are grateful to Iwona Kukulak-Dolata, Łukasz Arendt, Leszek Kucharski, Paweł Baranowski and anonymous reviewers for their helpful comments, which enabled us to improve the initial version of this paper.

References

- ADB. (2012). *Labour Force Data Analysis: Guidelines with African Specificities*. Retrieved March 28, 2019, from www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Labour%20Force%20Data%20Analysis_WEB.pdf
- Ahituv, A., & Lerman, R. I. (2007). How do marital status, work effort, and wage rates interact? *Demography*, 44(3), 623–647. <https://doi.org/10.1353/dem.2007.0021>
- Ahn, N., & Sanchez-Macros, V. (2017). Emancipation under the great recession in Spain. *Review of Economics of the Household*, 15(2), 477–495. <https://doi.org/10.1007/s11150-015-9316-7>
- Arendt, L., & Grabowski, W. (2019). Technical change and wage premium shifts among task-content groups in Poland. *Economic Research – Ekonomska Istraživanja*, 32(1), 3392–3410. <https://doi.org/10.1080/1331677X.2019.1661788>
- Artz, B., & Taengnoi, S. (2019). The Gender Gap in Raise Magnitudes of Hourly and Salary Workers. *Journal of Labor Research*, 40(1), 84–105. <https://doi.org/10.1007/s12122-018-9277-8>
- Autor, D. H., Levy, F., & Murane, R. J. (2003). The skill content of recent technological change. An empirical exploration. *The Quarterly Journal of Economics*, 118(4), 1279–1333. <https://doi.org/10.1162/003355303322552801>
- Blau, F. D., & Kahn, L. M. (2007). The gender pay gap: Have women gone as far as they can? *Academy of Management Perspectives*, 21(1), 7–23. <https://doi.org/10.5465/amp.2007.24286161>
- Central Statistical Office. (2018). *Labour Force Survey in Poland. II quarter 2018*. Retrieved from http://stat.gov.pl/download/gfx/portalinformacyjny/en/defaultaktualnosci/3293/2/30/1/labour_force_survey_in_poland_2nd_quarter_2018.pdf
- Cieślak, A., & Rokicki, B. (2016). Individual wages and regional market potential: evidence from the Polish Labour Force Survey. *Economics of Transition*, 24(4), 661–682. <https://doi.org/10.1111/ecot.12102>
- Dias da Silva, A., & Turrini, A. (2015). *Precarious and less well-paid? Wage differences between permanent and fixed-term contracts across the EU countries* (Economic Papers 544). Brussels: European Commission.
- European Commission. (2018). *EU Labour Force Survey Database User Guide*. Retrieved from <http://ec.europa.eu/eurostat/documents/1978984/6037342/EULFS-Database-UserGuide.pdf>
- Freeman, R., & Katz, L. (1994). Rising wage inequality: the U.S. versus other advanced countries. In R. Freeman (Ed.), *Working Under Different Rules* (pp. 29–62). New York, NY: Russel Sage Foundation.
- Gallen, Y., Lesner, R. V., & Vejlin, R. (2019). The labor market gender gap in Denmark: Sorting out the past 30 years. *Labour Economics*, 56, 58–67. <https://doi.org/10.1016/j.labeco.2018.11.003>
- Gannon, B., Plasman, R., Tojerow, I., & Rycx, F. (2007). Inter-industry wage differentials and the gender wage gap: Evidence from European countries. *Economic and Social Review*, 38(1), 135–155. Retrieved from <http://hdl.handle.net/2262/60127>
- Goos, M., & Manning, A. (2007). Lousy and lovely jobs: The rising polarization of work in Britain. *Review of Economics and Statistics*, 89(1), 118–133. <https://doi.org/10.1162/rest.89.1.118>
- Grabowski, W. (2019). Does the use of professional legal assistance bring measurable benefits? *Applied Economics Letters*, 26(17), 1444–1447. <https://doi.org/10.1080/13504851.2019.1578850>
- Hara, H. (2018). The gender wage gap across the wage distribution in Japan: Within- and between-establishment effects. *Labour Economics*, 53, 213–229. <https://doi.org/10.1016/j.labeco.2018.04.007>
- Hardy, W., Keister, R., & Lewandowski, P. (2018). Educational upgrading, structural change and the task composition of jobs in Europe. *Economics of Transition*, 26(2), 201–231. <https://doi.org/10.1111/ecot.12145>
- Jonek-Kowalska, I. (2015). Employment and Remuneration Trends in Polish Hard Coal Mines in the Context of the Relations Between Boards and Trade Unions. *International Journal of Synergy and Research*, 3, 27–43. <http://dx.doi.org/10.17951/ijrsr.2014.3.0.27>
- Katz, L. F., & Autor, D. H. (1999). Changes in the wage structure and earnings inequality.

In O. Ashenfelter & D. Card (Eds.), *Handbook of Labor Economics* (Vol. 3, pp. 1463–1555). Amsterdam: Elsevier.

Kerr, A., & Wittenberg, M. (2015). Sampling methodology and fieldwork changes in the October Household Surveys and Labour Force Surveys. *Development Southern Africa*, 32(5), 603–612. <http://dx.doi.org/10.1080/0376835X.2015.1044079>

Kukk, M., & Staehr, K. (2014). Income underreporting by households with business income: Evidence from Estonia. *Post-Communist Economies*, 26(2), 257–276. <https://doi.org/10.1080/14631377.2014.904110>

Kukk, M., & Staehr, K. (2017). Identification of households prone to income underreporting. Employment status or reported business income? *Public Finance Review*, 45(5), 599–627. <https://doi.org/10.1177/1091142115616182>

Majchrowska, A., & Strawiński, P. (2016). Regional differences in gender wage gaps in Poland: New estimates based on harmonized data for wages. *Central European Journal of Economic Modelling and Econometrics*, 8(2), 115–141. Retrieved from <http://www.cejeme.org/publishedarticles/2016-09-30-636028709931093750-5582.pdf>

Majchrowska, A., & Strawiński, P. (2018). Impact of minimum wage increase on gender wage gap: Case of Poland. *Economic Modelling*, 70, 174–185. <https://doi.org/10.1016/j.econmod.2017.10.021>

McCulloch, C. E. (1997). Maximum Likelihood Algorithms for Generalized Linear Mixed Models. *Journal of the American Statistical Association*, 92(437), 162–170. <https://doi.org/10.1080/01621459.1997.10473613>

Melly, B. (2005). Public-private sector wage differentials in Germany: Evidence from quantile regression. *Empirical Economics*, 30(2), 505–520. <https://doi.org/10.1007/s00181-005-0251-y>

Mikucka, M., & Valentova, M. (2013). Employed or inactive? Cross-national differences in coding parental leave beneficiaries in European Labour Force Survey data. *Survey Research Methods*, 7(3), 169–179. <http://dx.doi.org/10.18148/srm/2013.v7i3.5308>

Mincer, J. (1974). *Schooling, Experience, and Earnings*. (Human Behavior & Social Institutions No. 2). Cambridge, MA: National Bureau of Economic Research.

Mincer, J., & Polachek, S. (1974). Family Investments in Human Capital: Earnings of Women. *Journal of Political Economy*, 82(2), S76–S108.

OECD. (2017). *Closing the Gender Gap – Poland*. Paris: OECD. Retrieved March 31, 2019, from www.oecd.org/gender/Closing%20the%20Gender%20Gap%20-%20Poland%20FINAL.pdf

O'Mahony, M., & Timmer, M. P. (2009). Output, input and productivity measures at the industry level: the EU KLEMS database. *The Economic Journal*, 119(538), F374–F403. <http://dx.doi.org/10.1111/j.1468-0297.2009.02280.x>

Orche Galindo, E. J., & Bueno Maroto, H. (2011). Obtaining Statistical Information in Sampling Surveys from Administrative Sources: Case Study of Spanish LFS 'Wages from the Main Job'. In *ESSnet Data Integration Workshop, Madrid, Spain*.

Ormerod, C., & Ritchie, F. (2007). Linking ASHE and LFS: can the main earnings sources be reconciled? *Economic & Labour Market Review*, 1(3), 24–31. <https://doi.org/10.1057/palgrave.elmr.1410041>

Parteka, A. (2018). Import Intensity of Production, Tasks and Wages: Micro-Level Evidence for Poland. *Entrepreneurial Business and Economics Review*, 6(2), 71–89. <https://doi.org/10.15678/EBER.2018.060204>

Pastore, F., & Socha, M. (2006). The Polish LFS: A Rotating Panel with Attrition. *Ekonomia*, 15(3), 3–24.

Peter, S., & Drobnič, S. (2013). Women and their memberships: Gender gap in relational dimension of social inequality. *Research in Social Stratification and Mobility*, 31, 32–48. <https://doi.org/10.1016/j.rssm.2012.09.001>

Psacharopoulos, G., & Ng, Y. C. (1994). Earnings and Education in Latin America. *Education Economics*, 2(2), 187–207. <https://doi.org/10.1080/09645299400000016>

Ryckowski, M., & Maksim, M. (2018). Low wages – Coincidence or a result? Evidence from Poland. *Acta Oeconomica*, 68(4), 549–572. <https://doi.org/10.1556/032.2018.68.4.4>

Seshan, G. K. (2013). Public-private-sector employment decisions and wage differentials in peninsular Malaysia. *Emerging Markets Finance and Trade*, 49(S5), 163–179. <https://doi.org/10.2753/REE1540-496X4905S510>

Skinner, C., Stuttard, N., Beissel-Durrant, G., & Jenkins, J. (2002). The measurement of low pay in the UK Labour Force Survey.

Oxford Bulletin of Economics and Statistics, 64(S1), 653–676. <https://doi.org/10.1111/1468-0084.64.s.5>

Strawiński, P. (2015). Krzyżowe porównanie danych o wynagrodzeniach z polskich badań przekrojowych. *Bank i Kredyt*, 46(5), 433–462. Retrieved from http://bankikredyt.nbp.pl/homen.aspx?f=/content/2015/05/bik_05_2015_en.html

Strawiński, P., Majchrowska A., & Broniatowska, P. (2018). Wage Returns to Different Education Levels. Evidence from Poland. *Ekonomista*, 2018(1), 25–49.

Williams, C. C. (2015). Evaluating cross-national variations in envelope wage payments in East-Central Europe. *Economic*

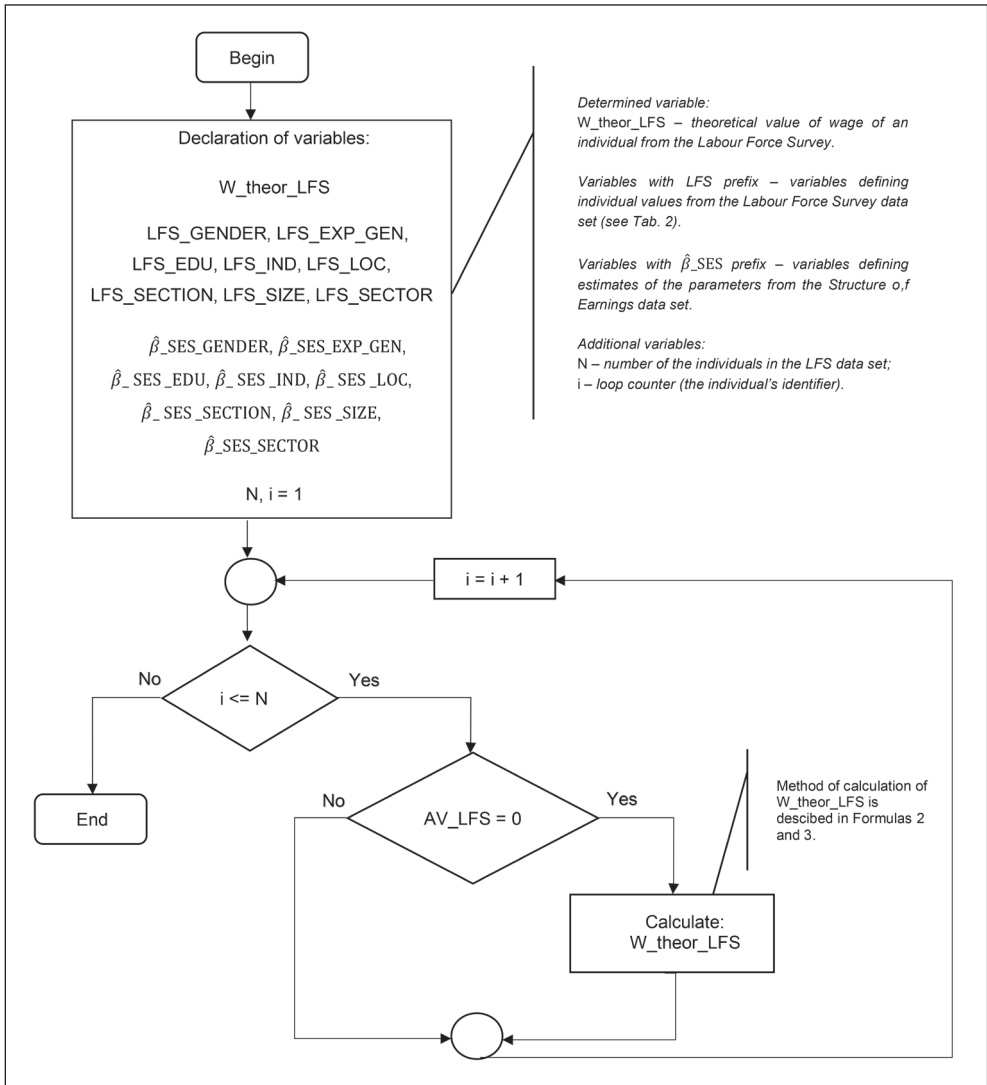
and Industrial Democracy, 36(2), 283–303. <https://doi.org/10.1177/0143831X13505120>

Williams, C. C., & Hordonic, I. A. (2015). Evaluating the prevalence of the undeclared economy in Central and Eastern Europe: An institutional asymmetry perspective. *European Journal of Industrial Relations*, 21(4), 389–406. <https://doi.org/10.1177/0143831X14568835>

Vehovar, V. (1999). Field substitution and unit nonresponse. *Journal of official Statistics*, 15(2), 335–350.

Zimermanová, K. (2010). Selected actual aspects of employees remuneration in small and medium-sized Companies. *E&M Economics and Management*, 13(3), 33–44.

Fig. 1: Simplified algorithm of complementing data on wages in the LFS source file



Source: own

Note: Fig. 1 presents a simplified algorithm of complementing data on wages in the LFS source file. Implementing the Formula on W_theor_LFS requires the use of conditional statements for each dummy variable (see Tab. 2). In a complete algorithm, there are 44 conditional statements for variables of this type (available upon request).

HEALTH-RELATED QUALITY OF LIFE AND SOCIO-ECONOMIC STATUS OF THE UNEMPLOYED

**Daniel Puciato¹, Michał Rozpara², Marek Bugdol³,
Piotr Oleśniewicz⁴, Helena Jáčová⁵**

¹ WSB University in Wrocław, Faculty of Finance and Management, Poland, ORCID: 0000-0002-2390-6038, daniel.puciato@wsb.wroclaw.pl;

² The Jerzy Kukuczka Academy of Physical Education in Katowice, Institute of Sport Sciences, Poland, ORCID: 0000-0003-3571-6677, m.rozpara@awf.katowice.pl;

³ Jagiellonian University, Faculty of Management and Social Communication, Institute of Economics, Finance and Management, Poland, ORCID: 0000-0001-9993-7765, marek.bugdol@uj.edu.pl;

⁴ University School of Physical Education in Wrocław, Faculty of Physical Education, Department of Tourism, Poland, ORCID: 0000-0002-0426-0630, piotr.olesniewicz@awf.wroc.pl;

⁵ Technical University of Liberec, Faculty of Economics, Department of Finance and Accounting, Czech Republic, ORCID: 0000-0001-8622-1899, helena.jacova@tul.cz.

Abstract: Unemployment has a number of negative, economic, social and psychological effects on unemployed people and their families. Lowered household income leads to a constrained fulfilment of individual and collective needs, which has a significant impact on the quality of life and perceived health condition of the unemployed. The aim of this study is the identification of relationships between the quality of life and socio-economic status of unemployed persons. The study was carried out among 403 registered unemployed persons (246 women, 157 men) from Wrocław, Poland. The main method used in the study was the diagnostic questionnaire survey. Respondents' quality of life was assessed using the World Health Organization Quality of Life (WHOQOL-BREF) questionnaire, and their socio-economic status with author's own S-ESQ questionnaire. Arithmetic means and standard deviation were calculated. Correlations between respondents' quality of life and socio-economic status were checked with the Kruskal-Wallis one-way analysis of variance and Dunn's post-hoc tests. The ex-ante level of statistical significance was set at $\alpha < 0.05$. The mean health-related quality of life score of the unemployed respondents under study was higher than the mean perceived health condition score. As for the four quality of life domains, the respondents reported the highest scores in the social domain and psychological domain, followed by the physical and environmental domains. The analysis of mean scores of overall quality of life of the unemployed revealed statistically significant differences between groups of jobless Wrocław residents with regard to such factors as age, number of household members, and per capita income. Respondents' age, education, marital status, persons per household, per capital income, and having savings were also significant differentiating factors of perceived health condition. The results of the study can be significant for public health policies in Poland and other countries at a similar level of economic development.

Keywords: Quality of life, WHO, unemployed.

JEL Classification: I31, J10, J60.

APA Style Citation: Puciato, D., Rozpara, M., Bugdol, M., Oleśniewicz, P., & Jáčová, H. (2020). Health-related Quality of Life and Socio-economic Status of the Unemployed. *E&M Economics and Management*, 23(3), 23–37. <https://doi.org/10.15240/tul/001/2020-3-002>

Introduction

Unemployment was the greatest social problem faced by the Poles during the political transformation and the transition from a centrally planned to a free market economy. The average unemployment rate in Poland was higher than in most other countries of Central and Eastern Europe. In the studied period, the unemployment rate amounted to 11.5% in 2014 and 9.7% in 2015, respectively (<https://bdm.stat.gov.pl>). However, there is a large regional variation in the unemployment rate, which means that despite the dynamic economic growth, the problem of unemployment still affects representatives of many social groups in Poland.

Unemployment, in particular long-term unemployment, has a number of negative, economic, social, and psychological effects on jobless people and their families. Reduced household income leads to various constraints of fulfillment of individual and collective needs. Joblessness results in a decline of professional skills and qualifications, which often hinders or even prevents a successful return to work (Zhang & de Figueiredo, 2018). A decline in social relationships can be observed as well as conflicts in families, sense of social exclusion, and loss of social standing (Vossemer et al., 2018). The costs are the highest for the unemployed individuals who experience emotional disorders, low life satisfaction, and higher susceptibility to diseases (Tøge, 2016).

Numerous studies have indicated the negative impact of unemployment on mental health. Buffel, Missinne and Bracke (2017), observed such symptoms as helplessness, frustration, low self-esteem, increased stress, and depression in jobless people. The unemployed also experience a higher incidence of psychosomatic disorders, e.g. heart diseases or tumors, than the employed (Meneton et al., 2017). Clemens, Popham and Boyle (2015), noted that the all-cause mortality risk was nearly twice as high for the unemployed as for the employed. A meta-analysis by Milner, Page and LaMontagne (2014) revealed that unemployment is significantly correlated with a higher relative risk of suicide. This observation was also shared by Meneton et al. (2017). Long-term structural unemployment was considered exceptionally hazardous by Blomgren and Valkonen (2007), late-career unemployment by Voss et al. (2018), and unemployment of young

people by Kawada (2018). Madureira-Lima et al. (2018) revealed an increased negative impact of unemployment on health status during the Great Recession, and Heggebo (2016), during an economic downturn.

The potential relationships between health and unemployment can be associated not only with the negative, indirect impact of joblessness on health condition, but also with the impact of poor health on unemployment. These relationships were examined by Van Zon et al. (2017). Leonardi et al. (2018) in their studies of Polish, Spanish and Finnish populations concluded that factors related to unemployment included physical disability, mental issues, and poor eyesight and hearing.

In this context not only is an objective health status important but also self-perceived health-related quality of life. Earlier studies indicated that a lower quality of life index is often associated with the incidence of motor function disorders and worse social functioning (Lee et al., 2005).

A key research issue is the impact of the socio-economic situation of unemployed people on their perception of health condition and quality of life. While researchers have previously examined this problem in relation to total working-age populations (Réklaityienė, Bacevičienė, & Andrijauskas, 2009; Huang et al., 2015; Zhang et al., 2015) and patients (Kokaliari, 2016; Opoku-Boateng et al., 2017; Raymakers et al., 2018), there have been relatively few studies concerning the unemployed (Chinweuba et al., 2018; Yang et al., 2016). So far no socio-economic factors, such as the number of persons per household, work-unrelated income (e.g. alimony benefits, child allowance, or financial assistance from family members), savings, or indebtedness, have been considered in assessments of health-related quality of life. The present study attempts to address this research gap.

1. Theoretical Background

Researchers have noted a worse health condition among the unemployed than among the employed (Tran, Canfield, & Chan, 2016). In Øverland et al. (2006), jobless respondents rated their health as worse than the employed. In a male Finnish population Griep et al. (2016) noted better perceived health condition among insecure permanent employees than among the short-term unemployed, and in particular,

than among the long-term unemployed. A study of an Italian unemployed population as well as first-job seekers and insecure temporary workers showed that all of them reported a worse perceived health status than secure permanent employees (Minelli et al., 2014).

Sołtysik et al. (2017), found a lower quality of life in the unemployed than in manual and white-collar workers. Czekirda et al. (2017) indicated, however, more complex associations between unemployment and quality of life. A comparison between the quality of life of working and jobless nurses and midwives showed that the working nurses perceived their quality of life better than their unemployed counterparts. However, jobless midwives assessed their quality of life higher than their working counterparts. Michalos and Orlando (2006) showed that unemployed working-age individuals rated their quality of life lower than the pre-working-age unemployed. A lower assessment of quality of life of the unemployed than of the employed was also observed by Worach-Kardas and Kostrzewski (2013) in an urban population aged more than 45 years. Carlier et al. (2013) also showed that re-employment significantly improved the self-rated health of unemployed respondents.

There have been rather few population-based studies regarding the links between the quality of life and socio-economic status of healthy persons. In a study of Chinese population Zhang et al. (2015), showed low income, older age, and unemployment to be significant factors of lower quality of life assessment. Huang et al. (2017) in their research on a Chinese population showed that lower quality of life (QoL) index scores were associated with older age, low levels of education, temporary accommodation, poverty, and unemployment. Studies of Lithuanians indicated associations between higher quality of life scores, higher education and income levels, and occupation. Unemployed and retired Lithuanians attained lower quality of life index scores than their working counterparts (Rėklaitienė, Bacevičienė, & Andrijauskas, 2009).

Kokaliari (2016) analyzed associations between quality of life and socio-economic status in Greece following the austerity measures imposed after the financial crisis. She recorded lower quality of life scores in women, single parents, low income workers, and the unemployed. In an interesting study of postpartum women Chinweuba et al. (2018),

showed that women with higher levels of education and income rated their quality of life better than women with lower education and income levels. Moreover, the quality of life assessment deteriorated with the studied women's age and was higher in working women than in non-working women. Yang et al. (2016) evaluated the quality of life in its physical and mental domains among 1,825 unemployed respondents from China, and examined the relationships between their quality of life and socio-economic status. Higher mean QoL physical domain scores were shown to be related with the male sex, younger age, and higher income. Single unemployed persons under 25 years of age, whose monthly income exceeded 2,000 yuans perceived their quality of life as the highest in the mental domain. The perception of quality of life in the physical and psychological domains also depended on employment length, and it was significantly worse among people who remained unemployed for longer than 6 months.

Earlier research also pointed to the impact of socio-economic status on perceived health condition. Janković, Janević and Knesebeck (2012) in their study of a Serbian population concluded that the odds of assessing their health as poor were four-times higher in individuals with a low education than with a higher education. The odds of poor self-perceived health by the unemployed was, however, about 1.5 times higher than by the employed. Griep et al. (2016) found statistically significant correlations between perceived health condition and such variables as age, education, having children, income, and place of residence. Negative correlations of self-rated health with age, and positive correlations with education, number of children under 18 years of age in the family, and place of residence were also found. Minelli et al. (2014), confirmed that young people with high incomes did rate their perceived health condition most highly.

In view of the above considerations the aim of this study is the identification and assessment of potential correlations between health-related quality of life and socio-economic status in unemployed individuals. Two specific research problems have been formulated:

1. What is the assessment of the quality of life of the unemployed from Wrocław?
2. Are gender, age and such factors of socio-economic status as: level of education,

marital status, household size, income per capita, savings and debt related to the assessment of the quality of life of the respondents?

2. Research Methodology

The survey was of a cross-sectional nature and was conducted from October 2014 to March 2015, in Wrocław, Poland. The study sample comprised 4,332 persons (2,276 women, 2,056 men) aged 18–64 years, i.e. about 1% of all working-age residents of Wrocław. The minimum sample size was calculated using the formula below (Brzeziński, 2011):

$$n = \frac{N}{1 + \frac{e^2(N-1)}{Z_{\alpha}^2 pq}} \quad (1)$$

where: N – number of Wrocław residents on December 31, 2013 (N = 632,067); p – fraction of working-age Wrocław residents on December 31, 2013 (p = 0.63); q – constant calculated as 1–p (q = 0.37); e – expected estimation error of p (e = 1.5%); Z_{α} = 1.96 for α = 0.05.

The sample selection was random using a three-level stratification. First, with the use of a random number table, ten residential areas were selected from all alphabetically ordered Wrocław areas. Next, three streets from each selected residential area were chosen, whose residents were asked to fill in the questionnaire. The number of respondents from particular residential areas was proportionate to the number of residents of these areas. The respondents were all informed about the purpose and the course of the study, and they expressed their written consent to participate.

403 respondents (246 women, 157 men) were registered unemployed persons, and they were divided into the following age ranges: 18–24 years (21% of women, 28% of men), 25–34 years (18% of women, 26% of men), 35–44 years (8% of women, 10% of men), 45–54 years (13% of women, 17% of men), and 55–64 years (40% of women, 20% of men). The majority of the unemployed respondents (68% of women, 70% of men) had a primary or vocational education; 24% of women and 22% of men – a secondary education, and 8% of both men and women – a higher education. Almost 53% of women and 52% of men among the unemployed under study were married, while 47% of women and 48% of men were

single. 15% percent of women and 13% of men lived alone, 31% of women and 29% of men lived in two-person households, 20% of women and 15% of men in three-person households, 21% of women and 31% of men in four-person households, and about 13% of both men and women in five-and-more person households. The monthly per capita income in a household up to PLN 500 was earned by 23% of women and 44% of men, PLN 501–1,000 by 30% of women and 22% of men, PLN 1,001–1,500 by 28% of women and 25% of men, PLN 1,501–2,000 by 9% of women and by 5% of men, and above PLN 2,000 by 10% of women and 4% of men. Almost 83% of the unemployed women and 95% of unemployed men under study had no savings, and over 82% of women and 81% of men were in debt (Tab. 1).

The main method used in the study was the diagnostic questionnaire survey. Respondents' quality of life was rated with the World Health Organization Quality of Life (WHOQOL-BREF) questionnaire (WHO, 2013) consisting of 26 items assessing: Overall Quality of Life (OQoL), Perceived Health Condition (PHC), and Quality of Life in four domains: Physical Domain (PHYD), Psychological Domain (PSYD), Social Domain (SD), and Environmental Domain (ED). Answers to the items were expressed on a scale: 1 to 5 points where the best score is: 5 and the worst is 1 for OQoL and perceived health condition (PHC); and 4 to 20 points for each of the four quality of life domains where the best score is: 20 and the worst is 4.

The socio-economic status of the unemployed was assessed using author's own socio-economic status questionnaire (S-ESQ), which considered such variables as: gender (female, male), age (18–24, 25–34, 35–44, 45–54, 55–64 years), education (primary and vocational, secondary, higher), marital status (single, married), number of persons per household (1, 2, 3, 4, 5–9), per capita income (\leq 500, 501–1,000, 1,001–1,500, 1,501–2,000, \geq 2,001 Polish zlotys [PLN]), having savings (NO, YES), and indebtedness (NO, YES). Before the application of the S-ESQ questionnaire its reliability was ensured with a test-retest method. To that end a group of 115 people (64 women, 51 men) filled the questionnaire twice, 14 days apart. The collected data were used for test repeatability analysis in order to remove all errors and inaccuracies in the test.

Tab. 1: Number and percentage of unemployed residents of Wrocław with regard to their socio-economic status

Variable	Category	Total (N = 403)		Women (n = 246)		Men (n = 157)	
		n	%	n	%	n	%
Age [years]	18–24	95	23.57	51	20.73	44	28.03
	25–34	85	21.09	44	17.89	41	26.11
	35–44	35	8.68	20	8.13	15	9.55
	45–54	58	14.39	32	13.01	26	16.56
	55–64	130	32.26	99	40.24	31	19.75
Education	Primary	277	68.73	167	67.89	110	70.06
	Secondary	94	23.33	59	23.98	35	22.29
	University	32	7.94	20	8.13	12	7.64
Marital status	Single	190	47.15	115	46.75	75	47.77
	Married	213	52.85	131	53.25	82	52.23
Persons per household	1	56	13.9	36	14.63	20	12.74
	2	121	30.02	76	30.89	45	28.66
	3	74	18.36	50	20.33	24	15.29
	4	99	24.57	51	20.73	48	30.57
	5–9	53	13.15	33	13.41	20	12.74
Per capita income [PLN]	≤ 500	125	31.02	56	22.76	69	43.95
	501–1,000	109	27.05	75	30.49	34	21.66
	1,001–1,500	108	26.8	68	27.64	40	25.48
	1,501–2,000	31	7.69	23	9.35	8	5.10
	≥ 2,001	30	7.44	24	9.76	6	3.82
Savings	No	352	87.34	203	82.52	149	94.90
	Yes	51	12.66	43	17.48	8	5.10
Indebtedness	No	75	18.61	45	18.29	30	19.11
	Yes	328	81.39	201	81.71	127	80.89

Source: own

Notes: n – number of respondents; % – percent of respondents.

The gathered data were ordered and further analyzed in terms of numbers and percentages with regard to respondents' gender, age, and socio-economic variables. Arithmetic means (M) and standard deviation (SD) for health-related quality of life and for perceived health condition in groups of respondents according to gender, age and socio-economic variables were calculated. Correlations between respondents' quality of life and socio-economic status were checked with the Kruskal-Wallis one-way analysis of variance (H) and Dunn's post-hoc tests. The level of statistical significance was

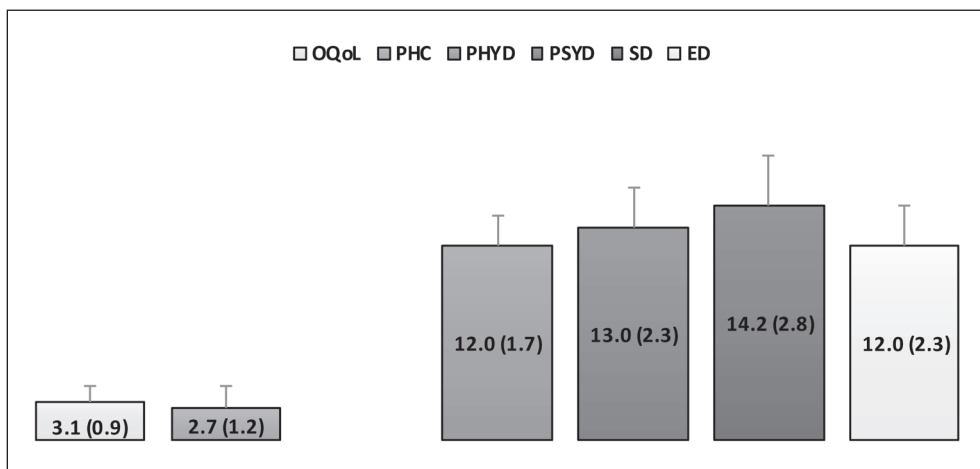
set at $\alpha < 0.05$. All calculations were made with the use of Statistica 13.0 software package (Dell Inc.).

3. Research Results

The mean health-related quality of life score of the unemployed respondents was 3.1 ± 0.9 pts. and was higher than the mean perceived health condition score, i.e. 2.7 ± 1.2 pts. As for the four quality of life domains, the respondents gave their highest scores in the social domain (14.2 ± 2.8 pts.) and psychological domain

Fig. 1:

Quality of life and perceived health condition of unemployed residents of Wrocław (N = 403). Data are mean and standard deviation M (SD)



Source: own

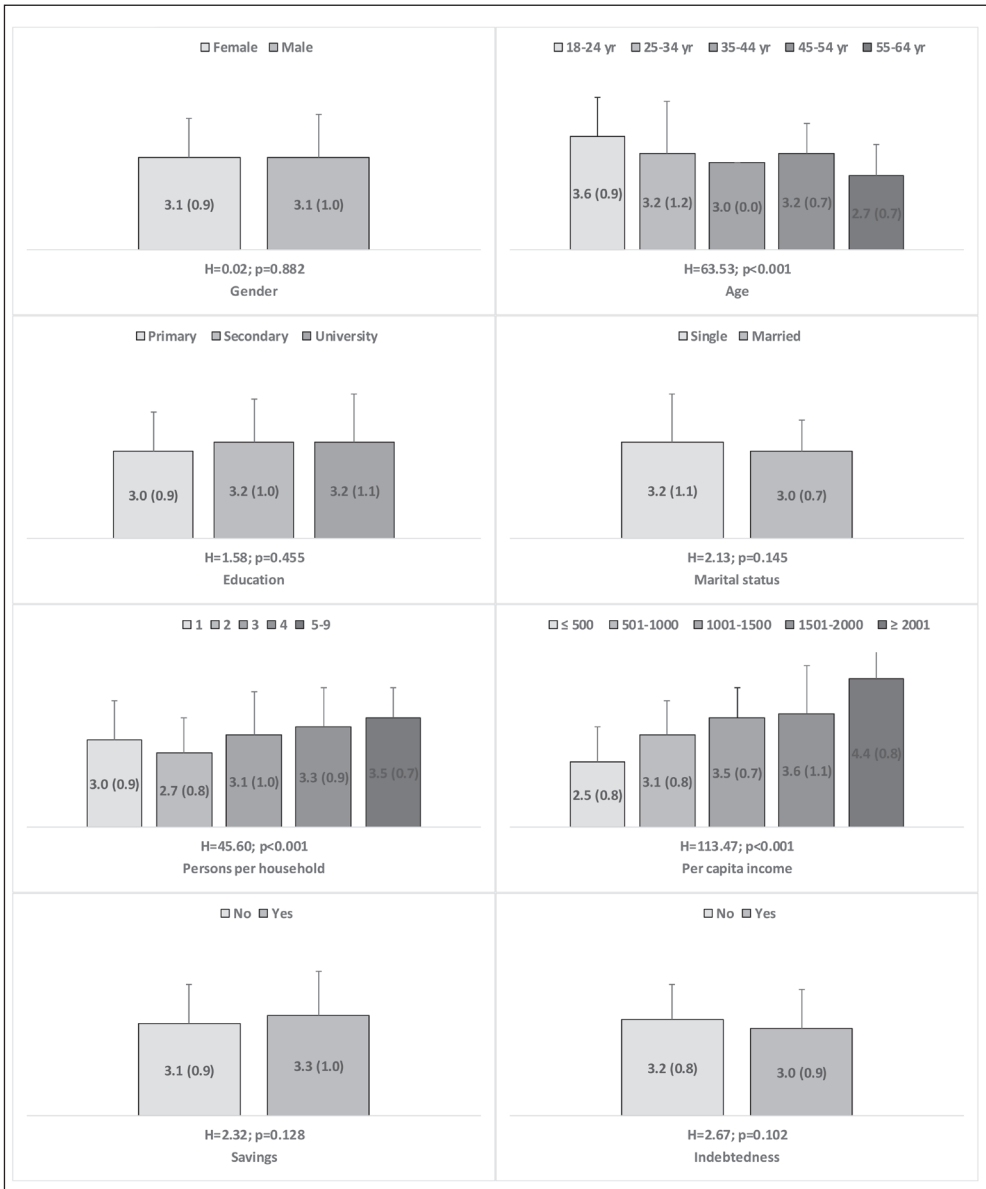
(13.0 ± 2.3 pts.), followed by the physical and environmental domains (12.0 pts. each) (Fig. 1).

The analysis of the mean overall health-related quality of life scores indicates statistically significant differences ($p < 0.001$) in groups of respondents according to age, persons per household, and per capita income (Fig. 2). The highest quality of life scores (3.6 ± 0.9 pts.) were attained by the youngest respondents, and the lowest (2.7 ± 0.7 pts.) by the oldest. The p-values for post-hoc multiple comparisons between mean rank values (\bar{R}) in particular groups point to significant differences in quality of life between respondents aged 18–24 and 55–64 years, 25–34 and 55–64 years, and 45–54 and 55–64 years. The highest quality of life scores were reported by the unemployed living in five-or-more-person households (3.5 ± 0.7 pts.) and four-person households (3.3 ± 0.9 pts.), and the lowest by the unemployed from two-person households (2.7 ± 0.8 pts.). Statistically significant differences in quality of life scores were also found between the unemployed from one-, two-, three-person households and from five- and more-person households, and between the unemployed from two-person households and four-person households. The mean quality of life assessment increased with the growing mean income per capita. The

highest quality of life scores were reported by respondents with an income level above 2,001 Polish zlotys (4.4 ± 0.8 pts.) and between 1,501 and 2,000 zlotys (3.6 ± 1.1 pts.), and the lowest by the unemployed whose income level was under or equal to 500 zlotys (2.5 ± 0.8 pts.). The differences in quality of life between the group of respondents with the income under 500 zlotys and all other income groups were significant. Statistically significant differences were also found between mean overall quality of life scores of respondents with income levels between 501 and 1,000 and 1,501–2,000, and between 501 and 1,000 and 2,000 and more zlotys.

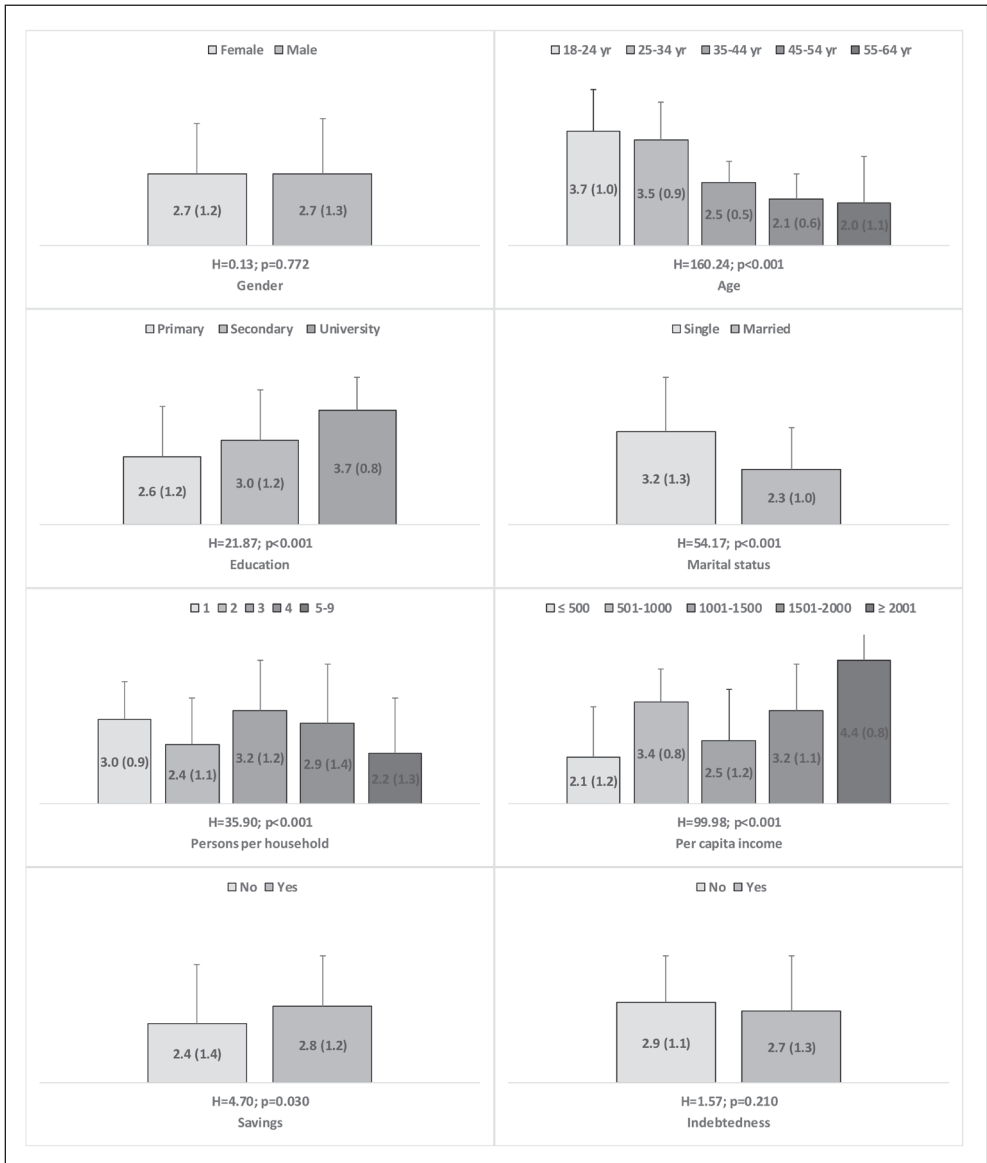
Respondents' age and such socio-economic variables as education, marital status, persons per household, per capital income, and having savings were also significant differentiating factors of perceived health condition (Fig. 3). The highest mean perceived health condition scores were reported by the unemployed aged 18–24 years (3.7 ± 1.0 pts.) and 25–34 years (3.5 ± 0.9 pts.), and the lowest by the unemployed aged 55–64 years (2.0 ± 1.1 pts.), 45–54 years (2.1 ± 0.6 pts.) and 35–44 years (2.5 ± 0.5 pts.). Post hoc comparisons between different age groups revealed statistically significant differences in perceived health condition assessments between the youngest

Fig. 2: Overall quality of life in groups of unemployed residents of Wrocław with regard to gender, age, and socio-economic status (N = 403); date are mean and standard deviation M (SD)



Source: own

Fig. 3: Perceived health condition in groups of unemployed residents of Wrocław with regard to gender, age, and socio-economic status (N = 403); data are mean and standard deviation M (SD)



Source: own

group and the three oldest age groups of unemployed respondents. The Kruskal-Wallis test results ($H = 21.87$, $p < 0.001$) and p post hoc multiple comparisons showed that the mean ranks of perceived health condition between groups of the unemployed according to education differed significantly. A significant determinant of perceived health condition assessment was also the respondents' marital status ($H = 54.17$, $p < 0.001$). Respondents who were single assessed their perceived health condition higher (3.2 ± 1.3 pts.) than respondents who were married (2.3 ± 1.0 pts.). The highest perceived health condition scores were reported by the unemployed respondents from three-person households (3.2 ± 1.2 pts.), one-person households (3.0 ± 0.9 pts.), and four-person households (2.9 ± 1.4 pts.); and the lowest by the respondents from five-and-more-person households (2.2 ± 1.3 pts.) and two-person households (2.4 ± 1.1 pts.). Statistically significant differences in self-rated health were also found between respondents from one-person households and three-, four- and five-and-more-person households, between respondents from two-person households and three- and four-person households, and between respondents from three- and four-person households and five- and more-person households. The mean perceived health condition scores were also significantly different between the per capita income range groups of respondents. The highest scores (4.4 ± 0.8 pts.) were found among the respondents with the highest income, and the lowest scores among the respondents with the lowest income (2.1 ± 1.2 pts.). Inter-group post hoc comparisons revealed significant differences between the group of respondents with the lowest income and the remaining income groups, between those with their income in the 501–1,000 zloty range and 1,001–1,500 range, and between those in the 1,001–1,500 zloty range and those earning more than 2,000 zlotys. Also perceived health condition was assessed significantly higher ($H = 4.70$, $p = 0.03$) by respondents with savings (2.8 ± 1.2 pts.) than by respondents without savings (2.4 ± 1.4 pts.).

4. Discussion

Socio-economic status, also referred to in social sciences as living standards or objective quality of life, constitutes a spectrum of possibilities of needs fulfillment. It also involves

a number of social behaviors considered to have a significant impact on the subjective (perceived) quality of life (Słaby, 2017). One of subjective quality of life categories is health-related quality of life. Consumption shortages affect, in particular, unemployed persons who often experience limited possibilities of fulfillment of their needs, including health-related needs (Sarti & Rodriguez, 2018).

Negative correlations between health-related quality of life and respondents' age have been well documented (Chinweuba et al., 2018; Huang et al., 2017; Yang et al., 2016; Zhang et al., 2015). Also the present study of the unemployed from Wrocław confirms these correlations. The youngest respondents reported the highest quality of life scores, while the oldest got the lowest scores. Similar observations can be made regarding self-perceived health assessment. This confirmation is empirical as objective health status has been proven to deteriorate with age (Sławińska, Połuszny, & Rożek, 2014; Wróblewska et al., 2015).

An important correlate of health-related quality of life is also the marital status. Single unemployed residents of Wrocław rated their quality of life higher than their married counterparts. Results of earlier studies into these correlations had been rather inconclusive. Raymakers et al. (2018) found no significant correlations between quality of life and marital status. In Durmaz et al. (2000) married individuals evaluated their quality of life higher than single individuals. However, Opoku-Boateng et al. (2017) found higher odds of better quality of life scores in single individuals than in married individuals. Few studies (e.g. Kurtinová, 2015) found no significant correlations between self-rated health and marital status. This issue still requires further empirical research.

The results of the present study considering the impact of the number of persons per household showed that the unemployed from households with the largest number of members reported the highest health-related quality of life scores and the lowest perceived health condition scores. The variable of persons per household had not been considered before in earlier studies. Griep et al. (2016) found, however, positive correlations between perceived health condition assessment and the number of children under 18 years of age in the family. It might be assumed that households with

the largest number of members include not only children but also other adults who most likely work or receive social benefits, which increases the overall household income and allows all household members, including the unemployed persons, to fulfill their needs. This can be reflected in the high assessment of quality of life by the unemployed under study. The low perceived health condition scores could have been affected by objective health factors or, as noted by some other authors, deterioration of mental health of the unemployed persons (Buffel, Missinne, & Bracke, 2017).

The level of education of the studied unemployed Wrocław residents was significantly correlated only with perceived health condition. The mean perceived health condition scores were the highest in the most educated and the lowest in the least educated respondents. Similar observations were also made by Griep et al. (2016) and Janković, Janević and Knesebeck (2012). Higher health awareness levels in better educated individuals have been well-documented (Tanvir, Sajjad, & Roshan, 2018). They more often lead a health-oriented lifestyle by undertaking physical activity, following a balanced diet, or avoiding any potential health hazards (Puciato et al., 2013). Better educated persons were also shown to display higher levels of optimism (Krypel, & Henderson-King, 2010), which can be a significant determinant of their health condition perception. Researchers also revealed frequent correlations between respondents' education and length of unemployment (Čabla, 2016; Čabla & Malá, 2017). Statistical data clearly show that better educated persons are less often unemployed and find re-employment sooner than persons with a lower education. At the end of the study period the unemployment rates in Wrocław amounted to 1.6% among people with a higher education, 2.8% – with a secondary education, 7.3% – with a vocational education, and 9.6% – with a primary education (GUS, 2016). Better educated persons also earn higher incomes than less educated persons. In Poland in the study period, the salaries of workers with a secondary education were 16% higher, and with a higher education – 77% higher than the salaries of workers with a vocational and primary education (Sedlak & Sedlak, 2016). Better educated persons who were temporarily unemployed could have had money savings

allowing them to meet their health needs at least partially, and this might have affected their perception of health condition.

The results of the present study concerning respondents' income and savings confirm the significance of financial resources for assessment of health-related quality of life and perceived health condition. The unemployed respondents under study with the highest income per capita assessed their perceived health condition at the highest level.

Among the unemployed residents, despite lack of current work income, the mean per capita income varied for any of these possible reasons:

1. Some remaining members of the household could have had their own sources of income.
2. The unemployed respondents and their families could have received welfare benefits that alleviated the negative consequences of their joblessness.
3. Some of the unemployed residents might have undertaken undeclared work but still declared the unemployed status.
4. Some of the unemployed respondents could have had money savings. In consequence, the actual financial situation of some of households under study might have been good enough to secure the fulfilment of all household members' health needs. Researchers confirmed the significant role of income for quality of life assessment by patients (Durmaz et al., 2000), the employed (Chinweuba et al., 2018; Huang et al., 2017; Kokaliari, 2016; Rėklaitienė, Bacevičienė, & Andrijauskas, 2009; Yang et al., 2016; Zhang et al., 2015), and the unemployed (Griep et al., 2016; Minelli et al., 2014).

An important, although previously empirically unconsidered determinant of perceived health condition by the unemployed is having money savings. Earlier studies did confirm the significance of savings for perceived overall quality of life (Oana & Cosmin, 2017). Moreover, following Kahneman and Tversky's loss aversion theory (1979), losses hurt more than gains feel good. Losing savings is hurtful and associated with lower self-perceived quality of life. For the unemployed respondents under study their savings could have been a "safety buffer" to ensure the fulfilment of their needs without current income. The correlations between having savings and the sense of safety

were confirmed before (Tovar & Urrutia, 2017). It should also be kept in mind that savings behaviors are culturally determined, e.g. the Dutch save money more often than Americans (De Graaf, 2010). In Poland, at the end of 2015, the savings rate, calculated as gross saving divided by gross disposable income, was only 1.6%. In terms of savings Poland ranked 39th place in the world (Kolasa & Premik, 2016). Furthermore, the distribution of savings in the Polish society is rather asymmetrical. According to *Diagnoza Społeczna 2015* (Czapiński & Panek, 2015), only 45% of Poles had any savings, and the majority of these savings were equivalent to one- to three-month salaries. In the Polish economic reality having savings is thus relatively rare, which can explain the role of this factor in perceived health condition assessment by the unemployed respondents.

Conclusions

The study results indicate the existence of correlations between health-related quality of life and such factors as age, household situation, education, income, and savings. These observations can be significant for public health policies in Poland and countries at a similar level of economic development.

According to Sarti and Rodriguez Espinola (2018), health inequalities are the greatest in countries at low and medium levels of economic development. However, the extent of these inequalities varies significantly in most advanced countries, e.g. within the European Union, and Poland is an example of a country with one of the highest rates of health inequalities (Pacáková & Kopecká, 2018). Shahidi, Siddiqi and Muntaner (2016) also showed that health inequalities occur within particular countries, between different social groups, e.g. the employed and the unemployed. Inequalities can be observed in terms of objective health status predictors as well as perceived health condition factors. These observations are confirmed by the results of the present study of unemployed residents of the city of Wrocław. The study indicates that health inequalities among the unemployed result from supranational differences in social security services and public welfare aid for the unemployed.

Recommendations should be made to the public authorities at different administrative levels to undertake actions aimed at reducing

unemployment-related health inequalities. Such actions should be direct, involving a wider availability of medical products and services, and indirect, aiming at improving the education and affluence levels of unemployed persons (Krupka et al., 2010). The authorities should become engaged in the development of the role of external environment as an objectivized measure for individual life satisfaction (Cernakova & Hudec, 2012). More and more often researchers discuss the notion of quality-of-life management in patients (Lewis, Pihlak, & McNamara, 2018), and healthy persons (Bucur, 2017), including employees (Bugdol & Jedynak, 2015). These activities are crucial as Yang et al. (2016) revealed in their studies that better quality of life and perceived health status are associated with enhanced stress management, mobility, and self-efficacy. These activities can improve the effectiveness of the job-seeking process. Public authorities' actions related to combating unemployment are also necessary. Particular attention should be paid to improving professional qualifications of the unemployed, their adaptation to the contemporary labor market, and supporting the unemployed in the process of relocation to places with a high demand for labour. This is important not only in the context of unemployed individuals but also national economies. An insufficient use of labor force is associated with limited production levels and, in consequence, with a gap between the potential GDP at full employment and the actual GDP in a given time period.

The present study has its strong and weak points. A strong point of the study is the character of the study group since the unemployed are not often a subject to research. Previous research did not consider such variables as the number of persons per household, savings and indebtedness as potential determinants of health-related quality of life and perceived health condition of the unemployed. The study results proved these determinants to be significant thus they should be considered in future research in addition to such factors as household structure and amounts of savings and debt. A weak point of the present study is the confinement of the study area to a single city. Future research should definitely cover the entire territory of Poland, or even the whole region of Central Europe. Prospective studies could also focus on the impact of socio-economic factors on each domain of health-

related quality of life: physical, psychological, social, and environmental. Such an analytical approach would permit identification of correlations between particular quality of life components and socio-economic factors.

References

- Blomgren, J., & Valkonen, T. (2007). Characteristics of urban regions and all-cause mortality in working-age population: Effects of social environment and interactions with individual unemployment. *Demographic Research*, 17, 109–134. <https://doi.org/10.4054/DemRes.2007.17.5>
- Brzeziński, J. (2011). *Methodology of psychological research*. Warsaw: PWN.
- Bucur, A. (2015). How can we apply the models of the quality of life and the quality of life management in an economy based on knowledge? *Economic Research – Ekonomska Istrazivanja*, 30(1), 629–646. <https://doi.org/10.1080/1331677X.2017.1314821>
- Buffel, V., Missinne, S., & Bracke, P. (2017). The social norm of unemployment in relation to mental health and medical care use: the role of regional unemployment levels and of displaced workers. *Work, Employment and Society*, 31(3), 501–521. <https://doi.org/10.1177/0950017016631442>
- Bugdol, M., & Jedynek, P. (2015). *Integrated management systems*. Cham: Springer. <https://doi.org/10.1007/978-3-319-10028-9>
- Central Statistical Office. (2016). *Economic activity of the population aged 15 and more by age and educational level*. Wrocław: GUS. Retrieved October 9, 2016, from <http://Wroclaw.stat.gov.pl/rynek-pracy-wynagrodzenia-i-swiadczenia-410>
- Carlier, B., Schuring, M., Lötters, F., Bakker, B., Borgers, N., & Burdor, A. (2013). The influence of re-employment on quality of life and self-rated health, a longitudinal study among unemployed persons in the Netherlands. *BMC Public Health*, 13(1), 503–509. <https://doi.org/10.1186/1471-2458-13-503>
- Chinweuba, A., Okoronkwo, I., Anarado, A., Agbapuwu, N., Ogbonnaya, N., & Ihudiebube-Splendor, C. (2018). Differentials in health-related quality of life of employed and unemployed women with normal vaginal delivery. *BMC Women's Health*, 18, 13. <https://doi.org/10.1186/s12905-017-0481-0>
- Clemens, T., Popham, F., & Boyle, P. (2015). What is the effect of unemployment on all-cause mortality? A cohort study using propensity score matching. *European Journal of Public Health*, 25(1), 115–121. <https://doi.org/10.1093/eurpub/cku136>
- Czapiński, J., & Panek, T. (2015). Social diagnosis 2015, Conditions and quality of life of Poles. *Quarterly of University of Finance and Management in Warsaw*, 9(4), 56–59.
- Czekirda, M., Chruściel, P., Czekirda, N., & Jarosz, M. (2017). Psychosocial aspect of quality of life among working and unemployed nurses and midwives. *Annals of Agricultural and Environmental*, 24(3), 472–476. <https://doi.org/10.5604/12321966.1235172>
- Čabla, A. (2016). Minimal adequate model of unemployment duration in the post-crisis Czech Republic. *Statistics and Economy Journal*, 96(1), 50–62.
- Čabla, A., & Malá, I. (2017). Modelling of unemployment duration in the Czech Republic. *Prague Economic Papers*, 26(4), 438–449. <https://doi.org/10.18267/j.pep.620>
- Černáková, V., & Hudec, O. (2012). Quality of life: Typology of European cities based on cluster analysis. *E&M Economics and Management*, 15(4), 34–48.
- De Graaf, J. (2010). Less work, more life. *Progressive*, 74(9), 22–24.
- Durmaz, T., Ozdemir, O., Ozdemir, B., Keles, T., Bayram, N., & Bozkurt, E. (2009). Factors affecting quality of life in patients with coronary heart disease. *Turkish Journal of Medical Sciences*, 39(3), 343–351. <https://doi.org/10.3906/sag-0901-26>
- Griep, Y., Kinnunen, U., Nätti, J., De Cuyper, N., Mauno, S., Mäkikangas, A., & De Witte, H. (2016). The effects of unemployment and perceived job insecurity: a comparison of their association with psychological and somatic complaints, self-rated health and life satisfaction. *International Archives of Occupational and Environmental Health*, 89(1), 147–162. <https://doi.org/10.1007/s00420-015-1059-5>
- Heggebo, K. (2016). Health effects of unemployment in Denmark, Norway and Sweden 2007–2010: Differing economic conditions, differing results? *International Journal of Health Services*, 46(3), 406–429. <https://doi.org/10.1177/0020731416636365>
- Huang, W., Yu, H., Liu, C., Liu, G., Wu, Q., Zhou, J., Zhang, X., Zhao, X., Shi, L., & Xu, X. (2017). Assessing health-related quality of life of Chinese adults in Heilongjiang using EQ-5D-3L. *International Journal of Environmental*

- Research and Public Health*, 14(3), 224–239. <https://doi.org/10.3390/ijerph14030224>
- Janković, J., Janević, T., & von dem Knesebeck, O. (2012). Socioeconomic inequalities, health damaging behavior, and self-perceived health in Serbia: a cross-sectional study. *Croatian Medical Journal*, 53(3), 254–262. <https://doi.org/10.3325/cmj.2012.53.254>
- Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–291.
- Kawada, T. (2018). Unemployment, precarious employment and health in young people. *Scandinavian Journal of Public Health*, 46(3), S382. <https://doi.org/10.1177/1403494817720104>
- Kokaliari, E. (2016). Quality of life, anxiety, depression, and stress among adults in Greece following the global financial crisis. *International Social Work*, 61(3), 1–15. <https://doi.org/10.1177/0020872816651701>
- Kolasa, A., Premik, F., & Tyrowicz, J. (2016). *Financial situation of the household sector in the fourth quarter of 2015*. Warsaw: National Bank of Poland.
- Krupka, J., Kasparova, M., & Jirava, P. (2010). Quality of life modelling based on decision trees. *E&M Economics and Management*, 13(3), 130–146.
- Krypel, M. N., & Henderson-King, D. (2010). Stress, coping styles, and optimism: are they related to meaning of education in students' lives? *Social Psychology of Education*, 13(3), 409–424. <https://doi.org/10.1007/s11218-010-9132-0>
- Kurtinová, O. (2015). Self-perceived health in the Czech population: recent evidence. *Central European Journal of Public Health*, 23(1), 45–53. <https://doi.org/10.21101/cejph.a3996>
- Lee, J. J. (2005). An exploratory study on the quality of life of older Chinese people living alone in Hong Kong. In D. T. Shek, Y. K. Chan, & P. S. Lee (Eds.), *Quality-of-Life Research in Chinese, Western and Global Contexts. Social Indicators Research Series* (Vol. 25, pp. 335–361). Dordrecht: Springer. https://doi.org/10.1007/1-4020-3602-7_11
- Leonardi, M., Guido, D., Quintas, R., Silvaggi, F., Guastafierro, E., Martinuzzi, A., Chatterji, S., Koskinen, S., Tobiasz-Adamczyk, B., Haro, J., Cabello, M., & Raggi, A. (2018). Factors related to unemployment in Europe. A cross-sectional study from the COURAGE Survey in Finland, Poland and Spain. *International Journal of Environmental Research and Public Health*, 15(4), 722–742. <https://doi.org/10.3390/ijerph15040722>
- Lewis, A., Pihlak, R., & McNamara, M. (2018). The importance of quality-of-life management in patients with advanced pancreatic ductal adenocarcinoma. *Current Problems in Cancer*, 42(1), 26–39. <https://doi.org/10.1016/j.currproblcancer.2018.01.013>
- Madureira-Lima, J., Reeves, A., Clair, A., & Stuckler, D. (2018). The Great Recession and inequalities in access to health care: a study of unemployment and unmet medical need in Europe in the economic crisis. *International Journal of Epidemiology*, 47(1), 58–68. <https://doi.org/10.1093/ije/dyx193>
- Meneton, P., Plessz, M., Courtin, E., Ribet, C., Goldberg, M., & Zins, M. (2017). Unemployment as a major public health issue. *La Revue de l'Ires*, 91–92(1), 141–154. Retrieved from <https://www.cairn.info/journal-revue-de-l-ires-2017-1-page-141.htm>
- Michalos, A. C., & Orlando, J. A. (2006). Quality of life of some under-represented survey respondents: youth, aboriginals and unemployed. *Social Indicators Research*, 79(2), 191–213. <https://doi.org/10.1007/s11205-005-4717-2>
- Milner, A., Page, A., & LaMontagne, A. D. (2014). Cause and effect in studies on unemployment, mental health and suicide: a meta-analytic and conceptual review. *Psychological Medicine*, 44(5), 909–917. <https://dx.doi.org/10.1017/S0033291713001621>
- Minelli, L., Pignini, C., Chiavarini, M., & Bartolucci F. (2014). Employment status and perceived health condition: longitudinal data from Italy. *BMC Public Health*, 14(1), 946. <https://doi.org/10.1186/1471-2458-14-946>
- Oana, O., & Cosmin, T. (2017). Aspects of population savings and quality of life in Romania. *Ovidius University Annals, Series Economic Sciences*, 17(1), 205–210. Retrieved from <http://stec.univ-ovidius.ro/html/anale/ENG/2017/Section-III/15.pdf>
- Opoku-Boateng, Y. N., Kretchy, I. A., Aryeetey, G. C., Dwomoh, D., Decker, S., Agyemang, S. A., Tozan, Y., Aikins, M., & Nonvignon, J. (2017). Economic cost and quality of life of family caregivers of schizophrenic patients attending psychiatric hospitals in Ghana. *BMC Health Services Research*, 17(2), 697. <https://doi.org/10.1186/s12913-017-2642-0>

Øverland, S., Glozier, N., Mæland, J. G., Aarø, L., & Mykletun, A. (2006). Employment status and perceived health in the Hordaland Health Study (HUSK). *BMC Public Health*, 6(2), 219. <https://doi.org/10.1186/1471-2458-6-219>

Pacáková, V., & Kopecká, L. (2018). Inequalities in health status depending on socio-economic situation in the European countries. *E&M Economics and Management*, 21(2), 4–20. <https://dx.doi.org/10.15240/tul/001/2018-2-001>

Puciato, D., Rozpara, M., Mynarski, W., Łoś, A., & Królikowska, B. (2013). Physical activity of adult residents of Katowice and selected determinants of their occupational status and socio-economic characteristics. *Medycyna Pracy*, 64(5), 649–657. <https://doi.org/10.13075/mp.5893.2013.0064>

Raymakers, A. J. N., Gillespie, P., O'Hara, M. C., Griffin, M. D., & Dinneen, S. F. (2018). Factors influencing health-related quality of life in patients with Type 1 diabetes. *Health and Quality of Life Outcomes*, 16(1), 27. <https://dx.doi.org/10.1186/s12955-018-0848-4>

Rėklaitienė, R., Bacevičienė, M., & Andrijauskas, K. (2009). Quality of life in Lithuanian population: the impact of country residence and socio-economic status. *Central European Journal of Medicine*, 4(4), 476–482. <https://dx.doi.org/10.2478/s11536-009-0058-x>

Sarti, S., & Rodriguez Espinola, S. (2018). Health inequalities in Argentina and Italy: A comparative analysis of the relation between socio-economic and perceived health conditions. *Research in Social Stratification and Mobility*, 55, 89–98. <https://dx.doi.org/10.1016/j.rssm.2018.04.004>

Sedlak, P., & Sedlak, K. (2016). *National Remuneration Survey conducted by Sedlak & Sedlak in 2015*. Warsaw: Sedlak & Sedlak. Retrieved October 9, 2016, from <https://sedlak.pl/zarobki>

Słaby, T. (2017). Conditions of the life quality – methodological remarks. *Economic and Environmental Studies*, 17(2), 297–317. <https://doi.org/10.25167/ees.2017.42.9>

Sławińska, T., Posłuszny, P., & Rożek, T. (2013). Relationship between physical fitness and quality of life in adults and the elderly. *Human Movement*, 14(3), 200–204. <https://doi.org/10.2478/humo-2013-0023>

Sołtysik, B., Kroc, Ł., Pięłowska, M., Guligowska, A., Śmigielski, J., & Kostka, T. (2017). An evaluation of the work and life conditions and the quality of life in 60 to 65

year-old white-collar employees, manual workers, and unemployed controls. *Journal of Occupational and Environmental Medicine*, 59(5), 461–466. <https://dx.doi.org/10.1097/JOM.0000000000001029>

Shahidi, F. V., Siddiqi, A., & Muntaner, C. (2016). Does social policy moderate the impact of unemployment on health? A multilevel analysis of 23 welfare states. *European Journal of Public Health*, 26(6), 1017–1022. <https://dx.doi.org/10.1093/eurpub/ckw050>

Tanvir, S., Sajjad, S., & Roshan, R. (2018). Awareness levels of prevention of cardiac diseases in general population of Rawalpindi and requirement of health education. *Public Health*, 157, 107–110. <https://doi.org/10.1016/j.puhe.2018.01.006>

Tøge, A. G. (2016). Health effects of unemployment in Europe (2008–2011): a longitudinal analysis of income and financial strain as mediating factors. *International Journal for Equity in Health*, 15(1), 75. <https://dx.doi.org/10.1186/s12939-016-0360-6>

Tran, T. V., Canfield, J., & Chan, K. (2016). The association between unemployment status and physical health among veterans and civilians in the United States. *Social Work in Health Care*, 55(9), 720–731. <https://dx.doi.org/10.1080/00981389.2016.1191582>

Worach-Kardas, H., & Kostrzewski, S. (2014). Quality of life and health state of long-term unemployed in older production age. *Applied Research Quality Life*, 9(2), 335–353. <https://dx.doi.org/10.1007/s11482-013-9240-z>

World Health Organization. (2014). *The World Health Organization Quality of Life (WHOQOL)*. Geneva: WHO. Retrieved July 9, 2014, from http://www.who.int/healthinfo/survey/WHOQOL_BREF.pdf

Wróblewska, I., Oleśniewicz, P., Kurpas, D., Sołtysik, M., & Błaszczuk, J. (2015). Analysis of spirometry results in hospitalized patients aged over 65 years. *Clinical Interventions in Aging*, 10, 1071–1076. <https://doi.org/10.2147/CIA.S85387>

Van Zon, S. K. R., Reijneveld, S. A., Mendes de Leon, C. F., & Bültmann, U. (2017). The impact of low education and poor health on unemployment varies by work life stage. *International Journal of Public Health*, 62(9), 997–1006. <https://dx.doi.org/10.1007/s00038-017-0972-7>

Voss, M. W., Wadsworth, L. L., Birmingham, W., Merryman, M. B., Crabtree, L., Subasic, K.,

- & Hung, M. (2018). Health effects of late-career unemployment. *Quality of Life Research*, 27, S87. <https://doi.org/10.1177/0898264318806792>
- Vossemer, J., Gebel, M., Täht, K., Unt, M., Högberg, B., & Strandh, M. (2018). The effects of unemployment and insecure jobs on well-being and health: The moderating role of labor market policies. *Social Indicators Research*, 138(3), 1229–1257. <https://dx.doi.org/10.1007/s11205-017-1697-y>
- Yang, X., Yao, L., Wu, H., Wang, Y., Liu, L., Wang, J., & Wang, L. (2016). Quality of life and its related factors in Chinese unemployed people: A population-based cross-sectional study. *International Journal of Environmental Research and Public Health*, 13(8), 797. <https://dx.doi.org/10.3390/ijerph13080797>
- Zhang, C., & de Figueiredo, J. M. (2018). Are recessions good for government hires? The effect of unemployment on public sector human capital. *Economics Letters*, 170, 1–5. <https://doi.org/10.1016/j.econlet.2018.05.008>
- Zhang, Y., Ou, F., Gao, S., Gao, Q., Hu, L., & Liu, Y. (2015). Effect of low income on health-related quality of life: A cross-sectional study in Northeast China. *Asia-Pacific Journal of Public Health*, 27(2), 1013–1025. <https://dx.doi.org/10.1177/1010539513496839>

YOUTH UNEMPLOYMENT AND SELF-EMPLOYMENT: TRENDS AND PERSPECTIVES

Rita Remeikienė¹, Jan Žufan², Ligita Gasparėnienė³, Romualdas Ginevičius⁴

¹ Mykolas Romeris University, Public Safety Academy, Lithuania, ORCID: 0000-0002-3369-485X, rita.remeikiene@mruni.eu;

² University College of Business in Prague, Department of Economy, Czech Republic, ORCID: 0000-0001-9031-5791, zufan@vso-praha.eu;

³ Mykolas Romeris University, Public Safety Academy, Lithuania, ORCID: 0000-0002-5535-6552, ligitagaspareniene@mruni.eu;

⁴ Vilnius Gediminas Technical University, Faculty of Business Management, Lithuania, ORCID: 0000-0003-2067-4398, romualdas.ginevicius@vgtu.lt.

Abstract: The main aim of this article is to research the relationship between youth unemployment and self-employment in the EU and categorise particular EU countries as the countries with youth self-employment driven by push factors or pull factors. It has been revealed that statistically significant relationships between unemployment and self-employment among young people from the 28 EU countries, in only 7 countries have been identified. Of these, Greece, Italy and Cyprus, the unemployment rate among young people would decrease if national governments were to reduce unemployment through self-employment support measures. In other countries such as Germany, Sweden, the Czech Republic and Malta, it would be inappropriate to reduce unemployment through support for self-employment. In other EU countries, fighting youth unemployment requires addressing other labor market issues, such as the reluctance of businesses to employ unqualified or low-skilled young people, reducing the chances of reducing the tax burden when hiring young people, making flexible use of education opportunities with employment. The fact was confirmed that is inappropriate for all countries (in this case EU countries) to apply universal strategies to combat unemployment, because by means of theories and pilot studies on the establishment of statistically significant relationships, it is possible to avoid mistakes by directing support to the needs of target groups.

Keywords: Self-employment, unemployment, young people, EU.

JEL Classification: J64, E24.

APA Style Citation: Remeikienė, R., Žufan, J., Gasparėnienė, L., & Ginevičius, R. (2020). Youth Unemployment and Self-employment: Trends and Perspectives. *E&M Economics and Management*, 23(3), 38–48. <https://doi.org/10.15240/tul/001/2020-3-003>

Introduction

As it was noted by Manyande (2006), “a typical characteristic of most labor markets around the world is that the youth unemployment rate is much higher than that of adults” (p. 3). Youth unemployment is sensitive to the changes in general economic conditions, fluctuations in aggregate demand and minimum wages. Youth

are often the first to be laid off when companies downsize and are not eligible for redundancy payments. Even higher education does not guarantee a decent job. If left uncared, high youth unemployment rates can negatively affect the economic growth potential of a country and create the conditions for social unrest (Burchell et al., 2015).

Self-employment is often advocated as a potential remedy for the perennial problem of youth unemployment (Williams, 2004; Manyande, 2006; Sheehan & Mc Namara, 2015; Dvouletý et al., 2018; etc) because it helps a person to enter the labour market despite limited work experience, low qualifications, caring responsibilities, health conditions, etc (Walsh, 2011; Dimian et al., 2018). What is more, self-employment provides a high degree of autonomy and flexibility (Jones et al., 2016). Nevertheless, it is also the case that self-employment is related to the risk of earning low financial returns (in comparison to the earnings in similar employee jobs), limited access to social protection and/or social insurance coverage, and limited opportunities of self-improvement. In such contexts, the issue of whether the young unemployed should be encouraged to engage in self-employment is still debatable, and in order to assess whether or not self-employment is simply lesser of two evils, it is important to know more about the links between youth unemployment and self-employment.

Thus far, the studies on the relationship between youth unemployment and self-employment have mostly covered assessment of the individual level factors that lead previously unemployed young people to engage in self-employment (Williams, 2004; Dvouletý et al., 2018; etc), the policy measures that help young unemployed into self-employment (Manyande, 2006; Walsh, 2011; Sheehan & Mc Namara, 2015; Burchell et al., 2015; Jones et al., 2016; Sasongo & Huruta, 2019) and the impact of the recession *push* and entrepreneurial *pull* factors (Frankjović et al., 2015; Sechele, 2016; etc). However, hardly any study categorises particular countries as the ones with youth self-employment “driven by *push* factors” or “driven by *pull* factors”. The primary purpose of this article is to research the relationship between youth unemployment and self-employment in the European Union (further – EU) and categorise particular EU countries as the countries with youth self-employment driven by *push* factors or *pull* factors. For fulfilment of the defined purpose, the following objectives were raised: 1) to review the statistical data on youth unemployment and self-employment in the EU; 2) to review the literature on the links between youth unemployment and self-employment; 3) to select and substantiate the methodology

of the research; 4) to introduce the results of the empirical research. The methods of the research include literature analysis, statistical data analysis, correlation and multiple regression analysis.

1. Links between Youth Unemployment and Self-employment: Literature Review

Youth unemployment is considered to be caused by numerous micro- and macro-economic factors. The main micro-economic factors include the lack of skills and experience (Páleník, 2011; Sechele, 2016; Jones et al., 2016; OECD, 2017; etc), family background (people from poorer families are more likely to have lower education and enter the labour market prematurely, while people with self-employed parents and higher parental incomes are more likely to become self-employed) (Hout & Rosen, 2000; Mlatsheni & Rospabe, 2002; Manyande, 2006; Hundley, 2006), and in rarer cases – gender (male are more likely to engage in self-employment than female) (Manyande, 2006). The main macro-economic factors cover the mismatches between the educational system and the labour market (Manyande, 2006), the aggregate demand (Páleník, 2011; Frankjović et al., 2015), wages (in particular, minimum wages) (Walsh, 2011; OECD, 2017), and the size of the youth labour force (Manyande, 2006; Escudero & López Mourelo, 2013). The mismatches between the educational system and the labour market cause higher supply of than the demand for labour, which, in its turn, ends in higher unemployment rates. The aggregate demand reflects the state of the general economic system, so a fall in the aggregate demand causes a subsequent fall in the demand in the labour force, i.e. a rise in the rate of unemployment. Manyande (2006) notes that youth unemployment is even more sensitive to the fluctuations in the aggregate demand than adult unemployment since the interests of young employees are less likely to be protected by legislation or trade unions. The fluctuations in the minimum wage significantly affect youth unemployment as young people with lower skills and limited work experience commonly do the lowest paying jobs. Finally, a greater size of the youth labour force means that a higher number of jobs need to be created (Perugini & Signorelli, 2010; Escudero & López Mourelo, 2013).

The interest in the relationship between youth unemployment and self-employment has remarkably increased over the last ten years, and this increase has been mainly determined by recognition of a small business as of a source of economic growth in both developing

and developed economies. The findings from previous studies on the links between youth unemployment and self-employment have been reviewed in Tab. 1.

Literature analysis reveals that youth self-employment is caused by two opposing sides

Tab. 1: The review of previous findings on the links between youth unemployment and self-employment – Part 1

Author(s), year	Purpose	Method(s)	Findings
Williams, 2004	To examine the content of self-employment, characteristics of the self-employed and the returns to self-employment experience for a sample of teenagers and young adults in the USA.	National longitudinal survey of youth	Self-employment is quite rare among young people, but they are much more likely to become self-employed in early adulthood.
Frankjović et al., 2015	To research whether youth self-employment is promoted by high youth unemployment in the EU.	Descriptive statistics, linear regression analysis	An increase in youth unemployment does not lead to an increase in youth self-employment.
Sechele, 2016	To reveal why unemployed young people are not entering self-employment in Botswana.	Analysis of documentary sources, focus groups, semi-structured interviews (methodological triangulation)	Young people find self-employment unfeasible due to their low skills and lack of work experience; self-employment is treated as an insecure and indecent employment opportunity.
Pálenik, 2011	To assess the policy measures to help young unemployed into self-employment in Slovakia.	Statistical data analysis, case analysis, systematic and comparative literature analysis	The lack of long-term business opportunities in regions with high unemployment and low population's purchasing power discourage young unemployed from self-employment.
Walsh, 2011	To review the pathways to support young people into self-employment in Spain.	Statistical data analysis, systematic and comparative literature analysis	Under the conditions of high youth unemployment, the main way to support young people into self-employment is through creating a start-up favourable climate with low bureaucracy and entry cost.
Dvouletý et al., 2018	To research the individual level factors that lead previously unemployed young people to engage in self-employment in 11 European countries.	Survey	Previous unemployment has a significantly moderating effect on the individual characteristics that increase the likelihood of self-employment.

Tab. 1: The review of previous findings on the links between youth unemployment and self-employment – Part 2

Sheehan & Mc Namara, 2015	To overview the policy literature on self-employment and entrepreneurship with a particular focus on six EU member states.	Statistical data analysis, systematic and comparative literature analysis	Youth unemployment may promote youth self-employment under the conditions of the appropriate support (financial support, coaching, counselling, building the entrepreneurial mind-set).
Manyande, 2006	To investigate how entrepreneurship can be promoted amongst the youth in South Africa.	Labour force surveys, cross-sectional data analysis	African and Coloured youth are particularly disadvantaged when it comes to participation in self-employment.
Jones et al., 2016	To investigate self-employment and enterprise as a route into work for young unemployed people.	Evidence review, case studies, interviews with stakeholders	Self-employment does not function as an alternative to waged employment for most young people; self-employment success depends on capital, experience and skills.
Burchell et al., 2015	To provide a comprehensive analysis of the key issues surrounding the use of self-employment interventions as labour market attachment mechanisms for young people.	Statistical data analysis, case studies	No clear evidence that the self-employment and entrepreneurship schemes actually create new jobs was found.

Source: own

– *push* and *pull* factors (Frankjović et al., 2015). The effect of *push* factors, also known as the refugee effect, desperation effect, recession push or unemployment push, means that when unemployment rate is rising (commonly under the conditions of an economic recession and a fall in the aggregate demand), an increasingly higher number of young people may start seeing self-employment as an attractive alternative to a wage job (Özerkek & Doğruel, 2015), although some authors (Constant & Zimmerman, 2014) treat unemployment-driven self-employment (or self-employment out of necessity) as destructive and destined to fail because an individual decision to start-up a business in this case is a consequence of limited opportunities. The effect of *pull* factors, also known as the prosperity pull or entrepreneurial effect, means that since self-employment promotes entrepreneurship, it stimulates business activities, which, in its turn, leads to a decreased unemployment rate

and higher minimum wages in subsequent periods (Özerkek & Doğruel, 2015; Blattman & Dercon, 2016). In other words, “pull factors are represented by entrepreneurs who are credited with stimulating job growth and encouraging innovation” (Frankjović et al., 2015, p. 248).

Nevertheless, the theoretical links between youth unemployment and self-employment are not always confirmed by empirical research. For instance, by applying the methods of descriptive statistics and linear regression, Frankjović et al. (2015) found some correlation between youth unemployment and self-employment in Nordic countries (Finland, Denmark, Sweden, Estonia, Latvia and Lithuania), but did not confirm that an increase in youth unemployment necessarily leads to an increase in youth self-employment. By employing evidence review, case studies and interviews with stakeholders, Jones et al. (2016) came to the conclusion that self-employment does not function as an alternative to waged employment for most young people

because the success of self-employment depends on capital, experience and skills. Páleník's (2011) study showed that high rates of youth unemployment not necessarily lead to higher rates of youth self-employment due to the negative effects of the current tax system, insufficient unemployment benefits, which do not provide enough resources to promote self-employment start-up, and most of all, due to the lack of long-term business prospects and low population's purchasing power in economically weak and/or crisis-affected regions. In other words, poor market opportunities limit the establishment of new small enterprises as any business is believed to be condemned without a boost in the local economy that would ensure a long-term stability. Dvouletý et al. (2018), who researched the individual-level factors that lead previously unemployed young people to engage in self-employment in eleven European countries, found that previous unemployment has a significant moderating effect on the individual characteristics which are related to a higher likelihood of starting-up a business (engagement in self-employment), i.e. young people who have previously been unemployed lose their individual characteristics that may push them into self-employment. This proposes that there might exist an inverse relationship between unemployment and self-employment, although the overall propensity of self-employment was found not to be affected by one's unemployment experience. The study carried out by Walsh (2011) revealed that under the conditions of high unemployment rate, self-employment is still more common among older (15–64 year old) rather than younger (15–24 year old) population, although the proportion of 15–24 year olds becoming self-employed in the UK increased from 2.6% in 2000 to 4.3% in 2010. IT advancement and start-up cost reduction are seen as the key reasons of this increase. The author supports the general approach following which youth self-employment should be encouraged by creating a start-up favourable environment whereby self-employment is facilitated through low bureaucracy and low entry costs (wage subsidies, training and individual pathways are considered to be less effective).

The significance of the role of the public and state sector, i.e. of public policies, in youth self-employment promotion was also highlighted by Manyande (2006), Sechele

(2016), Sheehan and Mc Namara (2015), Hinks et al. (2015) and many others. As it was noted by Sechele (2016), a large number of unemployed young people are disadvantaged in the labour market due to their low levels of skills and work experience, which makes it difficult to them to enter either wage or self-employment sectors. For this reason, appropriate public policies (i.e. provision of financial support, coaching, counselling, building the entrepreneurial mindset (Sheehan & Mc Namara, 2015)) may serve as an additional factor *pushing* young people to self-employment. What concerns the types of the support provided, Sheehan and Mc Namara (2015) revealed that a lack of the access to financial resources is a very significant barrier for the youth to start-up a business. Having investigated the situation in six EU member states (Germany, Estonia, Ireland, Poland, Spain and the UK), the authors found that thirty-two percent of the policies (i.e. 65 out of the 203 policies examined) in the countries under consideration specifically target the issue of financial constraint. Apart from that, the programs focus on young people's financial education (sources, risks, availability, suitability) (OECD/European Commission, 2014). Nevertheless, it is recognized that the most effective self-employment promotion programs should include both financial (*hard*) and education (*soft*) support (OECD/European Commission, 2012) because the combination of them (the hybrid approach) may significantly contribute to a more sustainable long-term effect (Sheehan & Mc Namara, 2015; Hinks et al., 2015). This approach is supported by Manyande (2006) who states that the development of entrepreneurship through the provision of financial support, mentoring and entrepreneurship skill training assist the youth in transferring from unemployment to self-employment.

Summarising, the links between youth unemployment and self-employment to a large extent depend on a stage of an economic cycle (recession or boost) and public policies. High rates of youth unemployment may promote self-employment in economically stable regions, where long-term business prospects are envisaged and the population has sufficient purchasing power, whereas the lack of long-term business opportunities in economically unstable regions and low population's purchasing power discourage young unemployed from self-employment. Appropriate public policies

(reduction of bureaucracy, lowering of taxes, provision of financial support, coaching, counselling, building the entrepreneurial mindset) may serve as an additional factor pushing young people to self-employment.

2. Youth Unemployment and Self-employment in EU: Review of the Statistical Data

In the European Union, youth unemployment rate refers to unemployed persons from 15 to 24 years of age. This population group is considered as an at-risk population since the

Tab. 2: Youth unemployment figures in the European Union between 2007 and 2017, percent

Country	Youth unemployment rate			
	2007	2015	2016	2017
Belgium	18.8	22.1	20.1	19.3
Bulgaria	14.1	21.6	17.2	12.9
Czech Republic	10.7	12.6	10.5	7.9
Denmark	7.5	10.8	12.0	11.0
Germany	11.8	7.2	7.1	6.8
Estonia	10.1	13.1	13.4	12.1
Ireland	9.3	20.5	17.0	14.5
Greece	22.7	49.8	47.3	43.6
Spain	18.1	48.3	44.4	38.6
France	19.5	24.7	24.6	22.3
Croatia	25.4	42.3	31.8	27.0
Italy	20.4	40.3	37.8	34.7
Cyprus	10.2	32.8	29.1	24.7
Latvia	10.6	16.3	17.3	17.0
Lithuania	8.4	16.3	14.5	13.3
Luxembourg	15.6	16.6	9.1	15.3
Hungary	18.1	17.3	12.9	10.7
Malta	13.5	11.8	11.0	10.4
Netherlands	9.4	11.3	10.8	8.9
Austria	9.4	10.6	11.2	9.8
Poland	21.6	20.8	17.7	14.8
Portugal	21.4	32.0	28.2	23.8
Romania	19.3	21.7	20.6	18.3
Slovenia	10.1	16.3	15.2	11.2
Slovakia	20.6	26.5	22.2	18.9
Finland	16.5	22.4	20.1	20.1
Sweden	19.2	20.4	18.9	17.8
United Kingdom	14.3	14.6	13.0	12.1
EU-28	15.8	20.3	18.7	16.8
Euro area	15.6	22.3	20.9	18.8

Source: Eurostat, 2018

general trend is that the youth unemployment rate is higher than the unemployment rate for other age groups. As for the rate of the total population, the youth unemployment rate in the EU-28 has taken an upward trend peaking in 24.0 percent in January of 2013 and receding to 16.8 percent in 2017 (see Tab. 2).

Although between 2007 and 2010 the EU-28 youth unemployment rate was close to that in the euro area, in 2012 the euro area youth unemployment rate overtook the EU-28 rate, and the gap became even larger in 2013 and during 2014. In 2015, 2016 and 2017 the gap

between the EU-28 and the euro area youth unemployment rate was close or equal to 2 percentage points. As of May 2018, the highest rates of youth unemployment in the EU-28 were suffered by Greece (43.2%), Spain (33.8%) and Italy (31.9%), while Malta, Germany and Estonia had the lowest youth unemployment rates (4.8%, 6.1% and 6.8%, respectively) (Statista, 2018).

The statistical data on the EU-28 youth self-employment reveals that only about 4.1% of working youth in the EU are self-employed (see Tab. 3).

Tab. 3: Youth self-employment figures in the European Union between 2007 and 2016, percentage of employment

Age group	2007	2015	2016
Total (15–64 year-olds)	14.4	14.1	14.0
Youth (15–24 year-olds)	4.0	4.2	4.1

Source: OECD, 2017

The EU-28 youth self-employment rate dropped to 3.8% in 2008 and reached its highest value of 4.3% in 2012. In 2016, the EU-28 had 30.6 million self-employed people, of which nearly 763,300 were youth (OECD, 2017). In 2017, the number of unemployed young people in the EU decreased to 3.37 million, i.e. below the pre-crisis (2008) level (European Commission, 2018).

Summarising, in spite of the fact that the number of unemployed young people in the EU has recently been decreasing, the statistical data indicate that there exists an unrealised entrepreneurial potential among the age group under consideration that appropriate public policies, designed to eliminate the barriers impeding business start-up, can help to unlock.

3. Research Results and Discussion

To achieve the purpose of the article – to research the relationship between youth unemployment and self-employment in the EU and categorise particular EU countries as the countries with youth self-employment driven by *push* factors or *pull* factors, the Spearman’s correlation coefficient (rS) is chosen to investigate the strength of the phenomena in question in terms of linearity. The calculations include the unemployment rate of people aged 15 to 24, expressed in thousands of people

(y) and self-employment between the ages of 15 and 24 (x), expressed in thousands of individuals in the EU-28 countries in the period 2007–2017.

Spearman’s correlation coefficient is a statistical measure of the strength of a monotonic relationship between paired data. In a sample it is denoted by r_s and is by design constrained as follows and its interpretation is similar to that of Pearson’s, e.g. the closer is to the stronger the monotonic relationship. Correlation is an effect size and so we can verbally describe the strength of the correlation using the following guide for the absolute value of: .00–.19 “very weak”; .20–.39 “weak”; .40–.59 “moderate”; .60–.79 “strong”; .80–1.0 “very strong”.

The linear multiply regression model is used to investigate the impact of youth self-employment on trends in youth unemployment rates. Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data. Every value of the independent variable x is associated with a value of the dependent variable y . The population regression line for p explanatory variables x_1, x_2, \dots, x_p is defined to be $\mu_y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_px_p$. This line describes how the mean response μ_y changes

with the explanatory variables. The observed values for y vary about their means μ_y and are assumed to have the same standard deviation σ . The fitted values b_0, b_1, \dots, b_p estimate the parameters $\beta_0, \beta_1, \dots, \beta_p$ of the population regression line.

In the first stage of the empirical study, calculating Spearman's correlation coefficient for the EU-28 countries, where Y_t is the unemployment rate for people aged 15–24 years in the period 2007–2017, the number of self-employed persons of X –15–24 years of age, thousand, can be concluded:

1. Of the 28 EU countries, statistically significant moderate-intensity relationships were only obtained in 7 EU countries: in Cyprus ($r_s = -0.772$, $p = 0.05$), in the Czech Republic ($r_s = 0.724$, $p = 0.012$), in Germany ($r_s = 0.627$, $p = 0.039$), in Greece ($r_s = -0.609$, $p = 0.047$), in Italy ($r_s = -0.618$, $p = 0.043$), in Malta ($r_s = 0.695$, $p = 0.018$), in Sweden ($r_s = 0.706$, $p = 0.015$).
2. Medium-strong positive relationships established in the Czech Republic, Germany, Greece, Malta and Sweden suggest that these countries are classified as *pull* theories, i.e. the unemployment rate in these countries tends to increase as the youth self-employment rate increases. Hence, in these groups of countries self-employed persons become faster not because of absence of the possibility of finding a job, but due to motivation and desire to create their own business.
3. The establishment of moderate negative correlations in Cyprus and Italy allows these countries to be categorized as *push* theories, when young people start to create their own business due to a lack of employment opportunities in the country or young people's limited opportunities to find a job.
4. In the remaining 21 EU countries, there were no statistically significant correlations

Tab. 4: Results of multiple regression

Countries	Equation	Explanation
<i>Positive relation</i>		
Czech Republic	$y = -8,409 + 2,737 \times \text{Self-employment}$	With an increase in youth self-employment by 1 thousand, the unemployment rate among young people increases by 2,737 thousand persons.
Germany	$y = -138,386 + 8,678 \times \text{Self-employment}$	With an increase in youth self-employment by 1 thousand, the unemployment rate among young people increases by 8,678 thousand persons.
Sweden	$y = 38,543 + 9,369 \times \text{Self-employment}$	With an increase in youth self-employment by 1 thousand, the unemployment rate among young people increases by 9,369 thousand persons.
Malta	$y = 2,580 + 1,306 \times \text{Self-employment}$	With an increase in youth self-employment by 1 thousand, the unemployment rate among young people increases by 1,306 thousand persons.
<i>Negative relation</i>		
Cyprus	$y = 18,620 - 6,601 \times \text{Self-employment}$	With the increase in youth self-employment by 1 thousand, the unemployment rate for young people is reduced by 6,601 thousand persons.
Italy	$y = 941,740 - 3,244 \times \text{Self-employment}$	With the increase in youth self-employment by 1 thousand, the unemployment rate for young people is reduced by 3,244 persons.
Greece	$y = 211,807 - 4,941 \times \text{Self-employment}$	With the increase in youth self-employment by 1 thousand, the unemployment rate for young people is reduced by 4,941 thousand persons.

Source: own

between the youth self-employment rate and the youth unemployment rate. It can be assumed that the calculation of statistically insignificant relationships leads to greater influence of other labor market factors on the reduction of the unemployment rate.

The results of multiple regression evaluated in the second stage of the empirical study are presented in Tab. 4.

The multi-regression analysis of the calculations revealed that (not) identifying positive or negative statistically significant relationships or assigning links to *push* and *pull* theories allows national governments to make effective strategic choices by choosing appropriate measures to tackle self-employment and unemployment.

In countries that have identified the effect of *pull* theory, reducing youth unemployment will be completely ineffective through business promotion or other self-employment support measures/programs. Meanwhile, in countries that have the effect of *push* theory, the youth unemployment rate can be effectively reduced by supporting young people's engagement in the labor market through a self-employment prism. Consequently, relationships based on correlation allow initiating further research to examine the content of self-supporting employment programs in accordance with the motives of the *push* and *pull* theory.

Conclusions

Most often, youth entrepreneurship measures or strategies are used to tackle youth unemployment, but most of the money invested in reducing the unemployment rate of young people does not produce the desired result. The theory of *push* and *pull*, which explains the emergence of the entrepreneurship concept, argues that identifying motivational causes is one of the most important determinants of the effectiveness of self-employment programs and the achievement of the target group. Hence, identifying and attributing autonomous employment motives to the aforementioned theories would make it possible to use targeted support for business start-ups by national governments. Empirically, it has been revealed that statistically significant relationships between unemployment and self-employment among young people from the 28 EU countries, in only 7 countries, have been identified. Of these, Greece, Italy and

Cyprus, the unemployment rate among young people would decrease if national governments were to reduce unemployment through self-employment support measures. In other countries such as Germany, Sweden, the Czech Republic and Malta, it would be inappropriate to reduce unemployment through support for self-employment. In other EU countries, fighting youth unemployment requires addressing other labor market issues, such as the reluctance of businesses to employ unqualified or low-skilled young people, reducing the chances of reducing the tax burden when hiring young people, making flexible use of education opportunities with employment, etc. The paper confirms the fact that it is inappropriate for all countries (in this case EU countries) to apply universal strategies to combat unemployment, because by means of theories and pilot studies on the establishment of statistically significant relationships, it is possible to avoid mistakes by directing support to the needs of target groups.

References

- Blattman, C. J., & Dercon, S. (2016). *Occupational choice in early industrializing societies: experimental evidence on the income and health effects of industrial and entrepreneurial work* (Discussion Paper No. 10255). Bonn: IZA – Institute of Labor Economics. Retrieved from <https://www.econstor.eu/bitstream/10419/147941/1/dp10255.pdf>
- Burchell, B., Coutts, A., Hall, E., & Pye, N. (2015). *Self-employment programmes for young people: A review of the context, policies and evidence* (Working Paper No. 198). Geneva: International Labour Organization. Retrieved June 5, 2019, from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_466537.pdf
- Constant, A. F., & Zimmermann, K. F. (2014). Self-employment against employment or unemployment: Markov transitions across the business cycle. *Eurasian Business Review*, 4(1), 51–87. <https://doi.org/10.1007/s40821-014-0005-x>
- Dimian, G. C., Aceleanu, M. I., Ileanu, B. V., & Şerban, A. C. (2018). Unemployment and sectoral competitiveness in Southern European Union countries. Facts and policy implications. *Journal of Business Economics and Management*, 19(3), 474–499. <https://doi.org/10.3846/jbem.2018.6581>

- Dvouléty, O., Mühlböck, M., Warmuth, J., & Kittel, B. (2018). "Scared" young entrepreneurs. Exploring young adults' transition from former unemployment to self-employment. *Journal of Youth Studies*, 21(9), 1159–1181. <https://doi.org/10.1080/13676261.2018.1450971>
- Escudero, V., & López Mourelo, E. (2013). *Understanding the drivers of the youth labour market in Kenya* (Research Paper No. 8). Geneva: International Labour Organization.
- European Commission. (2018). 2018 review of employment and social developments in Europe – questions and answers. Retrieved July 10, 2018, from http://europa.eu/rapid/press-release_MEMO-18-4394_en.htm
- Eurostat. (2018). Unemployment statistics. Retrieved November 18, 2019, from https://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics#Youth_unemployment
- Frankjović, J., Šebalji, D., & Živković, A. (2015). Youth: Does unemployment lead to self-employment? *Interdisciplinary Management Research*, 11, 247–257. Retrieved November 15, 2018, from <https://bib.irb.hr/datoteka/761597.lanak.pdf>
- Hinks, R., Fohrbeck, A., & Meager, N. (2015). *Business start-ups & youth self-employment – a policy literature review* (National Report from the UK Contributing to D.7.1). Brighton: Institute for Employment Studies. Retrieved June 15, 2019, from <https://www.style-research.eu/wp-content/uploads/2015/03/STYLE-Working-Paper-WP7.1-UK.pdf>
- Hout, M., & Rosen, H. (2000). Self-employment, family background, and race. *The Journal of Human Resources*, 35(4), 670–692. <https://doi.org/10.2307/146367>
- Hundley, G. (2006). Family background and the propensity for self-employment. *Industrial Relations: A Journal of Economy and Society*, 45(3), 377–392. <https://doi.org/10.1111/j.1468-232X.2006.00429.x>
- Jones, K., Brinkley, I., & Crowley, L. (2016). *Going solo: Does self-employment offer a solution to youth unemployment?* (Report TD/TNC 123.575). London: Work Foundation. Retrieved June 10, 2019, from http://www.theworkfoundation.com/wp-content/uploads/2016/11/392_Going-Solo-does-self-employment-offer-a-solution-to-youth-employment.pdf
- Manyande, N. N. (2006). *Encouraging self-employment amongst the youth in South Africa: Will this help tackle the unemployment problem?* (Master Thesis). Cape Town: University of Cape Town. Retrieved June 18, 2019, from https://open.uct.ac.za/bitstream/handle/11427/14610/thesis_com_2006_manyande_nyarai_n.pdf?sequence=1
- Mlatsheni, C., & Rospabe, S. (2002). *Why is youth unemployment so high and unequally spread in South Africa?* (Working Paper No. 02/65). Cape Town: Development Policy Research Unit.
- OECD/European Commission. (2012). *Policy Brief on Youth Entrepreneurship – Entrepreneurial Activities in Europe*. Luxembourg: Publications Office of the European Union. Retrieved October 25, 2019, from https://www.oecd.org/employment/leed/Youth%20entrepreneurship%20policy%20brief%20EN_FINAL.pdf
- OECD/European Commission. (2014). *Policy Brief on Access to Business Start-up Finance for Inclusive Entrepreneurship – Entrepreneurial Activities in Europe*. Luxembourg: Publications Office of the European Union. Retrieved November 24, 2019, from <http://www.oecd.org/cfe/leed/Financing%20inclusive%20entrepreneurship%20policy%20brief%20EN.pdf>
- OECD. (2017). *The Missing Entrepreneurs 2017 – Policies for Inclusive Entrepreneurship*. Paris: OECD Publishing. <https://doi.org/10.1787/9789264283602-en>
- Özkerke, Y., & Doğruel, F. (2015). Self-employment and unemployment in Turkey. *Topics in Middle Eastern and North African Economies*, 17(1), 133–152. Retrieved from https://pdfs.semanticscholar.org/129d/bed6e5ef21c54e148c5593fc8b3e48f6aff6.pdf?_ga=2.148791871.900472165.539084415-1907629831.1539084415
- Páleník, M. (2011). *Young unemployed: help them into self-employment or wait until they have long term unemployment status?* (Mutual Learning Programme 2011, Peer Review). Retrieved December 10, 2019, from ec.europa.eu/social/BlobServlet?docId=10639&langId=en
- Perugini, C., & Signorelli, M. (2010). Youth labour market performance in European regions. *Economic Change and Restructuring*, 43(2), 151–185. <https://doi.org/10.1007/s10644-009-9082-8>
- Sasongko, G., & Huruta, A. (2019). The causality between inflation and unemployment: The Indonesian evidence. *Business Theory*

and Practice, 20, 1–10. <https://doi.org/10.3846/btp.2019.01>

Sechele, L. (2016). Unemployed youth and self-employment in Botswana. *Mosenodi Journal*, 19(1–2), 31–44. Retrieved June 20, 2019, from https://www.researchgate.net/publication/320417086_UNEMPLOYED_YOUTH_AND_SELF-EMPLOYMENT_IN_BOTSWANA

Sheehan, M., & Mc Namara, A. (2015). *Business Start-Ups & Youth Self-Employment A Policy Literature Review Synthesis Report* (STYLE Working Papers, WP7.1). Brighton: CROME, University of Brighton. Retrieved July 21, 2019, from https://www.style-research.eu/wp-content/uploads/ftp/D_7_1_Business_Start-Ups_Youth_Self-Employment_Policy_Literature-Review_FINAL.pdf

Statista. (2018). Youth unemployment rate in Europe (EU member states) as of May 2018 (seasonally adjusted). Retrieved June 20, 2019, from <https://www.statista.com/statistics/266228/youth-unemployment-rate-in-eu-countries/>

Walsh, K. (2011). *The encouragement and support for youth self-employment in the United Kingdom: comparisons with the approach in Spain*. (Mutual Learning Programme 2011, Peer Review). Retrieved December 15, 2018, from ec.europa.eu/social/BlobServlet?docId=10641&langId=en

Williams, D. R. (2004). Youth self-employment: its nature and consequences. *Small Business Economics*, 23(4), 323–336. <https://doi.org/10.1023/B:SBEJ.0000032035.30738.01>

COMPETITIVENESS OF MUTUAL AGRARIAN FOREIGN TRADE OF THE POST-SOVIET COUNTRIES

Irena Benešová¹, Luboš Smutka², Jana Hinke³, Adriana Laputková⁴

¹ Czech University of Life Sciences, Faculty of Economics and Management, Department of Economics, Czech Republic, ORCID: 0000-0002-9381-063X, benesova@pef.czu.cz;

² Czech University of Life Sciences, Faculty of Economics and Management, Department of Economics, Czech Republic, ORCID: 0000-0001-5385-1333, smutka@pef.czu.cz;

³ University of West Bohemia, Faculty of Economics, Department of Finance and Accounting, Czech Republic, ORCID: 0000-0001-6767-1253, hinke@kfu.zcu.cz;

⁴ Czech University of Life Sciences, Faculty of Economics and Management, Department of Languages, Czech Republic, ORCID: 0000-0001-6483-9081, laputkova@pef.czu.cz.

Abstract: The paper is an analysis of foreign trade of the post-Soviet countries conducted for years 2000 and 2015. The aims of the research were thus twofold: to examine the bilateral trade scheme for the selected countries and to attempt to explore relations between competitiveness and thus the position of the agricultural commodity aggregates. The UN COMTRADE database was used. In the monitored countries, there is continuous growth of the commodity aggregate 0 – Food and live animals, which is strongly influenced by the commodity sub-aggregates 02 – Dairy products and bird eggs, S3-04 – Cereals and cereal preparations. The first phase entailed calculations of individual indicators of mutual trade (RCA, LFI, GLI and coverage of import). Subsequently, the indicators were used as input variables for further analyses. Using RCA and LFI indexes, the commodity aggregates were classified into 4 quadrants according to their position within the comparative advantage and competitiveness.

Using a cluster analysis (based on Euclidian distance and Ward's method), individual commodity aggregates for the monitored countries were divided into groups based on the values of GLI, LFI and coverage of import. The groups were subsequently characterized for individual countries. Based on the conducted analyses, it can be stated that hypothesis 0 about the non-existence of significant changes within the group structure does not reflect the reality. Between 2000 and 2015, substantial changes occurred in terms of dividing the commodity aggregates into groups based on their common characteristics with regard to foreign trade.

In addition, the diversity within foreign trade decreased between 2000 and 2015, and more commodity aggregates attain values around or below the average of a given aggregate. When assessing the intra-industry trade, it can be stated that some commodity aggregates can be regarded as important only with regard to Azerbaijan, Russia, Belarus, Kazakhstan and Ukraine. In these countries, this phenomenon is most frequently evident in the commodity aggregates Beverages or Vegetables and fruit.

Keywords: Post-Soviet countries, cluster analysis, LFI, RCA, GLI, commodity group.

JEL Classification: F14, Q02.

APA Style Citation: Benešová, I., Smutka, L., Hinke, J., & Laputková, A. (2020). Competitiveness of Mutual Agrarian Foreign Trade of the Post-Soviet Countries. *E&M Economics and Management*, 23(3), 49–66. <https://doi.org/10.15240/tul/001/2020-3-004>

Introduction

Agrarian foreign trade represents an integral part of the majority of the world countries'

foreign trade. Agriculture in the countries with a lower economic performance can represent potential for economic growth when excess

workforce is employed in sectors with higher added value and surpluses are realized through foreign trade or, on the contrary, can also be restrictive. This case concerns the countries with an inadequate agricultural foundation or the so-called net food importing countries. Agricultural foreign trade can thus serve as a source as well as an obstacle to economic growth. It is also necessary to mention that agriculture also produces public property in the form of tackling hunger or combating poverty.

The post-Soviet republics represent a substantially heterogeneous group despite their common history. The group of selected post-Soviet countries (not those in EU) comprises Armenia (AR), Azerbaijan (AZ), Belarus (BE), Georgia (GE), Kazakhstan (KZ), Kyrgyzstan (KG), the Republic of Moldova (MO), the Russian Federation (RU), Tajikistan (TJ), Turkmenistan (TR), Ukraine (UA) and Uzbekistan (UZ). For some of these countries, agrarian foreign trade represents an important part of their overall foreign commerce. Due to the existence of certain regionalizing tendencies, the question arises whether, for instance, more trade is conducted within individual groupings or the structure of the trade is significantly different (Azizov, 2017). The post-Soviet republics also represent a different political structure – mostly autocratic regimes in which entire agreements on free trade or higher levels of integration do not reflect the strongest economic relations but rather mutual dependency (Libman & Vinokurov, 2018; Portanskii, 2012). Both foreign trade and regional integration agreements also promote installation or consolidation of autocratic regimes in other countries (Obydenkova & Libman, 2016).

Currently, more than a half (circa 55%) of the global trade is conducted as a part of regional trade agreements. Although regional integration is frequently discussed in the world economy, it is not a new topic. In this regard, it is necessary to state that although there is relatively extensive literature which discusses the reasons leading to regional integration or the impact of integration groupings on the national or regional economy, very few authors discuss the political or social aspect of this issue. The benefits and assessment of regional cooperation have been addressed by (Cavoli, 2012; Commendatore, Kubin, Petraglia, & Sushko, 2014; Espinoza, Prasad, & Williams,

2011; Geldi, 2012; Guesmi & Teulon, 2014; Ke, 2015; Kumar, Sen, & Srivastava, 2014; Minniti & Parello, 2011). When discussing economic integration, the term itself contains elimination of various barriers to trade. This concerns tariff and non-tariff measures which hinder free trade. In this regard, national borders also represent an obstacle to free trade and for this reason it is impossible to perceive the competition as perfect when considering regional integration groupings.

1. Current State of Knowledge

The problem of foreign trade in the majority of the post-Soviet republics lies in its structure with heavy dependence on primary commodities (Hare, Estrin, Lugachyov, & Takla, 1998; Horváth & Zeynalov, 2014). This mainly concerns natural raw materials which represent the basic source of economic growth (Bildirici & Kayıkçı, 2013; Cavalcanti, Mohaddes, & Raissi, 2011; Havránek, Horváth, & Zeynalov, 2016). However, this condition is unsustainable long-term.

Agriculture represents one the most protected areas of economic activity in every country. At the same time, international trade is important for a large number of agricultural products. Liberalization of the global trade provides sufficient market opportunities for individual commodities. However, it also represents a threat to the countries which do not possess a competitive advantage over their trading partners and might also lead to deterioration of the food security situation.

In the case of the post-Soviet republics, the situation is different both in agriculture and in agrarian foreign trade. Land reform still has not been undertaken in some of the countries and agricultural production is more or less controlled by the state (Benešová, Novotná, Šánová, & Laputková, 2016b; Cormier, 2007; Lerman, 2009). Even though this concerns the countries which, despite their heterogeneity, possess the same legislative environment, their approach to liberalization of not only their agrarian foreign trade differs (Mazhikeyev & Edwards, 2013; Mazhikeyev, Edwards, & Rizov, 2015). It is also widely accepted in these countries that through regional cooperation and establishment of a supranational competition policy they can contribute to a greater degree to market liberalization (Libman, 2007). Nonetheless, inclusion of agrarian markets

in economic liberalization or directly in free trade or customs union can be particularly problematic, not only because it includes a very sensitive and specific area of the national economy, but predominantly in socio-political terms (Rueda-Junquera, 1998). One of the factors that can contribute to agrarian market liberalization is one's membership in WTO which expects customs barriers to be reduced or removed (Portanskii, 2012). However, should the market liberalization occur, the competitiveness of agrarian commodities would have to be significantly strengthened. Nevertheless, this is extremely difficult in the case of linking the economy and politics, which is typical for hybrid regimes (Hale, 2010, 2011). Malle (2012) adds that regarding Russia, this concerns a symbiosis between the government and large industrial sectors at both local and central levels. However, an economy that is semi-closed or entirely closed to international competition does not have an opportunity to modernize and increase its international competitiveness.

Nevertheless, the structure of Russian export depends on the differences between domestic and world prices with very low competitiveness of, for example, food, agricultural and wood products (Benešová, Maitah, Smutka, Tomšik, & Ishchukova, 2017). Gnidchenko and Salnikov (2013), Gnidchenko and Sa'nikov (2014) mention that Russia is competitive in regard to raw materials. (Salnikov, Gnidchenko, & Galimov, 2016) also state that the mere reduction of import rates does not always result in an increase in the competition.

Currently, there are no studies focusing on the competitiveness of the mutual agrarian foreign market within the post-Soviet republics.

1.1 Hypothesis Development

Weber (2003) states that Russia represents the major exporter of agri-food products, whereas Kazakhstan is more export-oriented. Garanina (2009), Garanina and Pankki (2008) mention that agricultural raw materials in the structure of the Russian foreign trade declined during the monitored period. There are countries that export more agricultural products to Europe than to Russia and other post-Soviet countries (Chiaruttini, 2014). On the other hand, the Central Asian republics have significant trade relations with China and other Asian countries (Linn, 2012; Spechler & Spechler, 2013; Yun & Park, 2012).

The majority of the post-Soviet republics focus on producing similar commodities and only occasionally produce different goods. However, similar production does not enable diversification of the risks connected with growing individual types of crops. On the other hand, these crops are closely connected to food security and represent an essential dietary component. In the case of the common approach of the post-Soviet republics, a similar commodity structure can also influence international prices as it allows monopoly systems to be employed (Benešová, Novotná, Šánová, & Laputková, 2016a). Other countries are crucial for many of the post-Soviet republics' agriculture owing to the necessity to utilize their infrastructure as well in order for them to be able to realize their products on the international market. This concerns for example Kazakhstan, Uzbekistan or Belarus which lack access to the sea, therefore they need to use other countries' facilities for maritime transport. Agricultural production of the post-Soviet republics represents a significant proportion of global production. However, for this reason volatility could influence prices of agricultural produce, namely of food on the global market. The prices of food are continuously rising, although substantial fluctuation is evident with some commodities, which results in this segment's instability. Erokhin (2020) investigates competitiveness of mutual trade within central Asia with the focus on the agricultural value chain. However, no author discusses the complex issue of these countries' mutual trade after the dissolution of the Soviet Union. Due to the existing, although in some cases weaker, mutual interconnection it is necessary to examine these countries not only as geographical units (Caucasus, central Asia, eastern Europe), but also as a complex of countries.

The factors mentioned above negatively influence competitiveness of agricultural production of the monitored countries. However, it is not clear whether there is any change in competitiveness during the monitored period nor what the position of the individual monitored countries within the post-Soviet region is.

Based on the information obtained by the authors, there is currently no study that compares competitiveness of agrarian commodity aggregates of these countries. The assessment of competitiveness should be based on two

complementary parts. One of these should involve evaluation of competitiveness of the monitored commodity aggregates across the monitored countries. The second should subsequently concern evaluation of competitiveness of the monitored countries regarding individual commodity aggregates. This complex approach will enable an analysis of the competitiveness of agrarian products in the monitored countries as well as the position of individual countries.

Based on the above facts, the research hypotheses related to the competitiveness of the monitored countries and their position in the mutual trade can be formulated:

H0: Competitiveness of the monitored countries in individual commodity aggregates is currently similar. This concerns commodities which do not represent key agrarian sector products.

H1: There are commodity aggregates which are key for individual countries whose competitiveness during the monitored period changed significantly.

2. Aim and Methodology

Foreign trade in agricultural commodities represents an important part of export of primary commodities. This paper explores agricultural trade between selected post-Soviet countries with respect to its contribution to the

overall foreign trade and the trade pattern. It measures the impact of agricultural trade on the competition of the countries within the group. The main aim of the paper is to conduct an analysis of competitiveness of the post-Soviet countries' agrarian foreign trade with regard to the position of individual countries as well as the position of individual commodity aggregates. The purpose of the analysis is to assess the position and the development of individual commodity aggregates and monitored countries.

Therefore, the authors will attempt to answer the following questions:

1. How have the changes of agrarian foreign trade been manifested in the overall competitiveness of this sector of foreign trade in the monitored period of 2000–2015?
2. How have the potential changes of the competitiveness of the monitored commodity aggregates been manifested in the individual countries' position?

2.1 Data Description

The export and import data have been retrieved from the UN COMTRADE database. These refer to the period between 2000 and 2015. The data are based on the Standard International Trade Classification (SITC) Rev. 2 nomenclature. A mostly two-digit level of aggregation is used, consisting of the products mentioned in Tab. 1.

Tab. 1: Commodity groups in analysis

One digit	Two digit	Description	Two digit	Description	One digit
0	00	Live animals other than animals of division 03	08	Feeding stuff for animals	0 Food and live animals
	01	Meat and meat preparations	09	Miscellaneous edible products and preparations	
	02	Dairy products and bird eggs	11	Beverages	1 Beverages and tobacco
	03	Fish, crustaceans, molluscs etc	12	Tobacco and tobacco manufactures	
	04	Cereals and cereal preparations	41	Animal oils and fats	4 Animal and vegetable oils, fats and waxes
	05	Vegetables and fruit	42	Fixed vegetable fats and oils, crude, refined or fractionated	
	06	Sugars, sugar preparations and honey	43	Animal or vegetable fats and oils, etc	
	07	Coffee, tea, cocoa, spices, and manufactures thereof			

Source: own

The initial analysis will be conducted at a one-digit level of aggregation. In this regard, only three commodity aggregates that include agricultural products will be analysed in more detail. This concerns group 0, 1 and 4.

2.2 Research Methods

An analysis of competitiveness can be conducted from the lowest level (company) through industry competitiveness to the highest possible level, the state competitiveness. The objective of this research is to analyse comparative advantages at the state level and internationally, for comparison. There are different assessment indicators for this comparison which will be used to explore foreign trade of the monitored countries.

Firstly, a trade flow analysis will be conducted with the focus on the development of import, export, their composition and dynamics. Subsequently, competitiveness indexes will be calculated:

1. Balassa Index (BI) (Balassa, 1965, 1977) in order to determine specialization of export. An assessment of competitiveness BI will be conducted according to Laursen (2015). $RCA > 1$ – the country possesses a competitive advantage. $RCA < 1$ – the country possesses a competitive disadvantage.
2. Gruber Lloyd Index (GLI) (Grubel & Lloyd, 1971) to evaluate intra-industry trade in the overall trade. $GLI = 1$ – only intra-industry trade exists $GLI = 0$ – there is no intra-industry trade, only inter-industry trade.

3. Lafay Index (LFI) in order to assess mutual trade (Iapadre, 2001; Lafay, 1992). It gains values $<-\infty, \infty>$, if the value exceeding zero is gained, the country possesses a comparative advantage.

Lafay and Balassa indexes are used to divide the countries into four quadrants (Fig. 1). The best is number I, the countries located in it possess a general comparative advantage. On the other hand, quadrant number III consists of the countries without any competitiveness and comparative advantage (more about this problem Benešová, Smutka, & Laputková, 2019). This analysis will be conducted for all the products and selected countries.

Individual calculations will subsequently be utilized as input variables for cluster analysis, using which individual countries and products will be classified. For the purposes of this research, hierarchical clustering will be used, based on Ward's method, in order to calculate the squared Euclidian distance (Ward, 1963). The values will be transformed using the z-score in order to prevent distortion resulting from different levels. Subsequently, individual categories will be characterized using average values of the utilized indicators. The final step will be to assess the differences between the categories. In this case, nonparametric tests will be used – relating samples of the Wilcoxon signed-rank test (Rosner, Glynn, & Lee, 2006) to H_0 : the median of the differences between two groups equals 0. The significance level is 0.05.

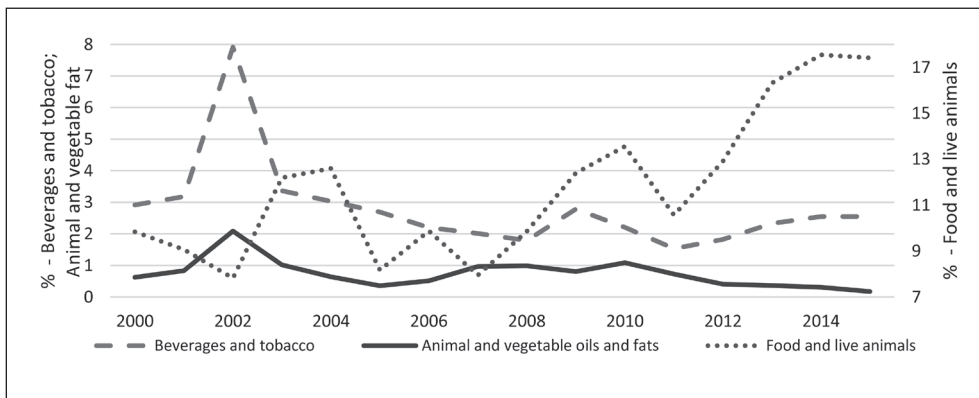
Multidimensional scaling will be used and perceptual maps will be created for graphic illustration (Buja & Swayne, 2002; Torgerson, 1952).

Fig. 1: Division of the countries according to LFI and RCA

RCA	IV.	$RCA > 1$ $LFI < 0$	I.	$RCA > 1$ $LFI > 0$
	III.	$RCA < 1$ $LFI < 0$	II.	$RCA < 1$ $LFI > 0$
		LFI		

Source: own

Fig. 2: Development of proportion of monitored commodity aggregates (one-digit) to overall trade



Source: own based on UN COMTRADE data

3. Composition of the Post-Soviet Countries' Foreign Trade

During the monitored period, the structure of foreign trade of the post-Soviet republics changed slightly. The proportion of agrarian commodities to overall foreign trade of the monitored countries has long-term amounted to approximately 15%. (Fig. 2). However, there are significant differences between the monitored countries, for example, the proportion of Russia is considerably lower than that of Uzbekistan.

When assessing the development tendencies of agrarian foreign trade, it is evident that the commodity aggregate Food and live animals (one-digit code) records long-term growth in the post-Soviet republics in the last monitored period between 2011 and 2015 (Fig. 2). The products included in this commodity aggregate were traded in the monitored period within CIS between the majority of the countries.

A comparative advantage is one of the key indicators of overall competitiveness of

a given country. The Russian Federation is one of the states with the largest proportion of comparative advantages in relation to the monitored countries. In 2000, Russia did not possess a comparative advantage in the commodity aggregate Food and Live animals (one digit) only in its trade with Belarus, Ukraine and Uzbekistan (Tab. 2). In 2015, this concerns Ukraine only.

In the case of Ukraine, the most noticeable decline in comparative advantages is evident. At the beginning of the monitored period, Ukraine possessed comparative advantages over all the countries except for Russia.

Regarding the analysis (Tab. 2) based on the higher level of classification (two-digit), the commodity aggregate Dairy products and bird eggs (02), Cereals and cereal preparations (04) and Beverages (11) record the highest values long-term. It is evident that between 2000 and 2015 the structure of export of the monitored countries changed.

Tab. 2: Composition of mutual export between post-Soviet countries (2000, 2015)

	S3-01	S3-02	S3-03	S3-04	S3-05	S3-06	S3-07	S3-08	S3-09	S3-11	S3-12	S3-41	S3-42	S3-43
2000	14.7%	11.7%	2.3%	12.8%	7.8%	13.8%	6.9%	0.7%	2.6%	12.0%	8.8%	0.1%	5.5%	0.4%
2015	9.4%	17.8%	3.1%	16.5%	11.2%	4.0%	6.8%	3.7%	8.0%	6.8%	7.3%	0.1%	4.8%	0.3%

Source: own based on UN COMTRADE data

As has been mentioned above, there is long-term growth of the commodity aggregate 0 – Food and live animals. This is strongly influenced by the commodity sub-aggregates 02 – Dairy products and bird eggs, 04 – Cereals and cereal preparations. The proportion of these aggregates to the overall agrarian foreign trade of the post-Soviet countries has long-term retained the level exceeding 10% for each monitored aggregate. Contrariwise, the commodity aggregates 00, 41 and 43 are insignificant.

According to the division mentioned in Fig. 1 and Tab. 3, it can be concluded that in 2000 Russia possessed the largest number of commodity aggregates (9x), followed by Azerbaijan (7x), Ukraine (6x) and Belarus (5x). This quadrant also includes products that possess a comparative advantage ($RCA > 1$), while the countries are also competitive within their mutual trade relations ($LFI > 0$). 05 – Vegetables and fruit was the most frequently occurring commodity aggregate in this quadrant (9x), at a considerable margin followed by 12 – Tobacco and tobacco manufactures (5x) and 11 – Beverages a 07 – Coffee, tea, cocoa, spices, and manufactures thereof (both 4x).

Armenia, Kyrgyzstan or Tajikistan occupy the opposite positions, that is possess no evident comparative advantage and competitiveness for the majority of the monitored commodities. 12 out of 15 of the monitored commodity aggregates are placed in quadrant number III for all of these countries. Kazakhstan (11 aggregates), Georgia and Turkmenistan (10 commodity aggregates each) follow. In terms of commodity aggregates, 10x 04 – Cereals and cereal preparations can be identified here, followed by 02 – Dairy products and bird eggs, 01 – Meat and meat preparations.

When drawing a comparison with 2015, a problem arises, namely that the data for Tajikistan and Turkmenistan are not available. The comparison will thus be performed excluding these two countries.

As in 2000, Russia records the largest number of comparative advantages connected with overall competitiveness of its production (Tab. 3). In total, 8 out of its monitored commodity aggregates are located in quadrant I. In comparison with 2000, the number of commodity aggregates decreased by one. The position of some commodity aggregates also changed. 7 out of them did not record

any change. With regard to Cereals and cereal preparations, the situation is reversed as the country lost its position within RCA and competitiveness, which is the result of the increasing proportion of animal production. A contrary situation occurred regarding Tobacco and tobacco manufactures, in which Russia improved its status and, in comparison with 2000, it records both a competitive advantage and competitiveness in this commodity aggregate.

When assessing individual aggregates for the whole group of countries, the worst position is recorded in the case of **Dairy products and bird eggs**, Coffee, tea, cocoa, spices, and manufactures thereof, Tobacco and tobacco manufactures. This position could be expected regarding the last two, although it was rather unexpected in the case of dairy products, considering the fact that cow milk in particular is produced in all the monitored countries. The participation of the monitored countries in the global milk production exceeds 10.5%. Russia, Ukraine, Uzbekistan and Belarus are among its most important producers. Concurrently, this commodity aggregate represents a significant proportion in the overall agrarian trade within the monitored countries.

However, except for cow milk, the monitored countries also produce goat, sheep, camel or buffalo milk. Regarding the last two, the production is merely minor and present in Georgia, Uzbekistan or Russia. On the contrary, goat or sheep milk is produced in the majority of the countries. Although this product is very important within agrarian markets, an evident comparative advantage is recorded only by Belarus, Ukraine and Kazakhstan. Simultaneously, coverage of import by export in the majority of the countries is negligible. In 2015, comparative advantages ($RCA > 1$) were gained only by Belarus. As regards Armenia, Kyrgyzstan and Moldova, intra-industry trade can be discussed, in which $GLI > 0.5$. When comparing 2000 and 2015, the position of the Russian Federation deteriorated sharply (Fig. 3). Its competitiveness decreased or its comparative advantages, intra-industry trade and coverage of import by export weakened. This decline is connected with the sanctions imposed against Russia by the European Union and other countries, since these profoundly affected trade in agricultural commodities (Kutlina-Dimitrova, 2017).

Tab. 3: Commodity groups according to division in Fig. 1

	2000				2015			
	I. RCA > 1 LFI > 0	II. RCA < 1 LFI > 0	III. RCA < 1 LFI < 0	IV. RCA > 1 LFI < 0	I. RCA > 1 LFI > 0	II. RCA < 1 LFI > 0	III. RCA < 1 LFI < 0	IV. RCA > 1 LFI < 0
00	AR, RU, TR	TJ	AR, AZ, GE, KZ, KG, MO, UA	UZ	GE, KG, RU, UA, UZ	BE	AR, AZ, KZ	--
01	UA	BE, MO	AR, AZ, GE, KZ, KG, RU, TJ, TR, UZ	--	BE, UA	MO	AR, AZ, GE, KZ, KG, RU, UZ	--
02	BE	RU, UA	AR, AZ, GE, KZ, KG, RU, TJ, TR, UA	--	BE, UA	KG, UA	AR, AZ, GE, KZ, MO, RU, UZ	--
03	RU	TR		BE	AR, BE	GE	AZ, KZ, KG, MO, RU, UA, UZ	--
04	KZ, RU	--	AR, AZ, BE, GE, KG, MO, TJ, TR, UA, UZ	--	KZ, RU	UA	AR, AZ, BE, GE, KG, MO, UZ	--
05	AR, AZ, BE, GE, KG, MO, TJ, TR, UZ	KZ	RU, UA	--	AR, AZ, GE, KG, MO, UZ	--	KZ, RU, UA	BE
06	BE, RU, UA	GE	AR, AZ, KZ, KG, MO, TJ, TR, UZ	--	BE, UA	--	AR, AZ, GE, KZ, KG, MO, UZ	RU
07	AZ, GE, RU, UA	BE	AR, KZ, KG, MO, TJ, TR, UZ	--	RU	AZ	AR, BE, GE, KZ, KG, MO, UZ	UA
08	AZ, RU, UZ	--	AR, BE, GE, KZ, KG, MO, TJ, TR	UA	RU, UA	KZ	AR, AZ, GE, KG, MO, UZ	GE
09	BE, RU	AZ	AR, GE, KZ, KG, MO, TJ, TR, UA, UZ	--	AZ, RU, UA	--	AR, BE, GE, KZ, KG, MO, UZ	--
11	AR, AZ, GE, MO	UZ	BE, KZ, KG, RU, TJ, TR, UA	--	AR, GE, MO	UZ	AZ, GE, KZ, KG, RU, UA	--
12	BE, KG, TJ, UA, UZ	--	AR, BE, RU, TR,	GE, MO	RU	UZ	AZ, BE, GE, KZ, KG, MO	AR, UA
41	MO, UA	--	BE, GE, KZ, KG, RU, TJ		BE, UA	GE, MO	AR, AZ, KZ, KG, RU, UZ	--
42	AZ, RU, UA	MO	AR, BE, GE, KZ, KG, TJ, TR, UZ		AZ, RU	UA	AR, BE, GE, KZ, KG, MO, UZ	--
43	AZ, RU, TR	KG, UA	AR, BE, GE, KZ, MO, TJ, UZ	--	AZ, RU	--	AR, BE, GE, KZ, KG, MO, UZ	UA

Source: own based on UN COMTRADE data

Regarding Ukraine, its inter-industry trade slightly declined, although it was already relatively low. However, Ukraine decreased its own comparative advantage. In 2000, its RCA

reached 0.879, whereas in 2015 its value was as low as 0.391. Nevertheless, based on the statistical tests, a significant change in the competitiveness of the monitored countries

in the commodity aggregate Dairy products cannot be confirmed.

When comparing the commodity aggregate Cereals and cereal preparations, it is Kazakhstan and Russia that record long-term competitiveness. Coverage of import by export in these countries is also extensive. Contrariwise, it is insignificant in the case of Azerbaijan, Kyrgyzstan, Moldova or Uzbekistan. Cereals play an important role in agricultural production of the post-Soviet republics. When comparing the overall segment of cereals, the production value of the post-Soviet republics represents 5.76% of the global production.

The contribution of Russia reaches 2.62% and of Ukraine 1.8%. Should the focus be on wheat only, that is a commodity connected with food security, then the post-Soviet republics' contribution to the overall production amounts to 14.5%, while the proportion of Russia and Ukraine exceeds 10% of the global production.

The commodity aggregate 11 – Beverages is the third most important component within agricultural trade. The Lafay index records long-term positive values in Armenia, Georgia, Moldova. These countries also record the highest value of the Balassa index, although their value of GLI is low, which signifies inter-industry trade only. In the case of LFI and GLI, the correlation between these two values is negative. Uzbekistan is another competitive country, even though the value of the Lafay index fluctuates around 0.4. The remaining countries' value of LFI and RCA is negative.

4. Division of Products According to Their Characteristics

A cluster analysis was used in order to assess the countries' position and individual commodity aggregates. The initial input variables were LFI, GLI, RCA, and coverage of import by export. The RCA index was excluded due to a high degree of correlation; other variables no longer demonstrate a statistically significant correlation. The cluster analysis was always conducted to compare years 2000 and 2015.

Individual commodity aggregates were classified into categories based on these variables (Tab. 4 and Tab. 5). This concerns four to six categories, in which Ukraine possesses the largest number of categories in 2000 and Kyrgyzstan in 2015, which was influenced by significant differences between individual commodity aggregates.

In 2000, the commodity aggregates in **Armenia** were divided into 5 categories, whereas in 2015 into 4. As regards Armenia, the number of the commodities with a low level of all the monitored indicators increased. The position of Beverages and Cereals is considerably different in comparison with other aggregates. Regarding Cereals, the values of all the indicators are low, while Beverages record high levels of LFI and simultaneously a significant decline in coverage of import by export during the period of 2000–2015.

The cluster analysis divided the commodity groups of **Azerbaijan** into 4 categories in 2000 and 5 in 2015, two of which remained similar. These are the aggregates whose calculated indicators are continuously low on the one hand (group 1) and, on the other hand, there are aggregates with high LFI (group 3 – 2015). These groups possess considerably different characteristics. Group 5 (2015) consists of Sugar and sugar preparations only and reaches a very high level of GLI and coverage of import by export. Regarding milk and cereals, Azerbaijan is uncompetitive and continuously records very low ratio of import to export.

While in 2000 **Belarus'** commodity structure was divided into 3 homogeneous categories, there was a dramatic change in 2015 in the position of Dairy products and Fish and crustaceans. The value of LFI and coverage of import by export for these two commodity aggregates greatly exceed the average of the group. As regards dairy products, however, the value of GLI remains low, which signifies lower value of intra-industry trade.

Georgia's classification is similar, where the number of categories increased from three to five between 2000 and 2015 when commodity aggregates Beverages and Tobacco became distinct. The value of the LFI index of the former is high, while the latter records extensive coverage of import by export. The structure of the category also changed, with a high rate of inter-industry trade. While in 2000 the values exceeded 0.9, in 2015 they decreased to around 0.6 and, simultaneously, the commodity aggregates which recorded these values changed. This therefore signifies that the country is beginning to focus more on inter-industry trade in the given aggregates. This is particularly evident in group three, where the GLI value is well below average and the value of LFI is also low. The commodity aggregate

Cereals also recorded a significant decrease with the GLI value decreasing from 0.39 to 0.09. Concurrently, this aggregate records extensive coverage of import by export.

Cereals and cereal preparations represent a commodity aggregate with the highest value of calculated indicators in both monitored periods. This aggregate records a high value of LFI as well as the most extensive coverage of import by export. In comparison with 2000, greater diversification between individual aggregates occurred in 2015, while the number of commodities with low values of GLI increased, which indicates non-existence of the intra-industry trade. However, this is not unusual in agrarian aggregates. Group 5 is interesting as it represents aggregates with a high value of LFI and GLI and also a low degree of coverage of import by export.

In terms of comparative advantages, live animals, vegetables and fruit and dairy products were the most important aggregates for Kyrgyzstan in 2015. Nevertheless, each of these exhibits different characteristics. The remaining groups are characterized, for instance, by negative LFI or average GLI – group 1, or by all the values below average – group 4.

Moldova's coverage of import is rather low for 10 commodity aggregates. On the contrary, meat and meat preparations occupy a very good position and also record high values of intra-industry trade. During the monitored period, the situation of vegetables and fruit improved. Contrariwise, beverages occupy a strong position and record extensive coverage of import by export throughout the entire monitored period. This is also the reason why this commodity aggregate is isolated.

The situation of **Russia** is fairly specific. The number of comparative advantages implies that the majority of the monitored commodity aggregates achieve a very good market position. One group consists of aggregates whose LFI and coverage of import exceeds the average. This concerns, for example, cereals and cereal preparations or feeding stuff for animals. Commodity aggregates Tobacco and Animal and vegetable fats are in a similar position. Values in group 4 greatly exceed the average. Group 2, containing dairy products only, appears problematic as all the indicators have been below average of the aggregates over the recent years. The impact of sanctions is clearly evident in this case.

When assessing the position of the Russian Federation only in terms of RCA and LFI, it can be stated that an improvement of the situation occurred in the commodity aggregates Fish (03), Coffee, tea, cocoa and spices (07) or Fixed vegetable fats and oils (42). There was no significant change in the position of the commodity aggregates Meat and meat preparations (01), Vegetables and fruit (05) and Beverages (11). These categories still do not attain competitiveness. The competitiveness of the commodity aggregate Dairy products and bird eggs (02) severely deteriorated. However, the position of Russia has long-term been specific. There is a regulation from 2010, in which the Russian president approved the Food Security Doctrine of the Russian Federation. Russian Presidential Administration Doctrine of Food Security, Strategy of National Security of the Russian Federation till 2020. Nevertheless, simultaneously, sanctions were imposed against Russia in 2014 by the European Union and other countries that concern food and agricultural products. In response to the sanctions, on August 6, 2014, president Putin issued the Decree No. 560 "On Special Economic Measures to Protect Russia's Security".

Based on the above, **it can be concluded that H_0 can be rejected. Competitiveness of the monitored countries in individual commodity aggregates is currently different.**

Regarding **Tajikistan** and **Turkmenistan**, the comparison is impossible since the data for 2015 are not available. Both countries are competitive with respect to vegetables and fruit, whereas they record negative values of LFI in commodity aggregates 01, 02, 08.

While in 2000 the commodity aggregates connected with Ukraine were divided into 6 groups, in 2015 there were only 4. In 2000, the structure of its foreign trade was slightly more diversified. Cereals and cereal preparations comprise a separate group which did not possess any comparative advantage, although the value of GLI exceeded the average of all the commodity aggregates. Also, fixed vegetable fats and oils recorded a high export – import ratio. The value of LFI for the commodity aggregate Meat and meat preparations exceeded 8.

Regarding **Uzbekistan**, the commodity aggregate Vegetables and fruit occupies a specific position. In both monitored years this

Tab. 4: Division of products according to their characteristics (2015)

2015	Group I		Group II		Group III		Group IV		Group V	
	02, 12, 41	LFI < average, GII > average	00, 01, 03, 07, 08, 09, 42, 43	all indicators are low	05, 11	LFI > 10, coverage of import very low	04, 06	negative LFI, very low GII, coverage of import very high	06	high coverage of import and low GII
AZ	00, 02, 03, 41, 43	all indicators < average	04, 12	LFI is lower than -14	01, 07, 08, 09, 11, 42	GII > average, coverage of import < average, LFI very low	05	LFI = 27, very low GII and coverage of import	06, 07, 08, 41	LFI below average, GII low
BE	00, 01, 42, 43	GII and import below average	02	LFI and coverage of import above average	03	all indicators above average	04, 05, 09, 11, 12	LFI negative, GII above average		
GE	00, 01, 03, 05, 08	GII > 0.6, coverage of import < average	11	very high LFI	02, 04, 06, 07, 09, 41, 43	GII < average, low LFI	04, 42	low LFI and GII, high coverage of import	12	very high coverage of import
KZ	00, 03, 06, 11	negative LFI and average GII	01, 07, 09, 42	negative LFI, GII below average, low coverage of import	02, 05	lowest LFI, GII and coverage of import	S-04	LFI above average, highest coverage of import	08, 12, 41, 43	LFI and GII above average, coverage of import below average
KG	00, 09, 11	negative LFI and average GII	01	positive LFI, very low GII, very high coverage of import	02	high LFI, GII above average, very low coverage of import	S-03, 06, 07, 08, 12, 41, 42, 43	negative LFI, low GII, coverage of import below average	04	all indicators very low
MO	00, 03, 04, 07, 08, 09, 41, 43	very low coverage of import	06, 12	high coverage of import	02, 05	high GII and low coverage of import	11, 42	--	01	very high coverage of import and GII
RU	04, 07, 08, 09, 41	LFI and coverage of import > average	00, 01, 03, 05, 06, 11	GII > average, coverage of import < average	02	all indicators < average	12, 43	LFI > average, coverage of import very high	42	very high coverage of import and LFI
UA	07, 11, 12	LFI and cover of import < average	00, 01	very high coverage of import	02, 06, 08, 41, 42	LFI > average, GII < average	03, 04, 05, 09, 43	GII > average, coverage of import < average – but still high		
UZ	01, 02, 03, 04, 08, 09, 41, 42, 43	all indicators < average	11, 12	LFI and GII > average, cover of import < average	00, 07, 06	GII > average	05	very high LFI and coverage of import		

Source: own based on UN COMTRADE data

Note: Data for Tj a TR are missing, Kyrgyzstan – group VI – S 0-5 - highest LFI and GII

Tab. 5: Division of products according to their characteristics (2000)

2000	Group I		Group II		Group III		Group IV		Group V	
	00, 01, 08, 42, 43	negative LFI, very low GLI and coverage of import	02, 03, 05, 06, 07, 09	GLI > average but still low, coverage of import < average	04	Lowest LFI, very low GLI	12	highest GLI	11	LFI 40, coverage of import > average
AZ	00, 01, 02, 03, 06	LFI < average	04	LFI = -25	05, 08, 43	LFI and coverage of import > average, GLI < average	07, 09, 11, 12, 42	GLI > average		
BE	03, 04, 08, 12, 41, 42, 43	LFI very low, coverage of import < average	05, 07, 09, 11	GLI > average, coverage of import < average	00, 01, 02, 06	high coverage of import				
GE	01, 09, 12	GLI > 0.9, LFI < 0	00, 02, 03, 05, 06, 07, 08, 41, 42, 43	GLI lower than 0.3	04	LFI very low, GLI > average	11	very high coverage of import		
KZ	07, 08, 09, 42, 43	negative LFI	01, 02	all indicators < average	00, 05, 06, 11	GLI > average	04	very high LFI and coverage of import		
KG	07, 08, 09, 11	LFI and coverage of import < average	01, 03, 41, 42	all indicators < average	04	LFI = -8	00, 02, 06, 43	GLI > average	05, 12	LFI and coverage of import > average
MO	03, 05, 41, 42	GLI < average	00, 04, 07, 12, 43	LFI and coverage of import < average	02, 06, 08, 09	GLI > average, LFI and coverage of import < average	01	high coverage of import	11	very high coverage of import
RU	02, 04, 06, 07, 42	LFI > average, coverage of import < average	00, 08, 43	LFI > average but < 1	03, 09	all indicators > average	01, 11, 12, 41	LFI negative	05	LFI = 6.8
TJ	01, 02, 03, 06, 08, 42	LFI negative	07, 09, 11	LFI and coverage of import < average	12	high coverage of import	00, 43	LFI < 1, coverage of import < average	05	very high LFI and coverage of import
TR	00, 01, 02, 04, 07, 08, 09, 11, 12	LFI < 0	06	coverage of import > average	43, 03	LFI and GLI > average	05	very high LFI		
UA	02, 06, 07, 12, 41, 43	LFI > average, coverage of import high	01	LFI higher than 8	08, 09, 11	GLI > average, LFI and coverage of import < average	00, 03, 05	negative LFI	04	negative LFI and GLI > average
UZ	01, 03, 08, 11, 12	GLI and coverage of import < average	04	all indicators < average	00, 02, 09, 42	GLI > average, LFI negative	06, 07, 43	LFI negative, coverage of import < average	05	very high coverage of import

Source: own processing based on UN COMTRADE data

Note: UA – also has group VI that includes commodity group S-42 with very high coverage of import

aggregate records a high value of coverage of import and LFI. Whereas in 2000 Uzbekistan's structure was more diversified, a significant change occurred in 2015 when all indicators for 9 commodity aggregates reach values below average of individual indicators. It might be stated that only few aggregates improve their positions.

Based on the results of the cluster analysis (Tab. 4 and Tab. 5), it can be concluded that *H1* does not reflect the reality since there are significant changes within the structure of the groups consisting of the monitored commodity aggregates.

When only a comparative advantage or a competitive advantage of the monitored commodity aggregates is considered (in the matrix of 10 countries x 15 aggregates), it might be stated that, in comparison with 2000, the

position of 6 aggregates improved in 2015 as these were placed in the 1st quadrant.

On the contrary, a deterioration in the position is evident in 15 aggregates (a combination of aggregate x country) which were excluded from the 1st quadrant. The 3rd quadrant contains the largest number of countries with no comparative advantage and no competitiveness. Unless Turkmenistan and Tajikistan are considered, deterioration in the position occurred in 10 aggregates.

The monitored countries continuously record the highest values of comparative advantages and competitiveness in group 05 – Vegetables and fruit. In four of these (RU, TJ, TR, UZ), these aggregates comprised a separate group in 2000, whereas in 2015 this concerned mere 2 countries (AZ, UZ).

Tab. 6: Hypothesis test summary – comparison of commodity group

Com.	00	01	02	03	04	05	06	07	08	09	11	12	41	42	S43
RCA	0.51	0.26	0.65	0.86	0.01	0.01	0.29	0.96	0.72	0.58	0.14	0.29	0.35	0.86	0.88
LFI	0.06	0.31	0.27	0.10	0.07	0.03	0.81	0.58	0.94	0.75	0.31	0.70	0.96	0.88	0.16

Source: own

Note: Asymp. Sig. (2-tailed), the significance level is 0.05

A comparison of the values of RCA and LFI in the period of 2000–2015 indicates that the null hypothesis can be rejected (Tab. 6) only in two cases concerning RCA – the commodity aggregate 04 – Cereals and cereal preparations and 05 – Vegetables and fruit, and in one case concerning LFI (again, Vegetables and fruit); the median value of the difference between two variables equals 0. In the remaining cases, the value exceeds 0.05, therefore the null hypothesis cannot be rejected. It is thus impossible to reject hypothesis *H1*. It might therefore be stated that there is no significant difference in the competitiveness between the monitored years for the given commodity aggregates with the exception mentioned above.

5. Discussion

When comparing years 2000 and 2015, a higher degree of individual countries'

interconnectedness is evident, mainly of those linked to Russia. This has been observed by Myant and Drahokoupil (2008). Concurrently, the structure of individual countries' foreign trade gradually changes. Closer connectedness between individual geographical units is evident. Contrary to 2000, there has been a significant shift in trade towards EU by Georgia, for instance, rather than towards Russia and other post-Soviet republics (Jenish, 2013). In terms of economic openness, it could be stated that Tajikistan and Uzbekistan rank among the countries closest to autarchy in 2015. Similar conclusions have also been drawn by Bose (2005), Cameron et al. (2012) and Korosteleva (2016) who add that the export structure of these countries is also problematic.

It seems that the post-Soviet countries are losing their competitive advantage although, for example, Russia is still exporting large volumes of its production. However, this trend can have

a negative impact on the entire economic situation in the future not only in the Russian Federation, but in all the post-Soviet republics. Its basic manifestation is overall deterioration of competitiveness, which will be manifested in the decline of terms of trade. Similar conclusions, reflected in the overall deterioration of the economic situation, have been supported by (Idrisov, Ponomarev, & Sinelnikov-Murylev, 2016) as well. Simultaneously, depending on the production focus and the degree of processing it is evident that, with the higher degree of aggregation, agricultural products along with natural raw materials comprise nearly 46% of the overall trade. There is a concurrent increase in the proportion of agricultural products. The trend is connected with the improving self-sufficiency of the Russian Federation in food production. However, it can be manifested again in the deterioration of economic prospects or, as (Belke, Dreger, & Dubova, 2019) remonstrate, in an impaired reaction to economic shocks.

Although in the case of the majority of the commodity aggregates Russia represents a country which possesses a comparative and competitive advantage, its position is fairly weak regarding Vegetables and fruit. The value of LFI in 2000 is the lowest in all the monitored countries and the second lowest in 2015. The value of RCA is also nearly the lowest in the monitored period.

Dairy products significantly contribute to the agrarian foreign trade of the post-Soviet countries. Russia and Kazakhstan are among the key players, although none of them occupy a clear position consisting of LFI and RCA values. However, in the case of Russia, these represented an important export commodity before the introduction of the sanctions (Erokhin, Heijman, & Ivolga, 2014). At the same time, it was a well-protected sector of Russian agricultural trade in the past (Wegren, 2005). As regards LFI, a significant decline in the position in 2015 is evident, which is influenced by the economic sanctions and by the increase of home production consumption. In the period before imposing the sanctions, the value of LFI was the third highest in the group of the monitored countries, after Belarus and Ukraine. This position was affected by high profitability of Russian dairy industry (Špička & Kontsevaya, 2016).

Since this matter is still topical, there has not been a sufficient theoretical base which

could be proceeded. Similarly, it is not possible to really utilize the examples of the sanctions already imposed on other countries (Erokhin, 2015; Haidar, 2017), since this concerns a strong economic player with significant international transactions. The economic relationship of Russia with the former Soviet Union countries is a significant factor related to the possible impact of the sanctions on the Russian Federation. At the beginning of the monitored period and before the start of the war, the Ukrainian position was improving, which corresponds with the conclusions drawn by (Qineti, Rajcaniova, & Matejkova, 2009). (Fal'tsman, 2014; Pokrivcak, van Berkum, Drgova, Mraz, & Ciaian, 2013) have discovered that, apart from the EU countries, the former post-Soviet countries were the most important business partners for Russia. These countries represent a potential source of income for Russia and mutually form an interconnected trading bloc. (Khorana & Martínez-Zarzoso, 2019) state that if the states trade within the existing regional bloc, their trade is 3x greater than in other countries.

Conclusions

Agrarian foreign trade represents an important source of income for the monitored countries. The commodity aggregate 0 – Food and live animals (one-digit) records a continuously growing trend. The development of the proportion of other aggregates is permanent without any significant changes. When categorizing into a two-digit code, the commodity aggregate 02 – Dairy products and eggs contributes to export at the greatest extent. During the monitored period, an increase by 6 percentage points occurred, also 04 – Cereals and cereal preparations (with a 4-percentage point increase). Contrariwise, 06 – Sugar, sugar preparations and honey and 11 – Beverages recorded a decrease.

RCA and LFI indexes were used in order to evaluate the position of the countries on international markets. A comparative advantage and competitiveness of these countries was evaluated using these indexes. As regards RCA, the position of the commodity aggregate 04 – Cereals and cereal preparations and 05 – Vegetables and fruit changed between 2000 and 2015. No changes were recorded in regard to the remaining aggregates. By applying the test to LFI a change in the

commodity aggregate 05 – Vegetables and fruit was confirmed. These aggregates recorded a change in competitiveness. No changes were confirmed in the remaining aggregates. Despite these partial changes, based on the conducted tests, it is not possible to clearly reject the hypothesis connected with the changes in the competitiveness of the majority of the monitored commodity aggregates.

Based on the division of individual commodity aggregates into quadrants that define their position within competitiveness and comparative advantage when comparing years 2000 and 2015, it can be concluded that there are significant differences between the monitored countries. Russia is the country with the largest number of variables included in the 1st quadrant, which represented the most competitive products, with 9 or 8 aggregates in the monitored years. Armenia, Kyrgyzstan or Tajikistan are on the opposite side. It is thus possible to reject H_0 that the competitiveness of the monitored countries in individual commodity aggregates is currently similar.

The cluster analysis enabled division of individual commodity aggregates for the monitored countries into groups based on the values of GLI, LFI and coverage of import/export. Subsequently, these groups of commodity aggregates were characterized for individual countries. Based on the conducted analyses, it might be stated that H_1 about the non-existence of significant changes within the group structure does not reflect the reality. Between 2000 and 2015, there were considerable changes in the division of commodity aggregates into groups formed according to their common characteristics as part of foreign trade.

The diversity of the foreign trade between 2000 and 2015 also decreased as more commodity aggregates attain values around or below average of a particular aggregate. Regarding the intra-industry trade, it could be stated that some commodity aggregates could be regarded as important in relation to the post-Soviet countries' market only in the case of Azerbaijan, Russia, Belarus, Kazakhstan and Ukraine. This phenomenon occurs most frequently in the commodity aggregates Beverages or Vegetables and fruit.

Acknowledgement: This paper was supported by the Grant Agency at the Faculty of

Economics and Management, Czech University of Life Sciences Prague: Economic specifics of the post-Soviet countries [no. 20181018] and by Ministry of Agriculture NAZV Duality in the Czech Agriculture [QK1920398].

References

- Azizov, U. (2017). Regional integration in Central Asia: From knowing-that to knowing-how. *Journal of Eurasian Studies*, 8(2), 123–135. <https://doi.org/10.1016/j.euras.2017.02.002>
- Balassa, B. (1965). Trade Liberalisation and Revealed Comparative Advantage. *The Manchester School*, 33(2), 99–123. <https://doi.org/10.1111/j.1467-9957.1965.tb00050.x>
- Balassa, B. (1977). 'Revealed' Comparative Advantage Revisited: An Analysis of Relative Export Shares of the Industrial Countries, 1953–1971. *The Manchester School*, 45(4), 327–344. <https://doi.org/10.1111/j.1467-9957.1977.tb00701.x>
- Belke, A., Dreger, C., & Dubova, I. (2019). On the exposure of the BRIC countries to global economic shocks. *World Economy*, 42(1), 122–142. <https://doi.org/10.1111/twec.12674>
- Benešová, I., Maitah, M., Smutka, L., Tomšík, K., & Ishchukova, N. (2017). Perspectives of the Russian agricultural exports in terms of comparative advantage. *Agricultural Economics (Czech Republic)*, 63(7), 318–330. <https://doi.org/10.17221/344/2015-AGRICECON>
- Benešová, I., Novotná, Z., Šánová, P., & Laputková, A. (2016a). Agriculture of the post-Soviet countries. In L. Smutka (Ed.), *Agrarian Perspectives XXV. Global and European Challenges for Food Production, Agribusiness and the Rural Economy, Proceedings of the 25th International Scientific Conference, 14–16 September 2016, Prague, Czech Republic* (pp. 41–50). Prague: Czech University of Life Sciences Prague.
- Benešová, I., Novotná, Z., Šánová, P., & Laputková, A. (2016b). Economic Comparison of Agricultural Sector of Eurasian Countries – Is There Any Potential for Development Through Economic Cooperation? *AGRIS On-Line Papers in Economics and Informatics*, 8(2), 19–31. <https://doi.org/10.7160/aol.2016.080202>
- Benešová, I., Smutka, L., & Laputková, A. (2019). Specifics of the Mutual Trade of the Post-Soviet Countries. *Entrepreneurial Business and Economic Review*, 7(1), 29–43. <https://doi.org/10.15678/EBER.2019.070102>

- Bildirici, M. E., & Kayikçi, F. (2013). Effects of oil production on economic growth in Eurasian countries: Panel ARDL approach. *Energy*, 49, 156–161. <https://doi.org/10.1016/j.energy.2012.10.047>
- Bose, N. (2005). Endogenous growth and the emergence of equity finance. *Journal of Development Economics*, 77(1), 173–188. <https://doi.org/10.1016/j.jdeveco.2004.03.005>
- Buja, A., & Swayne, D. F. (2002). Visualization Methodology for Multidimensional Scaling. *Journal of Classification*, 19(1), 7–43. <https://doi.org/10.1007/s00357-001-0031-0>
- Cameron, D. R. et al. (2012). Post-Soviet Authoritarianism: The Influence of Russia in Its “Near Abroad”. *Post-Soviet Affairs*, 28(1), 1–44. <https://doi.org/10.2747/1060-586X.28.1.1>
- Cavalcanti, T. V. de V., Mohaddes, K., & Raissi, M. (2011). Growth, development and natural resources: New evidence using a heterogeneous panel analysis. *The Quarterly Review of Economics and Finance*, 51(4), 305–318. <https://doi.org/10.1016/j.qref.2011.07.007>
- Cavoli, T. (2012). Exploring dimensions of regional economic integration in East Asia: More than the sum of its parts? *Journal of Asian Economics*, 23(6), 643–653. <https://doi.org/10.1016/j.asieco.2012.07.001>
- Chiaruttini, M. S. (2014). *EU, Russia and the Reshaping of the Post-Soviet Space: An International Trade Analysis*. Paper presented at the 54th Congress of the European Regional Science Association: “Regional development & globalisation: Best practices”, 26–29 August 2014, St. Petersburg, Russia.
- Commendatore, P., Kubin, I., Petraglia, C., & Sushko, I. (2014). Regional integration, international liberalisation and the dynamics of industrial agglomeration. *Journal of Economic Dynamics and Control*, 48, 265–287. <https://doi.org/10.1016/j.jedc.2014.07.011>
- Cormier, K. E. (2007). Grievance practices in post-Soviet Kyrgyz agriculture. *Law and Social Inquiry*, 32(2), 435–466. <https://doi.org/10.1111/j.1747-4469.2007.00065.x>
- Erokhin, V. (2015). Contemporary Reshaping of Eurasian Integration: Russia’s Policies and their Implication for the EU and EurAsEC. *Procedia Economics and Finance*, 22, 402–411. [https://doi.org/10.1016/S2212-5671\(15\)00313-5](https://doi.org/10.1016/S2212-5671(15)00313-5)
- Erokhin, V., Diao, L., & Du, P. (2020). Sustainability-Related Implications of Competitive Advantages in Agricultural Value Chains: Evidence from Central Asia – China Trade and Investment. *Sustainability*, 12(3), 1117–1145. <https://doi.org/10.3390/su12031117>
- Erokhin, V., Heijman, W., & Ivolska, A. (2014). Trade Tensions Between EU and Russia: Possible Effects on Trade in Agricultural Commodities for Visegrad Countries. *Visegrad Journal on Bioeconomy and Sustainable Development*, 3(2), 52–57. <https://doi.org/10.2478/vjbsd-2014-0010>
- Espinoza, R., Prasad, A., & Williams, O. (2011). Regional financial integration in the GCC. *Emerging Markets Review*, 12(4), 354–370. <https://doi.org/10.1016/j.ememar.2011.04.005>
- Fal’tsman, V. K. (2014). Evaluation of the competitiveness of Russian products in world, CIS, EAEC, and non-CIS markets. *Studies on Russian Economic Development*, 25(1), 69–76. <https://doi.org/10.1134/S1075700714010055>
- Garanina, O. (2009). What beyond oil and gas? Russian trade specialisation in manufactures. *Post-Communist Economics*, 21(1), 1–29. <https://doi.org/10.1080/14631370802663596>
- Garanina, O., & Pankki, S. (2008). *What beyond oil and gas? Russian trade specialisation in manufactures* (BOFIT Discussion Paper No. 23/2008). Helsinki: Bank of Finland.
- Geldi, H. K. (2012). Trade effects of regional integration: A panel cointegration analysis. *Economic Modelling*, 29(5), 1566–1570. <https://doi.org/10.1016/j.econmod.2012.05.017>
- Gnidchenko, A. A., & Salnikov, V. A. (2013). Dynamics of Russia’s Competitive Positions on Foreign Markets. *Studies on Russian Economic Development*, 24(6), 555–569. <https://doi.org/10.1134/S1075700713060051>
- Gnidchenko, A., & Sal’nikov, V. (2014). Price Competitiveness in Russian Foreign Trade. *Problems of Economic Transition*, 57(5), 3–36. <https://doi.org/10.2753/PET1061-1991570501>
- Grubel, H. G., & Lloyd, P. J. (1971). The Empirical Measurement of Intra-Industry Trade. *Economic Record*, 47(4), 494–517. <https://doi.org/10.1111/j.1475-4932.1971.tb00772.x>
- Guesmi, K., & Teulon, F. (2014). The determinants of regional stock market integration in middle east: A conditional ICAPM approach. *International Economics*, 137, 22–31. <https://doi.org/10.1016/j.inteco.2013.10.006>
- Haidar, J. I. (2017). Sanctions and export deflection: evidence from Iran. *Economic Policy*, 32(90), 319–355. <https://doi.org/10.1093/epolic/eix002>
- Hale, H. E. (2010). Eurasian politics as hybrid regimes: The case of Putin’s Russia.

- Journal of Eurasian Studies*, 1(1), 33–41. <https://doi.org/10.1016/j.euras.2009.11.001>
- Hale, H. E. (2011). The Myth of Mass Russian Support for Autocracy: The Public Opinion Foundations of a Hybrid Regime. *Europe-Asia Studies*, 63(8), 1357–1375. <https://doi.org/10.1080/09668136.2011.601106>
- Hare, P., Estrin, S., Lugachyov, M., & Takla, L. (1998). Russia's Foreign Trade: New Directions and Western Policies. *The World Economy*, 21(1), 95–119. <https://doi.org/10.1111/1467-9701.00121>
- Havránek, T., Horváth, R., & Zeynalov, A. (2016). Natural Resources and Economic Growth: A Meta-Analysis. *World Development*, 88, 134–151. <https://doi.org/10.1016/j.worlddev.2016.07.016>
- Horváth, R., & Zeynalov, A. (2014). *The natural resource curse in post-soviet countries: The role of institutions and trade policies* (IOS Working Paper No. 341). Regensburg: Institut für Ost- und Südosteuropaforschung. Retrieved from <http://nbn-resolving.de/urn:nbn:de:101:1-2014070810451>
- Iapadre, P. L. (2001). Measuring international specialization. *International Advances in Economic Research*, 7(2), 173–183. <https://doi.org/10.1007/BF02296007>
- Ildrisov, G., Ponomarev, Y., & Sinelnikov-Murylev, S. (2016). Terms of trade and Russian economic development. *Russian Journal of Economics*, 2(3), 279–301. <https://doi.org/10.1016/J.RUJE.2016.09.002>
- Jenish, N. (2013). *Regional Trade and Economic Growth in the CIS Region* (Working Paper No. 13). Bishkek: Institute of Public Policy and Administration.
- Ke, S. (2015). Domestic market integration and regional economic growth – China's recent experience from 1995–2011. *World Development*, 66, 588–597. <https://doi.org/10.1016/j.worlddev.2014.09.024>
- Khorana, S., & Martínez-Zarzoso, I. (2019). Twenty-First-Century Trade Governance: Findings From the Commonwealth Countries. *Contemporary Economic Policy*, 38(2), 380–396. <https://doi.org/10.1111/coep.12450>
- Korosteleva, E. A. (2016). The European Union and Belarus: Democracy promotion by technocratic means? *Democratization*, 23(4), 678–698. <https://doi.org/10.1080/13510347.2015.1005009>
- Kumar, S., Sen, R., & Srivastava, S. (2014). Does economic integration stimulate capital mobility?? An analysis of four regional economic communities in Africa. *Journal of International Financial Markets, Institutions and Money*, 29, 33–50. <https://doi.org/10.1016/j.intfin.2013.11.001>
- Kutlina-Dimitrova, Z. (2017). The economic impact of the Russian import ban: a CGE analysis. *International Economics and Economic Policy*, 14(4), 537–552. <https://doi.org/10.1007/s10368-017-0376-4>
- Lafay, J. (1992). The Measurement of Revealed Comparative Advantages. In M. G. Dagenais & P. A. Muet (Eds.), *International Trade Modeling* (pp. 209–234). London: Chapman and Hall.
- Laursen, K. (2015). Revealed comparative advantage and the alternatives as measures of international specialization. *Eurasian Business Review*, 5(1), 99–115. <https://doi.org/10.1007/s40821-015-0017-1>
- Lerman, Z. (2009). Land reform, farm structure, and agricultural performance in CIS countries. *China Economic Review*, 20(2), 316–326. <https://doi.org/10.1016/j.chieco.2008.10.007>
- Libman, A. (2007). Regionalisation and regionalism in the post-Soviet space: Current status and implications for institutional development. *Europe-Asia Studies*, 59(3), 401–430. <https://doi.org/10.1080/09668130701239849>
- Libman, A., & Vinokurov, E. (2018). Autocracies and regional integration: the Eurasian case. *Post-Communist Economies*, 30(3), 334–364. <https://doi.org/10.1080/14631377.2018.1442057>
- Linn, J. (2012). Central Asian Regional Integration and Cooperation: Reality or Mirage? In *EDB Eurasian Integration Yearbook 2012* (1st ed., pp. 96–117). Almaty: Eurasian Development Bank.
- Malle, S. (2012). The Policy Challenges of Russia's Post-Crisis Economy. *Post-Soviet Affairs*, 28(1), 66–110. <https://doi.org/10.2747/1060-586X.28.1.66>
- Mazhikeyev, A., & Edwards, T. H. (2013). *Central Asian Trade Relations in the Post-Soviet Era* (Discussion Paper Series 2013_02). Loughborough: Loughborough University. Retrieved from <http://www.etsg.org/ETSG2013/Papers/126.pdf>
- Mazhikeyev, A., Edwards, T. H., & Rizov, M. (2015). Openness and isolation: The trade performance of the former Soviet Central Asian countries. *International Business Review*,

24(6), 935–947. <https://doi.org/10.1016/j.ibusrev.2015.03.001>

Minniti, A., & Parello, C. P. (2011). Trade integration and regional disparity in a model of scale-invariant growth. *Regional Science and Urban Economics*, 41(1), 20–31. <https://doi.org/10.1016/j.regsciurbeco.2010.07.003>

Myant, M., & Drahokoupil, J. (2008). International Integration and the Structure of Exports in Central Asian Republics. *Eurasian Geography and Economics*, 49(5), 604–622. <https://doi.org/10.2747/1539-7216.49.5.604>

Obydenkova, A., & Libman, A. (2016). *Autocratic and Democratic External Influences in Post-Soviet Eurasia*. London: Taylor and Francis.

Pokrivcak, J., van Berkum, S., Drgova, L., Mraz, M., & Ciaian, P. (2013). The role of non-tariff measures in EU dairy trade with Russia. *Post-Communist Economies*, 25(2), 175–189. <https://doi.org/10.1080/14631377.2013.787737>

Portanskii, A. (2012). Russia and the World Trade Organization. *Problems of Economic Transition*, 55(1), 63–77. <https://doi.org/10.2753/PET1061-1991550106>

Qineti, A., Rajcaniova, M., & Matejkova, E. (2009). The competitiveness and comparative advantage of the Slovak and the EU agri-food trade with Russia and Ukraine. *Agricultural Economics (Czech Republic)*, 55(8), 375–383. <https://doi.org/10.17221/42/2009-AGRICECON>

Rosner, B., Glynn, R. J., & Lee, M.-L. T. (2006). The Wilcoxon Signed Rank Test for Paired Comparisons of Clustered Data. *Biometrics*, 62(1), 185–192. <https://doi.org/10.1111/j.1541-0420.2005.00389.x>

Rueda-Junquera, F. (1998). Regional integration and agricultural trade in Central America. *World Development*, 26(2), 345–362. [https://doi.org/10.1016/S0305-750X\(97\)10038-9](https://doi.org/10.1016/S0305-750X(97)10038-9)

Salnikov, V. A., Gnidchenko, A. A., & Galimov, D. I. (2016). Industry-level effects from integration between Russia, Belarus and Kazakhstan through industrial cooperation. *Studies on Russian Economic Development*, 27(1), 101–113. <https://doi.org/10.1134/S1075700716010123>

Spechler, M. C., & Spechler, D. R. (2013). Russia's lost position in Central Eurasia. *Journal of Eurasian Studies*, 4(1), 1–7. <https://doi.org/10.1016/j.euras.2012.08.001>

Špička, J., & Kontsevaya, S. R. (2016). Differences of Financial Management Strategy of Central European and Russian Milk Processors. *AGRIS On-Line Papers in Economics and Informatics*, 8(1), 89–102. <https://doi.org/10.7160/aol.2016.080109>

Torgerson, W. S. (1952). Multidimensional scaling: I. Theory and method. *Psychometrika*, 17(4), 401–419. <https://doi.org/10.1007/BF02288916>

Ward, J. H. J. (1963). Hierarchical Grouping to Optimize an Objective Function. *Journal of American Statistical Association*, 58(301), 236–244. <https://doi.org/10.1080/01621459.1963.10500845>

Weber, G. (2003). Russia's and Kazakhstan's agro-food sectors under liberalized agricultural trade: a case for national product differentiation. *Economic Systems*, 27(4), 391–413. <https://doi.org/10.1016/j.ecosys.2003.11.002>

Wegren, S. K. (2005). Russian Agriculture during Putin's First Term and Beyond. *Eurasian Geography and Economics*, 46(3), 224–244. <https://doi.org/10.2747/1538-7216.46.3.224>

Yun, Y., & Park, K. (2012). An Analysis of the Multilateral Cooperation and Competition between Russia and China in the Shanghai Cooperation Organization: Issues and Prospects. *Pacific Focus*, 27(1), 62–85. <https://doi.org/10.1111/j.1976-5118.2012.01076.x>

TECHNOLOGICAL AND ORGANIZATIONAL INNOVATION IN WAREHOUSING PROCESS – RESEARCH OVER WORKLOAD OF STAFF AND EFFICIENCY OF PICKING STATIONS

Izabela Kudelska¹, Rafał Niedbał²

¹ Poznan University of Technology, Faculty of Engineering Management, Poland, ORCID: 0000-0002-8717-4315, izabela.kudelska@put.poznan.pl;

² Czestochowa University of Technology, Faculty of Management, Poland, ORCID: 0000-0001-6898-8818, rafal.niedbal@pcz.pl.

Abstract: In their response to the necessity to meet the demands of customers, the enterprises are forced to reduce the time of order delivery. Today, almost every enterprise has its own warehouse facilities or outsources warehouse processes. Therefore, the contemporary warehouses play a significant role in production and service networks. The maintenance of high efficiency of warehouse processes determines the competitive functioning of enterprises. Continuous progress in this area sets the pace for these changes. Nevertheless, despite of the desire to reduce costs while increasing the efficiency of the warehouse process, you cannot forget about employees. In addition to efficiency and the level of generated costs, a warehouse employee is one of the factors that not only affects the shape of the logistics system in an enterprise, but also affects all links in the supply chain. This study is intended to research the impact of technological and organizational innovation implemented in the warehousing process on the efficiency of picking processes and staff workload on picking stations. The research was performed with warehouse simulation models developed in FlexSlim 3D Simulation Software. The simulated warehouses represent the warehouses in B2C (Business to Customer) logistics. They are about the layout of bag-type warehouse and the size and shape of the assortment varies. The size of storage zone is the same for all three warehouses. In these warehouses the assortment is arranged randomly. For each model, several simulations have been performed. The conducted research has shown that the results of technological and organizational innovation implemented in the warehousing process should be in general evaluated positively. Both the warehouse productivity and the picking process efficiency increased. The staff workload decreased, which is reflected in greater work comfort for a man and which supports implementation of control activities. However, it should be noted that implementation of the technological and organizational innovation in the warehousing processes adopted in various enterprises changes the labor market, thus it is possible that some problems with maintaining current employment levels will occur.

Keywords: Warehousing, order-picking, automation, simulation, innovation, labor productivity.

JEL Classification: C63, D24, O33, J21.

APA Style Citation: Kudelska, I., & Niedbał, R. (2020). Technological and Organizational Innovation in Warehousing Process – Research over Workload of Staff and Efficiency of Picking Stations. *E&M Economics and Management*, 23(3), 67–81. <https://doi.org/10.15240/tul/001/2020-3-005>

Introduction

Contemporary enterprises operate on a highly competitive market. Turbulent environment

and individual needs of consumers cause that plenty of enterprises cooperate with other organizations within a supply chain. The above

conditions determine the need for the managers to make effective logistics decisions.

Over the last few years, the enterprises faced some high cost pressures in numerous industries. Therefore, they started reorganizing and improving logistics process in order to allow further reduction in operating expenses. A demanding customer and shorter economic life-time increase the demand for flexible and fast deliveries (Grosse & Glock, 2013). Enterprises introduce changes and seek saving also in the area of warehousing.

Warehouses pose some important links in an enterprise. They determine places where goods are deposited and stored in a given supply chain link, until they are released. Warehouses as defined by Shah and Khanzode (2017) are a kind of buffer which serves to store goods between processes carried out in enterprises and between the enterprises themselves, thus allowing continuous movement of goods. Today's warehouses should be characterized with quick implementation of warehousing processes, first of all the picking and warehouse issue stages.

Enterprises invest in new technologies and digitalization which leads to increased automation in a warehouse. Robots start to do such operations as packing or shelf-stacking. However, the use of automation and robotization in warehousing processes in contemporary enterprises should be generally assessed as unsatisfactory. An example of such a state of affairs may be the research results obtained by St. Onge Company from the USA – dealing with engineering consultancy (Bonkenburg, 2016). The research carried out by the company among its own customers confirm a low degree of automation and robotization in warehousing processes. As many as 80% of warehouses do not use any process automation. There is mechanization in 15% of warehouses – these are first of all solutions adopted in the field of conveyors, sorters and equipment that support the picking of the ordered goods. Only 5% of the warehouses are automated, but they still have employees hired to hold the key functions. Examples of use of automation and robotization in warehousing processes are: unloading and loading robots, transport warehouse robots, stationary and mobile warehouse robots. Warehouse automation systems are most often based on implementation of tools allowing for remote control of warehouse vehicles (Sosnowski, 2017).

Along with the concept of the warehousing processes automation, new solutions support the implemented processes (e.g. introduction of cooperating robots) – which in the long run also results in a return on invested capital, elimination of bottlenecks, etc. Improperly implemented storage processes may result in inefficient use of the organization's resources. This may generate some delays in deliveries to the client and as a result leads to a deteriorated customer service level.

Managing warehouse facilities and processes in the warehouse is a big challenge for managers. This requires skills and trade-offs between increasing throughput and lowering labor costs, increasing picking speed and accuracy of tasks.

The purpose of this study, which is to attempt to answer the below questions, was formulated while realizing the importance of the warehousing processes and their automation for an enterprises and whole supply chains, and taking into account the results of automation for enterprises and the society:

1. *Will the introduction of a technological and organizational innovation in a warehouse improve the picking process efficiency?*
2. *How will the staff workload and demand for workers change after introducing the technological and organizational innovation in the picking process?*

Research of scientists covers primarily the area related to the speed of introduced innovations, or covers the area related the impact of innovations on the company. Whereas our research involves the impact of innovation on warehouse workers in the picking process – one of the most labor-intensive and time-consuming warehouse processes. This knowledge is important because the implementation of technological and organizational innovations in this area is not always positive.

This paper presents the results of simulation tests on the efficiency of picking station and staff workload within the picking process, along with a discussion over the effects of introducing the organizational and technological innovation in a warehouse. It contributes to the literature on implementation of innovation in a warehousing process.

The paper is composed of three chapters. Chapter 1 provides an overview of related literature. Chapter 2 clarifies the way which

the warehouse models were developed, and the simulation tests were carried out in. The next chapter describes the results from the experiment, presents the discussion on the effects of implementing the innovations and attempts to answer the research questions. The last chapter sums up the paper and presents some suggestions on further research work.

1. Literature Review

Supply chain management in a global dimension is becoming important an issue for numerous enterprises. It covers the interests of suppliers all over the world as well as the focus on a local, domestic and international consumer. One process that exerts some significant impact on product quality, customer service level and global logistics costs is the warehousing process.

It includes not only physical storage but also receiving, picking and issue of goods as well as processing of necessary information regarding the warehoused goods. The warehousing also covers some organizational aspects, material carriers and equipment.

One of the most labor-intensive and time-consuming warehouse processes is picking (Franzke et al., 2017). De Koster (2007) defined the picking process as a procedure of collecting SKUs from storage areas with an intention to deliver customers' orders.

If order picking is not adequately organized, improper or damages SKUS are chosen, then implementation of the order may have negative impact on the customer satisfaction (Gue, Meller, & Skufca, 2006; Parikh & Meller, 2009). Efficient picking processes are therefore a prerequisite for an efficient supply chain (Chen et al., 2013; Franzke et al., 2017).

A lot of work is done manually in a warehousing process. A traditional warehouse worker spends most of the time walking around a warehouse or seating while driving a means of internal transport. Moving around the warehouse they can cover a total of up to 25km during a shift (Kudelska & Pawłowski, 2019). Hence, the issues related to the picking process are still relevant and widely discussed by researchers and enterprises.

According to the research by Grosse, Glock and Neumann (2017), the greatest number of articles in this areas were recorded in the Journal of Production Research, where 30 papers of this kind were published. These

topics were also raised in such magazines as: European Journal Operational Research, IIE Transactions, Computers & Industrial Engineering. The notions considered in the above-mentioned works first of all included the research on designing and managing the picking process (Kudelska & Pawłowski, 2019).

Gu, Goetschalckx and McGinnis (2007, 2010) provided a broad review and assessment of the picking processes performance – including route allocation. De Koster, Le-Duc and Roodbergen (2007) presented a planning approach that can ensure efficient warehouse process management.

One of the most significant topics raised in the literature is development of planning procedures that will help reduce the travel time of a worker picking an order. Strategies for 'S-shape' and 'Return' have been developed (Petersen & Aase, 2004; Theys et al., 2010). Petersen, Siu and Heiser (2005), De Koster, Le-Duc and Roodbergen (2007) and Gu, Goetschalckx and McGinnis (2010) explored how to deploy goods to reduce the time needed for order picking. The criterion of demand frequency was used in the above cases. In the meantime, Glock and Grosse (2012) considered the correlation of demand in allocation of products. Some authors like: Kovacs (2011), Chackelson et al. (2013), or Battini et al. (2015, 2016) used the class-based method of storage, which divides products into groups, which are afterwards stored in dedicated areas of the warehouse. However, storage in a given area is random.

Also the indicators of efficiency measurements in a warehouse were researched. In their paper, Staudt et al. (2015) pointed to four basic indicators of efficiency in a warehouse, namely the time, quality, cost of labor and efficiency.

Another important researched aspect in a warehouse is inventory control and proper warehouse management which is reflected in the enterprise's success. It is therefore so important to measure the warehouse efficiency based on organizational strategies. Effective performance measurement systems go beyond the history of reporting and improve future operations (Gunasekaran, Marri, & Menci, 1999).

The Lean topics were also undertaken in the field of warehousing. Ackerman (2007) studied the storage process from a Lean

perspective. Sharma and Shah (2016) presented the Lean Manufacturing model for performance assessment. Shah and Khanzode (2017) presented an approach to support the Lean Thinking strategy in designing rules for allocating heterogeneous loads in order to improve material flow.

Furthermore, an analysis of the literature of the subject also revealed some topics related to technological and organizational innovation. Baker and Halim (2007) raised the notion of exploring the warehouse automation implementations (costs and flexibility), using the survey questionnaire and interviews, but only with a selected group of enterprises. E-commerce warehouses also use AGVs (Automated Guided Vehicle). Such solutions have some restriction related to space or traffic management (collisions, congestion). Therefore, Yan, Zhang and Qi (2017) proposed some control principles and strategies to improve the efficiency of the AGV system. Innovative solutions for the use of robots in a warehouse were also presented in the article by Bogue (2016). These robots have a function of collecting shelves and navigate autonomously. As for now, mobile robots play an important roles in picking activities – they navigate to a certain location, lift a given object and transport it to the packing area. QR (Quick Response) codes are used for this purpose. Such codes are located on the ground in strategic locations of the warehouse where a proper shelf must be collected, and thus the desired objective can be achieved. The work focuses on developing an efficient algorithm for planning a robot path using a QR code (Teja & Kumar, 2018; Enrigh & Wurman, 2011; Wurman, D'Andrea, & Mountz, 2008).

The literature studies prove that the discussed topics are mainly related to development of methods that reduce the transport time, distance and storage time. The work include supporting managerial decisions on financial effectiveness and performance of a warehouse. There are also issues related to the automation of warehouse processes. However, the interest in implementing automation into the warehouse is usually related only to the reasons for its application (improvement in product/service quality, increased storage capacity, improve customer service level, improve customer quality, increase in the number of served customers).

The results of implementations of innovations are treated in general terms, often analyzed through the prism of increasing the picking process efficiency.

The human factor is considered in a narrower scope as the main aspects of deliberations and research on effects of technological and organizational innovations implemented in the picking process. Works by Calzavara et al. (2019) and by Glock et al. (2019) are worth stressing here as these authors considered not only the economic but also ergonomic objectives in their research. In turn, Vujica Herzog et al. (2018) conducted a study on the effects of the use of smart glasses during the order picking process.

The contemporary technologies and innovations implemented in the area of manufacturing and warehousing process allow for both process activities capable of supporting the sensual and intellectual operations of a worker, and actuation operations capable of supporting and replacing the worker's energetic functions (Olszewski, 2016). Research in the field of innovation includes examines the relationship between external knowledge sourcing and firm innovation efficiency (Asimakopoulos, Revilla, & Slavova, 2019). Was examined the impact of foreign companies on innovative companies, e.g. in the UK (Xia & Liu, 2018) and was examined what and to what extent impact to innovation radicalness and innovation speed (Behrens & Patzelt, 2018).

However implementation of the technological and organizational innovations in the mentioned area may have negative social impact on the workers. They are related to the issue of reducing the employment – so-called technological unemployment (Rąb & Rąb, 2016). Reduction in the number of jobs may appear not only as a result of workers being replaced by machines. It is enough that machines support workers in an increasingly broader scope, improving their work performance. This fact alone makes other employees less needed (Niedbał, 2018). There is one simple argument for such solutions from the perspective of an employer – it is more cost-effective, cheaper.

Automation of the warehousing and production processes is adequate for routine operations that are carried out systematically, in particular by low-skilled workers. In the case of medium- and high-skilled workers

such a situation may emerge as well, but only when human actions become routine. Work features that contribute to replacement of a man by machines and automated systems include repeatability, algorithmization, demand for high physical strength, work in hazardous conditions. While the features that are difficult to replace are: originality, creativity, social skills, requirement for motor coordination or work in unusual conditions. However, it is stressed in the literature of the subject that our judgment on automation will change, which according to the majority is a threat only for poorly educated and low-skilled workers. Such an opinion is rooted in the fact that these persons usually perform routine and repetitive tasks. As Ford (2016) observed, the technological boundaries shift extremely fast, and currently the term 'routine work' is not a proper designation of a job endangered by technology – 'predictable work' is more accurate here.

Does the introduction of technological innovation – for example in a warehouse – means that there is a problem of technological unemployment? Matuzeviciute, Butkus and Karaliute (2017) carried out some extensive empirical studies using panel data from 25 European countries between 2000 and 2012. The studies were performed on a macroeconomic level, and the so-called Triadic Patent Family per million inhabitants was taken as a source of information about technological innovation. However, the performed studies did not show any impact of technological innovation on the increase in unemployment. As the authors of those works suggest, the research result may come from certain restrictions in measurements – among others the unemployment rate may be too broad a variable to capture the effects of technological innovations. Moreover, they believe it is hard to estimate the impact of technological innovation on unemployment at the time the innovation is being introduced, because the compensation effects may be delayed, so the research over long-term effects of innovation could be more valid.

Extensive research analyzing the impact of technological innovation on job creation was also carried out by Van Roy, Vértesy and Vivarelli (2018). In their surveys, they took into account a panel data set covering almost 20,000 patent companies from Europe between 2003 and 2012. The obtained results

suggested that the positive impact of innovation on employment is statistically significant only in manufacturing sectors of high and medium technological level. It is not relevant in the case of low-tech manufacturing and services.

Will low-skilled workers be replaced because of the introduction of automation of selected processes in an enterprise? To answer that question, Cords and Prettner (2018) developed a job search and matching model for employees, which includes two types of skills (high and low) and the capital of automation as an additional factor of production. Using this type of model, the above-mentioned authors proved that accumulation of the automation capital reduces the labor market tightness for low-skilled workers and increases it when it comes to the high-skilled employees. This leads to an increase in unemployment among people with low qualifications and a decrease in unemployment among those with high qualification. Furthermore, the automation leads to a drop in wages of low-skilled workers and an increase in wages for high-skilled employees.

In turn, Konečný (2016) presented the link between technological unemployment and an enterprise life cycle. In his opinion, enterprises that are in the growth or stabilization phases should replace human work with machines, but they should also prevent leading out the redundant workers to competition – as this would be an indirect form of support for this competition. Replacement of human work with machines is one of the most responsible and risky managerial decisions, so managers should provide it with a high priority. As noted by Konečný, preparation for the replacement of workers with machines should take about ten years.

Introduction of new machines and innovations in work organization are not the only determinants contributing to the necessity to redefine and marginalize human work from the perspective of production and service networks. It is also important to address market issues, knowledge structures, social practices and the interests of companies and corporations that stabilize technological innovation (Afeltowicz, 2007).

2. Research Method

In order to answer the research questions formulated by the authors, the research was conducted on simulation models. These models

were developed with discrete events simulation software – FlexSim 3D Simulation Software (version 18.2.2). Models of three warehouses for an enterprise were developed in order to carry out a simulation. For the sake of simplicity, it was assumed that the receipt and dispatch zone is located on one wall of the warehouse, which means that a bag-type warehouse is analyzed. The size and shape of assortment vary. There are 500 storage locations in the storage area for all warehouse models. The assortment is arranged randomly, and in the first model it is stored in shelf racks that allows their retrieval by workers without a need of using any additional devices.

This is an example of a warehouse that may belong to an operator specializing in logistics services for B2C (Business to Customer) or online stores. In this type of warehouses a key piece is a unit. Such a warehouse should be organized in a way that allows quick and easy access to the product. A simulated warehouse is a fulfillment warehouse with full service for receptions and deliveries of goods, as well as packing products in own boxes or packaging provided by the customer.

Orders for all types of warehouses were generated randomly (a source code fragment is presented in Listing 1). The system creates a picking list with a random integer value in the range from 1 to 20.

Listing 1: Source code for order picking in warehouse simulation models

```
/**Custom Code – The algorithm of generating orders for particular goods*/  
Object current = ownerobject(c);  
Object item = param(1);  
int rownumber = param(2); //row number of the schedule/sequence table  
for (int i = 1; i <= 20; i++) {  
    string a = concat(„B“, numtostring(i));  
    item.labels.assert(a).value = 0;  
}  
int b = duniform(3,6);  
for (int j = 1; j <= b; j++) {  
    int c = duniform(1,20);  
    string d = concat(„B“, numtostring(c));  
    item.labels.assert(d).value++;  
}  
item.Type = 11;
```

Source: own

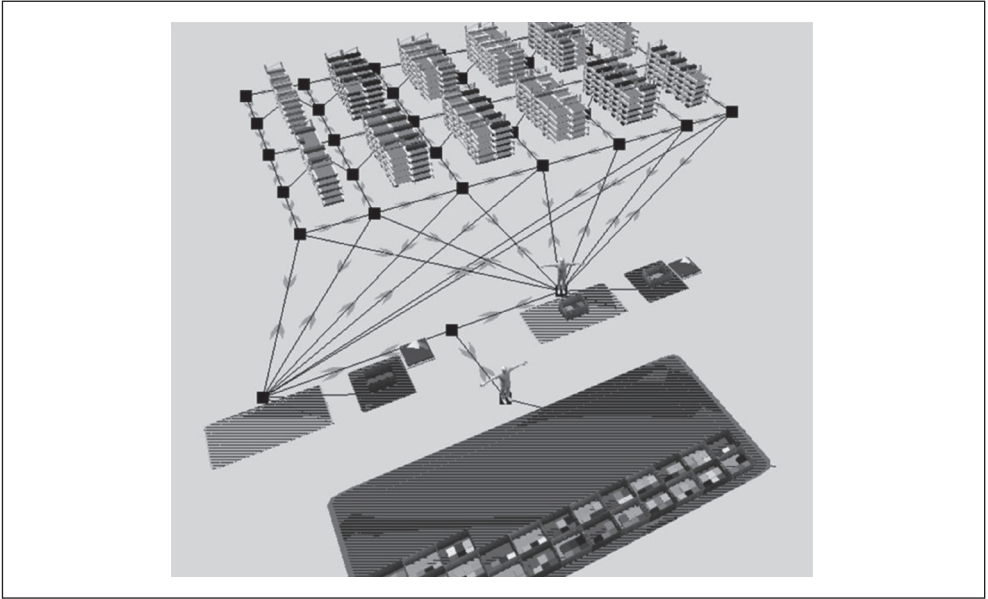
In the first warehouse presented in Fig. 1, the picking process is performed by 2 workers. Simple picking is used. It means strict order picking, 1:1, namely that an individual picking order is implemented by a single warehouse worker. This model includes a picker to part system – meaning that a worker that performs the picking must reach the storage place of the goods in order to retrieve them.

The second and third model implement technological and organizational innovation consisting in the use of 2 robots (Fig. 2). This warehouse adopts a part to picker system,

meaning that a given assortment item is moved to the picking person by means of special robots. Robots of that type used in warehouses (e.g. by Amazon) are quite simple in terms of their construction – they have a pair of wheels and a mechanism for moving shelves/racks with goods. Front and rear sensors for obstacle detection allow two-way transport. They are also equipped with a navigation system intended to search for the codes located on the ground and transport the goods to a correct place.

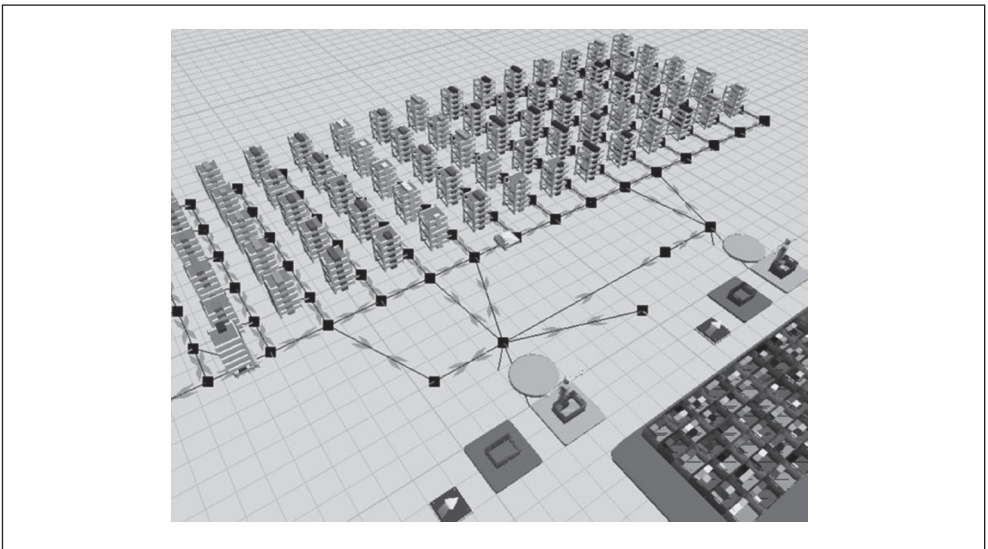
A change introduced in model second (2 workers and 2 robots) and model third (1 worker

Fig. 1: First warehouse simulation model



Source: own

Fig. 2: Second warehouse simulation model



Source: own

and 2 robots) covers four basic steps (Fig. 3) regarding the robot's operations:

1. Go from the current robot location to the current shelf location.
2. Transport the shelf from the current location to the picking station.
3. Stay in line at the station.
4. Retrieve the assortment from the shelf.
5. Transport the shelf back to the location in the storage area.

The mentioned operations are marked with numbers in Fig. 3. Having received the demand for given goods, the robot goes to a particular location. Afterwards, it 'retrieves' the shelf with the demanded goods and transports it to the picking station. When the worker picks up the goods from the shelf, the robot goes back with it to the storage area so it can be put down in a given location. In Fig. 3, the retrieved item is marked as a white square on the shelf. At the picking stations, the workers pack the goods in shipping containers/ cardboard boxes and move it to the buffer zone. One robot may transport one shelf at a time, and the shelf can 'visit' one or two picking stations.

The third model also encompasses a unit-load system, which means that a worker does not need to search for and transport unit loads necessary to pick up an order. There are still 2 robots that retrieve the shelves with products and transport them to the picking locations. However, an important aspect of this model is the number of the picking employees. The authors of the paper implemented only one picking station in this model.

The purpose of the simulations performed on models second and third is to obtain data allowing to formulate an answer for a research question considering the impact of robots operating in the picking process on staff workload and the demand for the number of employees.

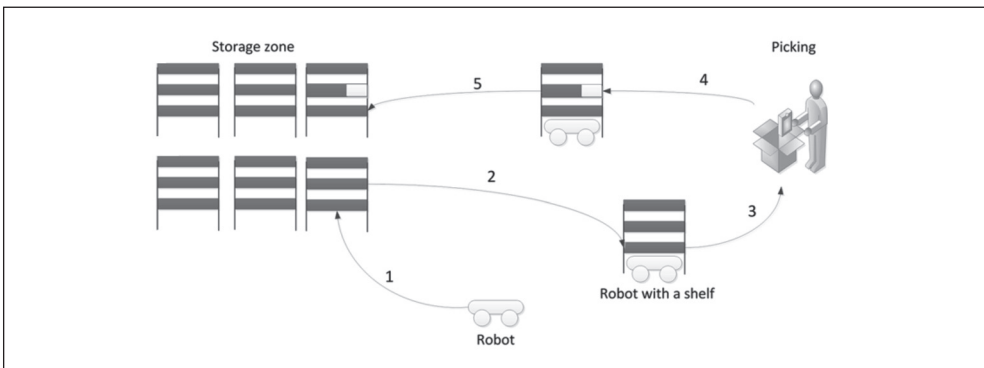
3. Simulation Results – Discussion

The simulation on individual models was performed for several initial samples, which included a different distribution of the location of goods and a different distribution of the demand for goods. These trials allowed to generate results regarding the station and worker workload in particular models.

This allowed to check which solution improves effectiveness of picking operations. Authors understand the warehouse management effectiveness as results of the operation in given technical and organizational conditions, intended to minimize the resources involved in implementation of tasks within assumed objectives. The measurement of effectiveness was the warehouse productivity presented as a relation of the number of picking orders to the number of devoted man-hours.

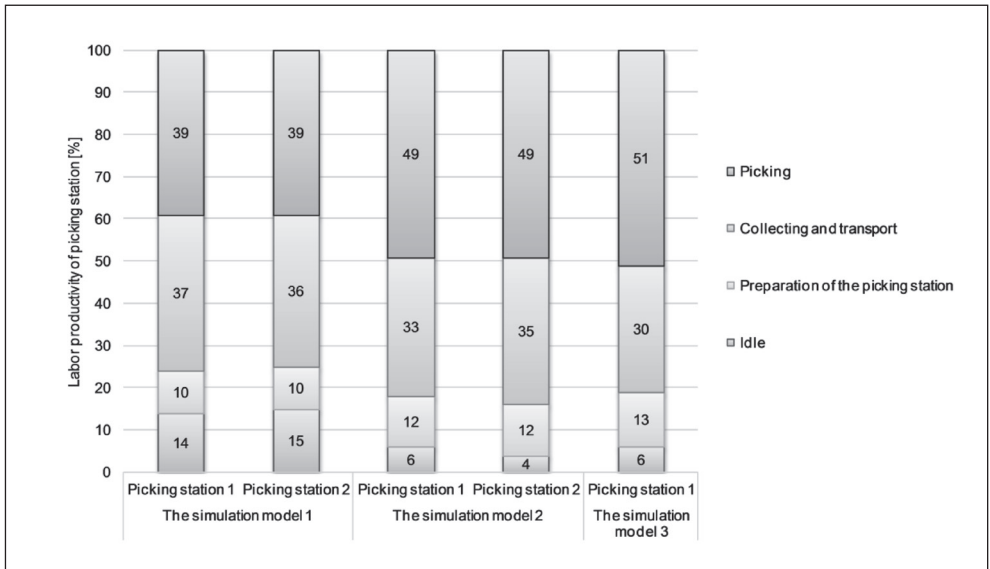
The results of the simulation experiment are presented in Fig. 4, which shows the efficiency of picking stations in all models. Four components of a station efficiency were measured: picking process, waiting for necessary materials (collecting and transporting), preparation of a station for work and idle. Their duration is given in relation to the total duration of the

Fig. 3: Robot activity in the second and third warehouse model



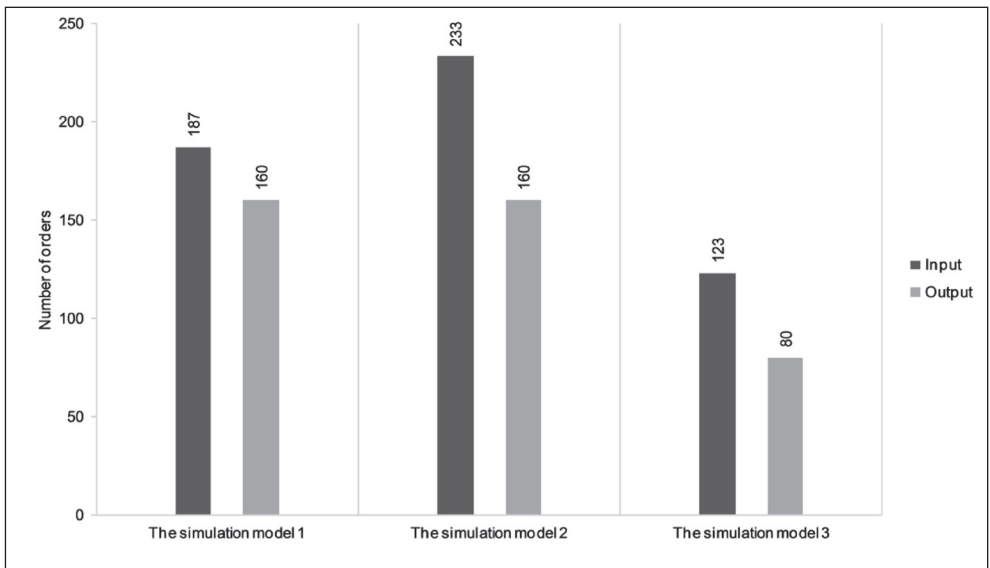
Source: own

Fig. 4: Labor productivity of picking stations in simulation models



Source: own

Fig. 5: Number of orders in simulation models



Source: own

process. In the FlexSim 3D Simulation Software the allocated idle means that the operator has been acquired by resource but has not been given a task yet.

The obtained results suggest (Fig. 4) that the time devoted to collecting and transporting of goods from the location in the first model is almost equal to the picking time itself, which is 39%. The collecting and transporting time is: 37% on station 1 and 36% on station 2. In the second model (2 robots and 2 picking stations) and in the third model (2 robots and 1 picking station) the collecting/transporting times are similar, while the picking time increases respectively: by 10% in the second model and by 12% in the third model.

Summarizing the results of the simulation, it should be noted that for an enterprise the largest number of completed orders is the second model variant (Fig. 5), in which the picking process takes place with the use of two robots and two picking stations. In the case of models with introduced innovations (second and third simulation models), the picking process in relation to the whole analyzed time was 49–51% (Fig. 4). However, these models experience some idles at the stations:

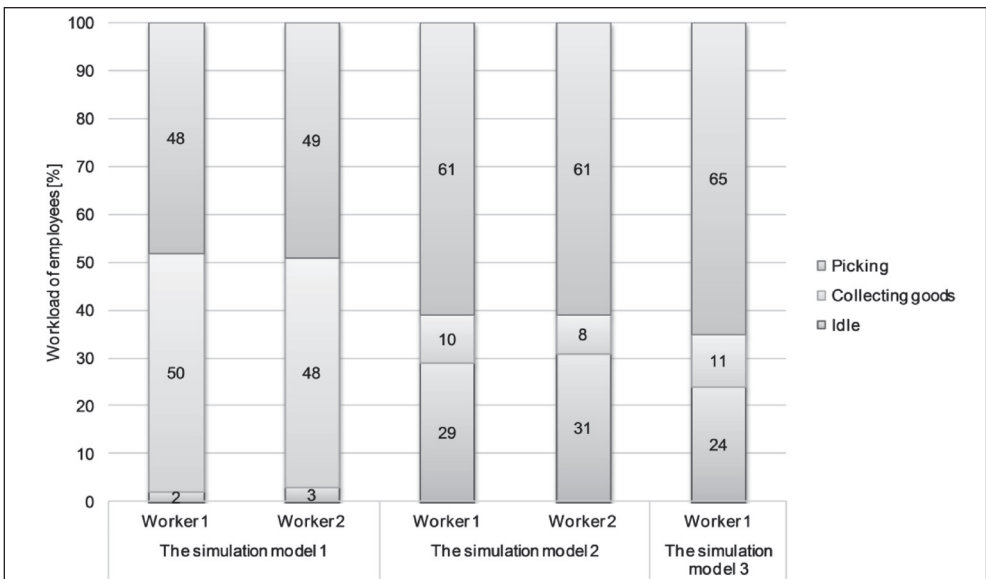
- in the first model it is 14–15% – the idle results from the employees who operate the stations;
- in the second model is 4–6% and in model third: 6% – the idle results from the operator’s waiting for the arrival of robot at the picking station with adequate goods.

The simulation tests conducted allow to attempt to answer the first research question formulated in the introduction to this paper: *Will the introduction of a technological and organizational innovation in a warehouse improve the picking process efficiency?*

In the first model, where the workers needed to search for the goods at the picking list and transport them on their own – the number of order was 187 (Input value). The greatest number of orders were handled in the second model (233 orders). The lowest number of orders were handled in the third model (123 orders), where only one picking station operated by one worker was implemented.

Summing up, the technological and organizational innovation introduced into the warehouse improve the picking stations efficiency, and thus the whole picking process.

Fig. 6: Workload of employees in simulation models



Source: own

The number of completed picking operations increased. The productivity grew by 21%, hence proving that the overall warehouse efficiency increased.

Comparing the results with other studies regarding introduction of innovations, e.g. the research conducted by Samattapong, performance gains have also been achieved once the alterations have been introduced. The result of the simulation (in FlexSim 3D Simulation Software) analysis showed that the conveyor belt was a bottleneck in the warehouse operation. Therefore, many scenarios have been generated to improve this problem and tested in the simulation analysis process. The researcher proposed three solutions (Samattapong, 2017). These solutions consisted in adding an additional employee in transporting products, adding a transport belt to reduce queues during transport, and adding both an additional employee and a transport belt. The researcher increased the number of shelves. For transport, the researcher applied the FIFO (First In First Out) principle, according to which previously manufactured products will be sent to the customer first. The result showed that the average waiting time in the queue was reduced from 89.8% to 48.7%, and the product's transport capacity increased from 10.2% to 50.9%.

How will the staff workload and demand for workers change after introducing the technological and organizational innovation in the picking process? The answer to the above, namely the second research question is not obvious. The simulations did not allow to examine the mental factor, which was separated in the studies by Grosse, Glock and Neumann (2015). This factor, even in real conditions, is difficult for direct and quantitative estimation. However, we can put forward a working hypothesis that introduction of innovations by adopting robots for transport of goods in warehouse second and third contributed to improvement of this factor. A worker no longer needs to carry out the work related to searching for and transporting good, which relieves his psyche from additional activities and allows to focus strictly on the activities related to picking (goods control, control of the picking list with delivered goods, securing containers, etc).

Moreover, by analyzing the models and the obtained data it is possible to draw conclusions related to the physical factor of a worker, which

will be determined mainly by work related to the transport of goods. In model first (Fig. 6), where no innovation has been introduced, a worker fatigue will result not only from work at the picking station, but also from searching, manipulating and transporting goods from the storage area to the workstation. The time devoted to collect the goods, which is 48–50%, is comparable with the time devoted to operating the picking process, which is 48–49%. These results prove great physical strain, as it is about 98% in both cases of workers. There is not much possible impact to be exerted on the station during the picking process. While the time related to transport can be extensively influenced. Therefore, the innovation was introduced in subsequent models. After adopting the robots to transport in models second and third, the picking time increased to 61–65%, while the collecting time was reduced to 8–11% – which generally indicates lower workload for the worker. Picking employees are most often exposed to countless injuries caused during reaching, lifting, picking and moving packages, moving between picking places. The introduction of technological innovation in this process in this case increases the safety of order pickers. It is true that the idle time increase, and it is 24–31% of the total time – unlike the value from the first model, which was 2–3%. But the time in the second and third models results from the workers waiting for the robot to arrive. Furthermore, this is when a worker can fill in the documentation, clean the workstation, etc, namely do those actions that were omitted in the simulation, but which are a part of the daily duties of each picking worker.

Therefore, while answering the question related to the workload, we can conclude that the innovation reduced the staff workload on the picking station in physical terms.

The conducted simulation test did not show any significant impact of introducing robots into the picking process on the number of workers needed for its implementation. Efficiency of picking activities at the picking station in model third (with 1 worker) is the highest (51%), but still comparable to model second (with 2 workers) – where it is 49%. Also the efficiency values related to picking/transporting the goods, preparing the station for work and with idle time are also comparable. Decrease of the number of workers from 2 to 1 proportionally reduces the number of completed orders (Output – from 160 to 80). However,

it should be stated that introduction of other innovations in the warehouse, in particular of technological nature (forcing technological changes) becomes a natural and often simply necessary matter. Especially if we take into account the important role that warehouses are to play in the implementation of the concept of Industry 4.0. The number of employees employed 24 hours a day is reduced by introducing solutions that increasingly automate warehouse processes. It is also worth noting that the decision on the degree of automation is connected with a preliminary analysis of labor costs and the local market for which a given warehouse system installation will be designed. A challenge in automation still includes large variety of packaging, integration of autonomous vehicles or reliable IT warehouse system.

The simulation tests performed do not take into account financial and economic factors nor the ones related to human resources in the context of personnel policy or sociology of work connected with introduction of robots to the picking process. Decisions concerning buying robots or renting them in the 'robots-as-a-service' (RaaS) model are still associated with high costs. It should also be emphasized that in the broader economic perspective the role of the warehouse operating within the modern supply chain is shaped by the features of volatility (e.g. fluctuations in consumer markets) and risk management (e.g. changes resulting from new legal regulations, the use of outsourcing services – third-party logistics or temporary employment of additional employees). In addition, the decision to introduce technological innovations in the picking process is not always the result of the expected improvement in efficiency, cost reduction and quality and safety at work. It also results from relationships with suppliers, markets in which the company competes. The problem of handling the increasing number of orders directed to warehouses, with relatively low employee wages, is often solved by temporary employment of additional workers. Thus, the decision to make expensive – and potentially risky – investments in technologies that change quickly is postponed. The result of picking processes automation is also the appearance of restrictions in the interaction of employees with colleagues. The possibilities of helping each other in performing tasks or solving problems are eliminated. The introduction of automation is accompanied by new forms of employee

control, detailed tracking of their movements, routes, speeds, breaks. Consequently, systems can encourage individual employees to be more productive. This can lead to deterioration of working conditions and negatively affect employee morale (Gutelius & Theodore, 2019).

Conclusions

In today's highly dynamic business environment, enterprises need to develop innovative strategies and tools to keep up with the technological changes and adapt to conditions of global competition. High variability of business surroundings triggers the need to introduce innovations in the area of production and warehouse processes. Important factors that determine application of new technologies and introduction of innovation include the tendency to reduce the time of product design, production and order picking so it can be delivered to the customer. A warehouse is becoming an increasingly critical link in operations of enterprises. The above-mentioned factors force enterprises to reduce inventory, shorten lead times and decrease operating costs. As a result, new and automated picking processes can significantly increase the efficiency of this process, but on the other hand they may result in organizational changes.

The results of tests presented in this study allow to formulate a positive general evaluation of the effects of introducing technological and organizational innovation in the warehousing process. A basic effect is an increase in 'productivity' of the warehouse operation understood as a relation of the number of picking orders to the number of devoted man-hours and an increase in efficiency of the picking process. Staff workload is reduced – in both the physical and mental dimensions. This may be reflected in greater comfort of work for a man and support implementation of control activities. However, it is difficult not to notice the potential problems with maintaining the previous employment levels due to the worker market and in a longer time horizon. Automation and digitalization processes taking place in enterprises change the labor market. This is not synonymous with the situation that human work becomes less necessary. New professions emerge, and effective introduction of innovation and the use of new technologies and new work organization models will require knowledge, quick decision making, and first of

all creativity, flexibility and the willingness to introduce changes.

The results of the research presented in the article indicate the need for further simulation experiments in the scope of the topics presented in the article. It would be interesting to provide the warehouse simulation models with other picking stations (for example in a configuration of two robots and three picking stations). A larger number of workers in the model would allow fuller response to the question on the impact of technological and organizational innovation on the number of employed workers. In addition, the literature analysis also revealed a research gap related to the impact of introduction of technological and organizational innovation on human work from the worker's perspective. Therefore, future research conducted by the authors will be focused on examining the innovation impact on the worker workload in real conditions in physical and mental terms.

Acknowledgement: *This research was conducted under Science Activity financed by Poznan University of Technology [11/140/SBAD/4172].*

References

- Ackerman, K. B. (2007). *Lean Warehousing*. Columbus, OH: Ackermann Publications.
- Afeltowicz, Ł. (2007). Does Technology Deprive Us of Work? Technology-Related Unemployment in an Actor-Network Theory. *Studia Socjologiczne*, 1(184), 107–126.
- Asimakopoulos, G., Revilla, A. J., & Slavova, K. (2019). External Knowledge Sourcing and Firm Innovation Efficiency. *British Journal of Management*, 31(1), 123–140. <https://doi.org/10.1111/1467-8551.12367>
- Baker, P., & Halim, Z. (2007). An exploration of warehouse automation implementations: cost, service and flexibility issues. *Supply Chain Management: An International Journal*, 12(2), 129–138. <https://doi.org/10.1108/13598540710737316>
- Battini, D., Calzavara, M., Persona, A., & Sgarbossa, F. (2015). Order picking system design: the storage assignment and travel distance estimation (SA&TDE) joint method. *International Journal of Production Research*, 53(4), 1077–1093. <https://doi.org/10.1080/00207543.2014.944282>
- Battini, D., Glock, C. H., Grosse, E. H., Persona, A., & Sgarbossa, F. (2016). Human energy expenditure in order picking storage assignment: A bi-objective method. *Computers & Industrial Engineering*, 94, 147–157. <https://doi.org/10.1016/j.cie.2016.01.020>
- Behrens, J., & Patzelt, H. (2018). Incentives, Resources and Combinations of Innovation Radicalness and Innovation Speed. *British Journal of Management*, 29(4), 691–711. <https://doi.org/10.1111/1467-8551.12265>
- Bogue, R. (2016). Growth in e-commerce boosts innovation in the warehouse robot market. *Industrial Robot: An International Journal*, 43(6), 583–587. <https://doi.org/10.1108/IR-07-2016-0194>
- Bonkenburg, T. (2016). *Robotics in Logistics. A DPDHL perspective on implications and use cases for the logistics industry*. Retrieved July 23, 2019, from https://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_trendreport_robotics.pdf
- Calzavara, M., Glock, C. H., Grosse, E. H., & Sgarbossa, F. (2019). An integrated storage assignment method for manual order picking warehouse considering cost, workload and posture. *International Journal of Production Research*, 57(8), 2392–2408. <https://doi.org/10.1080/00207543.2018.1518609>
- Chackelson, C., Errasti, A., Ciprés, D., & Lahoz, F. (2013). Evaluating order picking performance trade-offs by configuring main operating strategies in a retail distributor: A Design of Experiments approach. *International Journal of Production Research*, 51(20), 6097–6109. <https://doi.org/10.1080/00207543.2013.796421>
- Chen, F., Wang, H., Qi, C., & Xie, Y. (2013). An ant colony optimization routing algorithm for two order pickers with congestion consideration. *Computers & Industrial Engineering*, 66(1), 77–85. <https://doi.org/10.1016/j.cie.2013.06.013>
- Cords, D., & Prettnner, K. (2018). *Technological Unemployment Revisited: Automation in a Search and Matching Framework* (Economics and Social Sciences, Hohenheim Discussion Papers in Business 19-2018). Stuttgart: Universität Hohenheim.
- De Koster, R., Le-Duc, T., & Roodbergen, K. J. (2007). Design and control of warehouse order picking: a literature review. *European Journal of Operational Research*, 182(2), 481–501. <https://doi.org/10.1016/j.ejor.2006.07.009>
- Enright, J. J., & Wurman, P. R. (2011). Optimization and Coordinated Autonomy in Mobile Fulfillment Systems. In *Paper from the 2011 Association for the Advancement*

of *Artificial Intelligence Workshop WS-11-09* (pp. 33–38). San Francisco, USA.

Ford, M. (2016). *Rise of the Robots: Technology and the Threat of a Jobless Future*. Warszawa: cdp.pl (in polish).

Franzke, T., Grosse, E. H., Glock, C. H., & Elbert, R. (2017). An investigation of the effects of storage assignment and picker routing on the occurrence of picker blocking in manual picker-to-parts warehouses. *The International Journal of Logistics Management*, 28(3), 841–863. <https://doi.org/10.1108/IJLM-04-2016-0095>

Glock, C. H., & Grosse, E. H. (2012). Storage policies and order picking strategies in U shaped order-picking systems with a moveable base. *International Journal of Production Research*, 50(16), 4344–4357. <https://doi.org/10.1080/00207543.2011.588621>

Glock, C. H., Grosse, E. H., Abedinnia, H., & Emde, S. (2019). An integrated model to improve ergonomic and economic performance in order picking by rotating pallets. *European Journal of Operational Research*, 273(2), 516–534. <https://doi.org/10.1016/j.ejor.2018.08.015>

Grosse, E. H., & Glock, C. H. (2013). An experimental investigation of learning effects in order picking systems. *Journal of Manufacturing Technology Management*, 24(6), 850–872. <https://doi.org/10.1108/JMTM-03-2012-0036>

Grosse, E. H., Glock, C. H., Jaber, M. Y., & Neumann, W. P. (2015). Incorporating human factors in order picking planning model: Framework and research opportunities. *International Journal of Production Research*, 53(3), 695–717. <https://doi.org/10.1080/00207543.2014.919424>

Grosse, E. H., Glock, C. H., & Neumann, W. P. (2017). Human factors in order picking: a content analysis of the literature. *International Journal of Production Research*, 55(5), 1260–1276. <https://doi.org/10.1080/00207543.2016.1186296>

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on Warehouse Operation: A Comprehensive Review. *European Journal of Operational Research*, 177(1), 1–21. <https://doi.org/10.1016/j.ejor.2006.02.025>

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2010). Research on Warehouse Design and Performance Evaluation: A Comprehensive Review. *European Journal of Operational Research*, 203(3), 539–549. <https://doi.org/10.1016/j.ejor.2009.07.031>

Gue, K. R., Meller, R. D., & Skufca, J. D.

(2006). The effects of pick density on order picking areas with narrow aisles. *IIE Transactions*, 38(10), 859–868. <https://doi.org/10.1080/07408170600809341>

Gunasekaran, A., Marri, H. B., & Menci, F. (1999). Improving the effectiveness of warehousing operation: A case study. *Industrial Management & Data Systems*, 99(8), 328–339. <https://doi.org/10.1108/02635579910291975>

Gutelius, B., & Theodore, N. (2019). *The Future of Warehouse Work: Technological Change in the U. S. Logistics Industry* (Report from the UC Berkeley Center for Labor Research and Education and Working Partnerships USA). Retrieved January 22, 2020, from <http://laborcenter.berkeley.edu/future-of-warehouse-work>

Konečný, Z. (2016). Corporate Life Cycle as a Tool to Solve Technological Unemployment just as to Lift out of Poverty. *Procedia – Social and Behavioral Sciences*, 220, 191–199. <https://doi.org/10.1016/j.sbspro.2016.05.484>

Kovacs, A. (2011). Optimizing the storage assignment in a warehouse served by milkrun logistics. *International Journal of Production Economics*, 133(1), 312–318. <https://doi.org/10.1016/j.ijpe.2009.10.028>

Kudelska, I., & Pawłowski, G. (2019). Influence of assortment allocation manage in the warehouse on the human workload. *Central European Journal of Operations Research*, 5, 1–17. <https://doi.org/10.1007/s10100-019-00623-2>

Matuzeviciute, K., Butkus, M., & Karaliute, A. (2017). Do Technological Innovations Affect Unemployment? Some Empirical Evidence from European Countries. *Economies*, 5(4), 48–66. <https://doi.org/10.3390/economies5040048>

McKinsey & Company. (2018). *Hand in hand with a robot. How to use the potential of automation in Poland* (Report by McKinsey & Company in Poland, prepared in cooperation with the Forbes monthly). Retrieved July 10, 2019, from https://mckinsey.pl/wp-content/uploads/2018/05/Rami%C4%99-w-rami%C4%99-z-robotem_Raport-McKinsey.pdf

Niedbał, R. (2018). Human work in economy's digitisation conditions. In L. Kiełtyka & A. Wrzałik (Eds.), *IT-aided management* (pp. 117–126). Częstochowa: Wydawnictwo Politechniki Częstochowskiej (in polish).

Olszewski, M. (2016). Mechatronization of the Product and the Production – Industry 4.0. *Pomiary Automatyka Robotyka*, 20(3), 13–28. https://doi.org/10.14313/PAR_221/13

- Pariikh, P. J., & Meller, R. D. (2009). Estimating picker blocking in wide-aisle order picking systems. *IIE Transactions*, 41(3), 232–246. <https://doi.org/10.1080/07408170802108518>
- Petersen, C. G., & Aase, G. (2004). A comparison of picking, storage and routing policies in manual order picking. *International Journal of Production Economics*, 92(1), 11–19. <https://doi.org/10.1016/j.ijpe.2003.09.006>
- Petersen, C. G., Siu, C., & Heiser, D. R. (2005). Improving order picking performance utilizing slotting and golden zone storage. *International Journal of Operations & Production Management*, 25(10), 997–1012. <https://doi.org/10.1108/01443570510619491>
- Rąb, K., & Rąb, Ł. (2016). Reengineering stanowiska pracy a wzrost bezrobocia [Job Reengineering and the Increase of Unemployment]. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, 91, 321–330.
- Rushton, A., Oxley, J., & Croucher, P. (2006). *The Handbook of Logistics and Distribution Management* (3rd ed.). London: Kogan Page.
- Samattapong, N. (2017). An efficiency improvement in warehouse operation using simulation analysis. In *IOP Conference Series: Materials Science and Engineering* 273. Bali, Indonesia. <https://doi:10.1088/1757-899X/273/1/012013>
- Shah, B., & Khanzode, V. (2017). Designing a lean storage allocation policy for non-uniform unit loads in a forward-reserve model. *Journal of Enterprise Information Management*, 31(1), 112–145. <https://doi.org/10.1108/JEIM-01-2017-0018>
- Sharma, S., & Shah, B. (2016). Towards lean warehouse: transformation and assessment using RTD and ANP. *International Journal of Productivity and Performance Management*, 65(4), 571–599. <https://doi.org/10.1108/IJPPM-04-2015-0061>
- Sosnowski, P. (2017). Modern mobile technologies in warehousing in the light of the Internet of Things. In B. Ocicka (Ed.), *Mobile technologies in logistics and supply chain management* (pp. 101–121). Warszawa: PWN (in polish).
- Staudt, F. H., Alpan, G., Di Mascolo, M., & Rodriguez, C. M. T. (2015). Warehouse Performance Measurement: A Literature Review. *International Journal of Production Research*, 53(18), 5524–5544. <https://doi.org/10.1080/00207543.2015.1030466>
- Teja, P. R., & Kumaar, A. A. N. (2018). QR Code based Path Planning for Warehouse Management Robot. In *2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI), IEEE* (pp. 1239–1244). Bangalore, India.
- Theys, C., Bräysy, O., Dullaert, W., & Raa, B. (2010). Using a TSP heuristic for routing order pickers in warehouses. *European Journal of Operational Research*, 200(3), 755–763. <https://doi.org/10.1016/j.ejor.2009.01.036>
- Van Roy, V., Vértesy, D., & Vivarelli, M. (2018). Technology and employment: Mass unemployment or job creation? Empirical evidence from European patenting firms. *Research Policy*, 47(9), 1762–1776. <https://doi.org/10.1016/j.respol.2018.06.008>
- Vujica Herzog, N., Buchmeister, B., Beharic, A., & Gajšek, B. (2018). Visual and optometric issues with smart glasses in Industry 4.0 working environment. *Advances in Production Engineering & Management*, 13(4), 417–428. <https://doi.org/10.14743/apem2018.4.300>
- Wurman, P. R., D'Andrea, R., & Mountz, M. (2008). Coordinating Hundreds of Cooperative, Autonomous Vehicles in Warehouse. *AI Magazine*, 29(1), 9–20. <https://doi.org/10.1609/aimag.v29i1.2082>
- Xia, T., & Liu, X. (2018). Foreign Competition and Innovation: The Mediating Role of Imitation. *British Journal of Management*, 29(3), 464–482. <https://doi.org/10.1111/1467-8551.12236>
- Yan, X., Zhang, C., & Qi, M. (2017). Multi-AGVs Collision-Avoidance and Deadlock-Control for Item-To-Human Automated Warehouse. In *International Conference on Industrial Engineering, Management Science and Application (ICIMSA)* (pp. 1–5). Seoul, South Korea. <https://doi.org/10.1109/ICIMSA.2017.7985596>

RELATIONSHIP BETWEEN IMPERSONAL TRUST AND INNOVATIVE CULTURE: AN EMPIRICAL STUDY

Katarzyna Krot¹, Dagmara Lewicka²

¹ Białystok University of Technology, Faculty of Engineering Management, Poland, ORCID: 0000-0002-7404-1724, katarzynakrot@gmail.com (corresponding author);

² AGH University of Science and Technology, Faculty of Management, Poland, ORCID: 0000-0002-6955-7371, dagal@poczta.fm.

Abstract: *In the contemporary economic reality, which is based on relations, the role of trust both in the intra- and inter-organisational context is growing in importance. Impersonal trust is characterized by considerable durability and forms a solid framework for developing interpersonal trust. In consequence, many researchers' attention is drawn towards practices aimed at the development of such trust. The goal of the paper is to analyse potential relations between the degree of impersonal trust and innovative culture and, in particular, to operationalise the variables, i.e. determine the dimensions of impersonal trust and innovative culture, estimate the impact of the individual dimensions of the former onto those of the latter. The survey was conducted in Poland among 630 employees of large and medium-sized enterprises. Verification of the theoretical model was performed based on structural equation modeling. The research led to the identification of dependencies between the particular dimensions of impersonal trust and innovative culture, confirming the importance of impersonal trust in the process of shaping organisational culture. Impersonal trust was recognized as a separate construct which determines the nature of innovative culture. Feeling of security has special significance at workplace because guarantees stability, durability and openness in relations, enhances creativity of staff and gives them freedom to try non-conventional solutions to problems. Organisational assurance, i.e. a conviction about the clarity of rules and principles, open communication and making staff feel they are included in organisational processes, has a weaker impact on the dimensions of innovative culture when compared to feeling of security.*

Keywords: *Impersonal trust, dimension of trust, innovative culture, Poland.*

JEL Classification: O15, O33.

APA Style Citation: Krot, K., & Lewicka, D. (2020). Relationship between Impersonal Trust and Innovative Culture: An Empirical Study. *E&M Economics and Management*, 23(3), 82–100. <https://doi.org/10.15240/tul/001/2020-3-006>

Introduction

In the uncertain and volatile environment of the modern world, the role of trust is growing. A volatile business environment has forced organisations to deconstruct some of their structures and build other structures internally (Lewicka & Rakowska, 2017). These often-occurring and sometimes hardly predictable transformations, trigger natural resistance and uncertainty among members of organisations and, in consequence, a need for trust is born,

not only towards the staff but also towards the entire organisation, which is expected to guarantee stability and predictability (Lewicka, 2010). So far, researchers have mostly focused on interpersonal organisational trust, pointing to its role in supporting innovation (Dirks & Ferrin, 2001; Heyns & Jearey, 2013), often disregarding the role of impersonal trust. However, as it turns out, impersonal trust may become a serious source of competitive advantage. Trust guarantees a feeling of

security and freedom of operation required in the context of risk connected with innovation and the uncertainty, ambiguity and complexity that accompany it (Six, 2005). For this reason, trust is necessary to generate new ideas but also to transform them into business solutions and new products. In an atmosphere of trust, employees do not waste their time controlling things, reviewing previous arrangements and agreements, do not participate in a game but are focused on creating innovation (Carolyn, 2009). Confidence that innovative ideas will be treated seriously by an enterprise is a prerequisite for their dissemination.

Recently, the role of impersonal trust is growing because interpersonal trust has been deteriorating, has become fleeting and extremely difficult to rebuild (Vanhala et al., 2011). According to Kramer (1999), impersonal trust may be permanent to the extent that it also exists when interpersonal trust is low.

An increasingly large group of researchers regard organisational culture as one of the core factors with a substantial impact on the operation of organisations, one which determines effectiveness and efficiency (Deal & Kennedy, 1982; Yilmaz & Ergun, 2008). Some claim that organisational culture lies at the heart of innovation (Trompenaars & Hampden-Turner, 2004). Some researchers show that culture can support the creativity and innovation of an organisation in a number of ways, including the process of socializing, communicated values, artefacts, practices and procedures. Motivation and decision-making by employees are largely determined by corporate culture (Guiso et al., 2015). This means that organisational culture should also be treated as one of the organisational determinants of innovation (Naranjo-Valencia et al., 2010). The above arguments prompt us towards the assumption that the phenomenon of innovative culture does exist (Ahmed, 1998; Dobni, 2008; Muñoz-van den Eynde et al., 2015). However, many researchers are still trying to identify the characteristics of organisational culture which support innovation, making it possible for business entities to achieve success and indicate that there are types of culture with greater potential to support innovation.

The relationship between trust (impersonal trust in particular) and organisational culture has not been studied very intensively through empirical research. For this reason, it would

be interesting to develop a clearer definition of the relationship between impersonal trust and innovative culture and, moreover, to answer the question whether and to what extent, the degree of impersonal trust shapes innovative culture. So far, research has focused on attempts to demonstrate the impact of organisational trust on innovativeness (Ellonen et al., 2008; Vanhala & Ritala, 2016). It should be remembered that there exist some difficulties with generating objective data on innovative achievements of enterprises and that the studies conducted so far have limitations arising from the fact that the measurement of the degree of innovation is often based on respondents' views. Further to the above, the authors of this paper believe that it is worthwhile to analyse innovative culture on the assumption that it is a source of values, models and stimuli for innovative attitudes and behaviours such as generating ideas, genuine acceptance of testing new approaches and solutions, tolerance for errors and mistakes, implementing initiatives and organisational solutions oriented towards supporting innovation.

Both 'impersonal trust' and 'innovative culture' are relatively new terms, not thoroughly researched yet, but promising as subjects of scientific inquiry. The studies conducted thus far have revealed a dependence between general trust and innovation (Semerciöz et al., 2011; Ellonen et al., 2008). There is a cognitive gap regarding factors based on impersonal trust which stimulate the development of innovative culture. Bearing in mind the special role of impersonal trust as a framework for organisational processes, it is worth investigating the impact of this trust on innovative cultures. Identification of the constructs of impersonal trust and innovative culture can (i) throw a spotlight on the strength of the influence of impersonal trust, and (ii) help to verify these constructs.

Therefore, this paper aims to identify the trust-related determinants of a culture of innovation, analysing and verifying the potential and possible relations between the degree of impersonal trust and innovative culture with dual goals: firstly, to operationalise the variables, i.e. determine the dimensions of impersonal trust and innovative culture and, secondly, to attempt to estimate the impact of the individual dimensions of impersonal trust onto the dimensions of innovative culture (Glińska-Noweś, 2013).

Our study contributes to the existing body of knowledge in the following ways. Firstly, the dimensions of impersonal trust are identified. So far, little research has focused on impersonal trust, favouring interpersonal trust instead. For this reason, our research contributes to the development of investigations related to impersonal trust. Secondly, the important role of impersonal trust in the process of shaping innovative culture is proved and it is pointed out that the dimensions of this type of trust tend to have a different impact on innovative culture. Thus far, impersonal trust has usually been approached as a mediator of a relationship (Lewicka & Krot, 2015; Vanhala & Ritala, 2016). In this paper, its real impact on the perception of an organisational culture is demonstrated and proven. Thirdly, the research results may inspire an academic debate about the nature of the relationship between trust, including impersonal trust, innovative culture and innovation; even more so that the issue has not been the focal point of many studies.

1. Literature Review

1.1 Impersonal Trust

In the literature on organisational trust, interpersonal trust, which applies to the relationship among an employee's line managers and colleagues, is differentiated from impersonal (institutional) trust (Bahman & Ipken, 2011). Trust in an organisation as a whole is how the organisation's credibility is assessed by its employees. Processes in organisations are assessed from the point of view of the potential benefits for employees and for the entire organisation (Atkinson & Butcher, 2003). Impersonal trust is a belief that some necessary structural conditions exist which increase the probability of achieving the desired outcome (McKnight et al., 2002).

Vanhala et al. (2011) define impersonal trust as employees' expectations about the opportunities created by their employer in the employment process and the fairness of the existing procedures. With this kind of trust, employees are fully convinced of the sense and benefits of the enterprise or project in which they are involved. At the same time, it assures security and stability in a variable environment (Krot, 2010).

Ellonen et al. (2008) emphasise that impersonal trust may also be defined as trust which the members of an organisation have

towards its vision and strategy, its technical and commercial competences, fair processes and its HR policy. Impersonal trust is built largely through effectiveness of management and fairness of the rules governing the operation of each level in the structure of an organisation and the entire enterprise.

Impersonal trust arises from evaluation of formal structures embedded in an organisation, such as: accreditations, certificates or licenses, which guarantee stability, security and predictability (Tschannen-Moran & Hoy, 2000). This is why impersonal trust is comprehended in two dimensions: structural assurance and situational normality. The first one stands for the conviction that formal structures, i.e. guarantees, regulations, promises and other procedures are aimed to promote the delivery of goals (Shapiro, 1987). The second dimension, situational normality, indicates a belief that the environment of the organisation is arranged in an orderly fashion and appropriately structured, and that it promotes success possible or more probable (Lewis & Weigert, 1985). This dimension is based on the employees' belief that the enterprise operates as planned and everything seems to be working correctly, enabling the delivery of plans. Ellonen et al. (2008) mention a third factor – vision, strategy and communication. According to Pavlou et al. (2002), the importance of these dimensions of impersonal trust changes in time. At the initial stage of building relations with an organisation, when other premises for trust are missing, structural assurance is the most important dimension supporting impersonal trust. Similarly, situational normality, at the initial stage, is of particular importance since any deviations noticed by employees may destroy the initial trust.

1.2 Innovative Culture

In the early 1980s, the concept of culture, derived from anthropology, began to be used in the context of organisations (Kluckhohn, 1951). Ever since, growing interest in the phenomenon of organisational culture has been observed in both organisational science (Schein, 1984; Smircich, 1983) and business practice (Deal & Kennedy, 1982).

Organisational culture encompasses shared assumptions, core values and standards (Schein, 1985); it is defined as collective programming of the minds of people who spend time in the same

environment (Hofstede, 1984), a pattern of one's convictions and beliefs, giving employees a purpose and providing them with rules of behaviour (Davis, 1985). Definitions of culture also imply its role as a factor affecting people's behaviour in an organisation (Armstrong, 2011). The dependence is strongly emphasised by Bjerke (2004, p. 28), who points out that culture means "basic behaviour standards, values and assumptions (convictions) which have been interpreted and given meaning in the process of interaction and which have an impact on behaviour while they are not behaviour themselves". Colquitt et al. (2002) define culture as shared social knowledge in an organisation, encompassing principles, standards and values which develop the attitudes and behaviour of staff. The impact of culture on the behaviour of participants in an organisation depends on the type of culture and its other features, e.g. its power. Organisational culture offers a common system of meanings which serves as the basis for communication and mutual understanding.

An analysis of the notion of organisational culture should also include the distinction between organisational *climate* and organisational *culture*, as these two terms are closely interrelated. The unique *culture* of an organisation creates a specific atmosphere, which is felt by employees and can be called 'organisational *climate*'. This phrase denotes the way in which employees experience organisational culture. Some researchers (e.g. Trunk Širca et al., 2013) treat *climate* as part of organisational *culture* and refer to it as "a climate for something", e.g. a climate for security, diversity, and/or innovation. As organisations tend to have many different priorities, there may be many types of *climates* (Schneider et al., 1994) which, interestingly, may be felt or experienced with a different intensity in the same organisation. Organisational *climate* is more susceptible to changes, e.g. through the activities of the top management, unlike *culture*, which lies outside managerial control (Alvesson, 1991) and which is not easy to change as it would take a long time and involve many coordinated actions to change it (Sułkowski & Sikorski, 2014). According to Bjerke (2004), studies of climate make it possible to verify whether people's expectations regarding their work in a given organisation are met, which is expressed by the degree of consistency between the organization's culture and the values expressed

by the employees. Climate studies disclose the root causes of some phenomena, e.g. low commitment or conservative attitudes of the staff. On the other hand, *culture* is about the nature of these phenomena. However, it should be remembered that there are very clear and strong links between the *culture* and *climate* of an organisation (Wallace et al., 1999).

Ahmed (1998) emphasises that culture has two components: explicit and implicit, which help to understand the method to be applied in its researching and managing. Explicit culture points out to the behavioural patterns and artefacts on the basis of which the culture manifests itself in an organisation. The implicit component of culture encompasses those values, standards, beliefs and premises which come as the basis for organisational behaviours and artefacts. Explicit culture is easier to study quantitatively than its outer layers.

When investigating the main research and analytical perspectives on organisational cultures, one must remember that they differ chiefly in terms of the origin of the factor which impacts the culture of organisations. In quantitative studies, organisational culture is treated either as an independent or dependent variable. In cross-national research and comparative management, it is usually regarded as an independent variable, i.e. an external factor which directly influences management styles and the behaviour of the members of organisations in a given country (Smircich, 1983; Hofstede, 1980; Hampden-Turner & Trompenaars, 2001).

The other approach considers organisational culture to be dependent on other organisational factors: type of ownership, sector, branch, transaction costs, the activity of entrepreneurs, strategy leaders, mission leaders, etc. Under this approach, culture is created within organisations (Smircich, 1983). Our paper concurs with this view. Deliberate and conscious nurturing of trust towards an organisation, as well as emphasis on forming relationships based on trust, should (along with other measures taken by leaders) contribute to the gradual emergence of the desirable changes in organisational cultures.

In essence, organisational culture is tantamount to a factor which affects human behaviour and management processes in an organisation (Sydow et al., 2009). Following this assumption, a culture may also stimulate

innovative or reactive actions of employees which represent a context for forming evaluating judgments about desirable and undesirable elements in an organisation. Many authors study dependencies between organisational culture and innovation in an organisation, pointing out strong relations between certain types of organisational culture and the degree of its innovation (Chang & Lee, 2007; Lau & Ngo, 2004). On this basis, the concept of innovation-supporting culture (or 'innovation culture') was created.

The concept of innovative culture is receiving increased attention from many researches (Quinn & Cameron, 2003; Dobni, 2008). From this attention grows a need to clarify what the term 'innovation culture' means and how to study it. Much work on innovative culture has been conceptual and theoretical rather than empirical in nature, which is understandable given the difficulties and methodological challenges of measuring the dimensions of culture. The construct certainly still needs to be operationalised and measured.

As various authors created their typologies of culture, they incorporated in them dimensions which were, to an extent, associated with innovation, e.g. long-term and short-term orientation (Hofstede, 1980) or introduced innovative culture as a separate type of culture. For instance, 'adhocracy culture', described by Cameron and Quinn (2003), is a model of culture which supports innovation. Such an organisation requires rapid growth, entrepreneurship and creativity. Its members are not afraid of risk. Cohesion of an organisation stems from its inclination to experiment and introduce innovation.

From the point of view of the considerations presented in this paper, the culture of an incubator, characteristic of Silicon Valley companies, is also interesting (Trompenaars, 2010). It is an egalitarian and individual-oriented culture. The leitmotif of this type of culture is the idea that 'existence comes before an organization', which is reflected in the conviction that it is the organisation that should be used by employees as a means for self-fulfillment. They are encouraged to free themselves from routine and turn to creative activity. It is mostly creativity and initiative that count. In such organisations, hierarchy is limited to the minimum and leadership is connected with creativity, intuition and seeking opportunities. An incubator culture

promotes emotional commitment to work and allows employees to find joy in the process of creation and innovation (Hampden-Turner & Trompenaars, 2001).

A holistic and empirically verified model of innovative culture is presented by Dobni (2008, p. 551). It is defined as a multi-dimensional construct which involves:

- an innovation intention, which consists of two sub-dimensions: an innovation propensity and organisational constituency, which set out the strategic conditions for innovation;
- innovation infrastructure, which encompasses two dimensions: organisational learning, creativity and empowerment;
- innovation influence, which encompasses two dimensions: market orientation and value orientation, focusing on the processes of producing customer value;
- innovation implementation concentrating on the implementation context which involves the ability to provide pro-active support of systems and processes in favour of changes, handling uncertainty, eliminating barriers and difficulties in the process of implementing and commercialising new ideas.

According to Dobni (2008), the above-presented model may be used for describing, diagnosing and comparing results in each dimension to identify the area of improvement to justify calling an organisation innovative.

On this basis, an innovation culture can be described as one which is founded on a deep-rooted conviction about the value of innovation. The shared values within an organisation form the basis for the development of norms which legitimise certain behaviours (Katz & Kahn, 1978). Norms are defined as expectations about behaviour or its results which are at least partially shared by a social group (O'Reilly, 1989). An innovation culture promotes such values, norms and behaviours which are oriented towards unhampered co-operation, creativity, self-reliance, free communication and discussion, sharing of knowledge and ideas, as well as mutual support and tolerance of mistakes. Among its inherent components is also orientation towards experimenting, support for new ideas, risk-taking, as well as a conviction that these attitudes and behaviours are conducive to the development of the organisation and its employees. The outcomes

that such behaviours generate include: innovations, increased customer satisfaction and streamlining of processes. Missions, visions and strategies of organisations often specify by what values and norms they are guided. Ideally, however, these values should permeate the activities undertaken by organisations, instead of being empty declarations.

1.3 Impersonal Trust versus Innovative Culture

So far, few researchers have focused on impersonal trust, although it evidently plays an important and unique role in creating innovation-supporting conditions. Research into the subject leads to the conclusion that impersonal trust may have both a direct and indirect impact on innovative culture. Some authors claim that impersonal trust is a prerequisite for building interpersonal trust. Pennington et al. (2003) confirm that impersonal trust precedes other types of trust. According to other studies, this kind of trust has a strong influence on general trust in managers (Nyhan, 1999) and on trust in particular dimensions (McKnight & Chervany, 2001). For this reason, impersonal trust seems to be a necessary background required to build trust between people in an organisation. Based on these conclusions, two hypotheses can be made:

H1: Organisational assurance has a positive and direct impact on managerial support.

H6: Feeling of security has a positive and direct impact on managerial support.

Some even claim that impersonal trust exerts a stronger impact on (product and process) innovation of companies than interpersonal trust (Semerciöz et al., 2011). It may signify that, in some cases, implementation of innovation relies more on procedural conveniences than on interpersonal relations (Atkinson & Butcher, 2003). Employees need formal protection to take up challenges which may sometimes end in failure. With a high level impersonal trust, employees are fully convinced about the sense and benefits of the enterprise or project they intend to be involved in. At the same time, it offers them security and a degree of stability in a volatile and unpredictable environment which surrounds innovative processes.

According to research results, impersonal trust affects a series of innovative culture components such as: employee commitment and identification with the organisation (Ellonen

et al., 2008), higher effectiveness and efficient communication (Shockley-Zalabak et al., 2000; Vanhala & Ahteela, 2011), expanding collaboration (Mayer et al., 1995; Tyler, 2003) and creativity (Bidault & Castello, 2008). As McEvily et al. (2003) state, it is a very important feature of impersonal trust that it helps build a dense, permanent and relatively compact network of cooperating persons (often from different departments or even companies). However, before interpersonal trust is built among people, impersonal trust is required. It is the bond, the binding material of the impersonal trust relationship springing from organisational procedures and rules of conduct. Based on the above, two further hypotheses have been made:

H2: Organisational assurance has a positive and direct impact on creativity.

H7: Feeling of security has a positive and direct impact on creativity.

Impersonal trust has a major bearing on knowledge processes. Employees as team members will share their knowledge to generate new knowledge if the created mechanisms facilitating and encouraging dissemination of information evoke trust (Rolland & Chauvel, 2000). Fear, cynicism and excessive caution will suppress all knowledge-sharing (Ford, 2004). Trust helps overcome the tension between the willingness to share knowledge and its protection (Bogers, 2011). As Rolland and Chauvel (2000) claim, trust is also the most important condition for transferring knowledge. Impersonal trust has, moreover, a huge impact on knowledge codifying processes. Persons engaged in a knowledge-creating process must be convinced that their knowledge is appropriately stored and protected against those who should not have access to the knowledge and that the knowledge will be used appropriately (Ford, 2004). This is why employees may search for a third party – an organisation – to reduce uncertainty and risk and to guarantee the securing of each party to the exchange information process (Ford, 2004). In view of the above, the next two hypotheses regard risk acceptance:

H5: Organisational assurance has a positive and direct impact on risk acceptance.

H10: Feeling of security has a positive and direct impact on risk acceptance.

Lastly, it should be noted that also the skill of employing external knowledge requires the

right procedures and organisational openness. Therefore, impersonal trust plays a significant role in this process as well (Davenport & Prusak, 2000).

As can be seen, impersonal trust creates conditions for initiating interactions, effective communication and, in a longer perspective, for development of collaboration, building relations and knowledge-sharing. So it seems that trust strengthens innovative cultures with procedural support required in decision-making processes concerning innovation and provision of impersonal conditions for efforts in support of innovation. In addition, it also creates a feeling of security required to implement risky projects which are often innovations themselves. Four hypotheses can be proposed here:

H3: Organisational assurance has a positive and direct impact on strategic orientation towards innovation.

H4: Organisational assurance has a positive and direct impact on operational orientation towards innovation.

H8: Feeling of security has a positive and direct impact on strategic orientation towards innovation.

H9: Feeling of security has a positive and direct impact on operational orientation towards innovation.

Further to the above, we may say that there is a strong dependence between trust and innovative culture. The above reasoning is the basis for formulating the research hypotheses presented in the paper.

2. Research Methodology

2.1 Research Assumptions

The objective of the research was to verify the relationship between impersonal trust and the individual dimensions of innovative culture. The majority of the work is focused on analysing the importance of interpersonal trust in different aspects of an enterprise's operation (Zebrane & Connell, 2003). As can be seen, the impact of impersonal trust on innovation

or other strategic objectives is equally strong or even stronger than that of interpersonal trust (Vanhala & Ritala, 2016; Semerciöz et al., 2011). However, culture is a more complex and, consequently, ambiguous object of research. Its multidimensional character increases the complexity of the research process and makes the identification of its "structure" more problematic. What is more, its multidirectional relations with other elements of an organisation and the environment render it more difficult to analyse. Many elements and dependencies are invisible and often even unaware to us, thus hardly observable and measurable (Gadomska-Lila, 2011). For this reason, the specific objectives of the study include:

- a) to identify the dimensions of impersonal trust;
- b) to discuss the dimensions of impersonal trust;
- c) to determine the strength and direction of the interdependence between the dimensions of impersonal trust and those of innovative culture.

It is assumed that trust is strictly connected with organisational culture; however, the nature and strength of these relationships have not been determined as yet, in particular with regard to impersonal trust. While Dobni (2008) suggests that trust is an element of innovative culture, it is not reflected in the dimensions of culture which she proposes. It should also be noted that the factor analysis conducted by the authors of this paper confirm that the dimensions of impersonal trust and innovative culture are separate constructs.

For this reason, the results presented here are among the very few attempts to demonstrate the relationship between impersonal trust and innovative culture on the basis of a large sample of employees in innovative companies.

The choice of the purpose of the research determined the scales used, i.e. the scale analysing impersonal trust and innovative culture. For more information about the scales, see Tab. 1 and attachment.

Tab. 1: Authors of the constructs

Scale	Bibliographical sources
Impersonal trust (14 items)	Robinson (1996), Ellonen et al.(2008)
Innovative culture (40 items)	Dobni (2008)

Source: own

Both scales were subject to explorative factor analysis by using the main component technique with Varimax rotation to reduce them to dimensions with higher internal homogeneity. But first, both cases were K-M-O tested to confirm the legitimacy of running the factor analysis:

- Impersonal trust: KMO measure = 0.923;
- Innovative culture: KMO measure = 0.975.

In the case of impersonal trust, the explorative factor analysis led to separating two dimensions: organisational assurance and feeling of security. They both have satisfactory Alfa Cronbach factors: feeling of security = 0.87 and organisational assurance = 0.90.

Organisational assurance (7 items, e.g., *“if anything in my organisation is going really wrong, I am sure I will be informed about it; there is a steady flow of information in my organization”*) as a dimension of impersonal trust is a conviction about the clarity of rules and principles, open communication and a sense among staff that they are included in organisational processes. What is more, employees should also feel informed on an ongoing basis about everything that is happening in their organisation. In addition, high efficiency of communication processes is also an element of organisational assurance. Meanwhile, the feeling of security (5 items, e.g., *“my organisation creates the best conditions for development for me; I feel safe at my workplace”*) is a conviction that everything in the organisation happens in a certain order, ensuring a sense of security and satisfying the essential needs of individuals, such as personal development and the ability to express their own ideas.

In the case of innovative culture, a similar approach was followed. First, the K-M-O test was run and then the dimensions to be analysed were identified in terms of their reliability. Factor analysis led to selecting five dimensions of innovative culture. For each of them, Alfa Cronbach factors reached satisfactory values:

- Managerial support – Alfa Cronbach: 0.929;
- Creativity – Alfa Cronbach: 0.900;
- Strategic orientation towards innovation – Alfa Cronbach: 0.918;
- Operational orientation towards innovation – Alfa Cronbach: 0.933;
- Risk acceptance – Alfa Cronbach: 0.743.

Managerial support (5 items, e.g., *“managers communicate openly their expectations regarding innovation to employees; if employees*

wish to look for innovative solutions, they have their managerial support”) is interpreted mainly as leadership skills oriented towards implementation of innovative undertakings. Creativity of employees (7 items, e.g., *“in my organisation, employees are expected to show initiative; Innovations stand more chance of success if employees may express non-standard and unique solutions in their daily operation”*) denotes their original and innovative way of thinking and acting, as well as showing initiative at work. Attitude to risk (3 items, e.g., *“in my organisation, risk is acceptable; in my organisation, employees decide about taking risk”*) is simply declared acceptance for participating in different risky projects. Another element contributing to the development of innovative culture – strategic orientation towards innovation (7 items, e.g., *“innovations are the key values in my organisation; in my organisation, resources are flexibly redirected toward innovative activities”*) – refers to clear communication of values and principles related to innovative undertakings and awareness on the part of employees that innovation is crucial to the development of a company, and that it depends, to a large extent, on the use of the stakeholders' potential.

The last component of innovative culture – operational orientation towards innovation (9 items, e.g., *“in my organisation, free access to information and knowledge was given; optimal conditions were created for us also to have cross-functional cooperation”*) – refers to organisational values and conditions conducive to innovation, manifested in the daily activities of the company, such as knowledge sharing, stimulating cooperation, initiative and responsibility for company development, and appreciation of employees' personal contribution to innovation.

In the process of structuring the business model, it was assumed that both dimensions of impersonal trust: organisational assurance and feeling of security affect individual dimensions of innovative culture. Find a graphic presentation of these assumptions on Fig. 1.

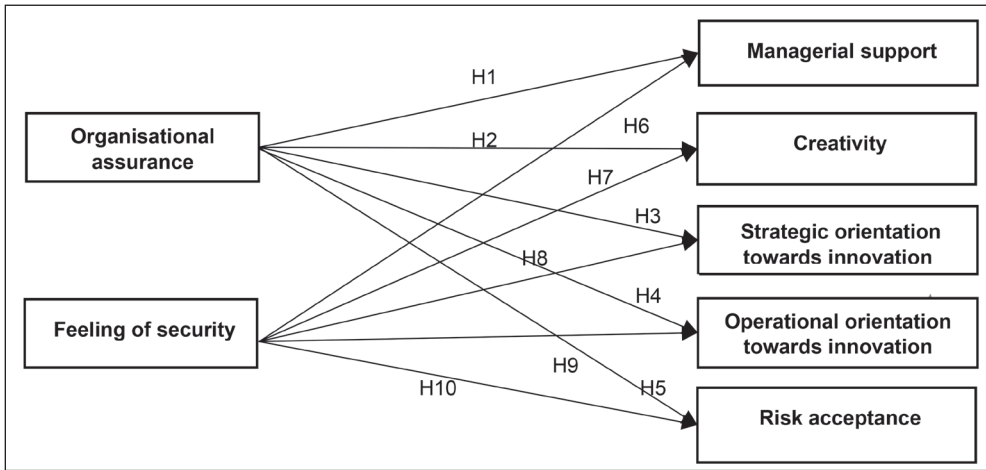
The dependence between these dimensions of impersonal trust and culture allowed us to formulate 10 research hypotheses:

H1: Organisational assurance has a positive and direct impact on managerial support.

H2: Organisational assurance has a positive and direct impact on creativity.

Fig. 1:

Theoretical model of relationship between impersonal trust and innovative culture



Source: own

H3: Organisational assurance has a positive and direct impact on strategic orientation towards innovation.

H4: Organisational assurance has a positive and direct impact on operational orientation towards innovation.

H5: Organisational assurance has a positive and direct impact on risk acceptance.

H6: Feeling of security has a positive and direct impact on managerial support.

H7: Feeling of security has a positive and direct impact on creativity.

H8: Feeling of security has a positive and direct impact on strategic orientation towards innovation.

H9: Feeling of security has a positive and direct impact on operational orientation towards innovation.

H10: Feeling of security has a positive and direct impact on risk acceptance.

To confirm the correctness of the proposed model, the opposite assumption was also verified, i.e. that the dimensions of innovative culture affect institutional trust. Such conceptualisation of the relationship between trust and innovative culture has not been the subject of scientific inquiry so far. Only the influence of national culture on trust has been analysed by Doney, Cannon and Mullen (1998). Analysis of the model of the

influence of innovation culture on institutional trust shows that most of the relationships between the dimensions of innovation culture and the dimensions of trust have proved to be insignificant. Statistically significant dependencies can be observed only between strategic orientation to innovation and trust, although overall goodness-of-fit test results are unsatisfactory. These results confirm the validity of the models adopted by the authors.

2.2 Sample and Data Collection

1,769 respondents took part in the questionnaire survey. These were employees representing Polish innovative companies and had been selected on the quota basis. The studied companies were selected using the level of innovation and sector (industry or service) as the criteria. In this case, innovation was diagnosed with an additional form. The authors of the "Ranking of the Most Innovative Businesses in Poland" made an attempt to identify the characteristics of innovative companies. In their research pool, industrial companies represented 35.3% while 51.4% were service companies (including trade companies). For this reason, it was decided that – in order to keep the structure of businesses the same as in the results of the research – businesses had to be selected to be included in the sample in the

right way. However, considering the objective of the paper, a decision was made to modify the structure of the sample, i.e. remove small enterprises (with fewer than 49 employees) from the studied group. The decision was dictated by the results of earlier analyses, which clearly showed the specific character of small entities, stemming from the very nature of impersonal trust. Because of the small number of employees working in such businesses, they often do not have any procedures and standards while their communication is often more personalised and informal, as a result of which they report exceptionally low impersonal trust (Krot & Lewicka, 2016).

Eventually, 630 respondents were included in the sample. They were working for large and medium-sized companies, mostly in the manufacturing sector. For the structure of the research sample, see Tab. 2. Most of the members of the sample were persons under 45 years old and with professional experience reaching 8 years. 50% are full-time employees, mainly with secondary or higher education.

3. Research Results

The descriptive statistics for the all the dimensions are reported in Tab. 3.

Structural equation modelling (SEM), which is a linear cross-sectional statistical modelling technique that includes path analysis and regression analysis, was applied to verify the theoretical model. Because SEM is mostly used to determine whether a model is valid rather than to 'find' a suitable model, it is the most applicable statistical method to validate the proposed model (Fig. 1). This is where theory plays an important role in justifying the model (Rodríguez & Pérez Gutiérrez, 2007).

To construct a model of the relationship between impersonal trust and innovative culture, the authors applied the maximum likelihood (ML) estimation method. The ML function is a structured means model which reflects how closely the sample mean vector is reproduced by the estimated model's mean vector. It also indicates how closely the sample covariance matrix is reproduced by the estimated model's covariance matrix. As a result, a model may fit

Tab. 2: Research sample structure

	Number	%		Number	%
Sex			Contract type		
Woman	281	44.7	Open full-time contract	311	50.0
Men	347	55.3	Term contract	256	41.2
Age			Probation	33	5.3
<25 years	68	10.9	A temp	19	3.1
25–35	245	39.2	Part-time	2	0.3
36–45	205	32.8	Self-employed	1	0.2
46–55	87	13.9	Work experience		
56 and more	20	3.2	Up to 3 years	208	33.9
Education			4–8	215	35.1
Elementary	11	1.7	9–13	111	18.1
Vocational	88	14.0	14–18	54	8.8
secondary	274	43.5	19 and more	25	4.1
College/university	246	39.0	Enterprise (size)		
Doctorate	5	0.8	40–200 employees	268	46.0
Sector			201–500 employees	44	7.5
Manufacturing	521	82.7	500+ employees	271	46.5
Service	109	17.3			

Source: own

Tab. 3: Descriptive statistics of dimensions

	M	SD	Organisational assurance	Feeling of security	Managerial support	Creativity	Strategic orientation towards innovation	Risk acceptance
Organisational assurance	24.45	5.79						
Feeling of security	19.07	4.36	0.71**					
Managerial support	20.98	5.23	0.65**	0.66**				
Creativity	25.72	5.47	0.61**	0.77**	0.75**			
Strategic orientation towards innovation	28.04	6.46	0.73**	0.73**	0.75**	0.80**		
Risk acceptance	9.97	2.39	0.58**	0.45**	0.55**	0.56**	0.61**	
Operational orientation towards innovation	37.52	8.92	0.77**	0.71**	0.80**	0.76**	0.83**	0.68**

Source: own

Note: ** Correlation significant at 0.01 bilaterally.

badly if the means are modelled poorly, or if the co-variances are modelled poorly, or both (Bentler, 1995).

Each major SEM model may be accompanied by at most two other indices of fit, such as CFI (comparative fit index) and RMSEA (root mean square error of approximation) (Bentler, 2007). The results revealed a chi-square of 4,263.44 based on 851 degrees of freedom with a probability level of 0.000. As the indicators show, the goodness-of-fit measures are satisfactory CFI = 0.84, RMSEA = 0.0798, HOELTER (0.05) = 136. All paths in the model are statistically significant.

The results of Fig. 2 confirm *H1*, *H3*, *H4* and *H5*, which is a statistically positive and direct relationship between organisational assurance and four dimensions of innovative culture, and namely: managerial support, strategic and operational orientation towards innovation, and risk acceptance. Organisational assurance has the strongest impact on operational orientation towards innovation and the weakest for managerial support. Confidence in the organisation's procedures and the way in which the organisation acts, clarity and transparency of organisational principles ensure a stability which allows employees to take risks, creates an atmosphere

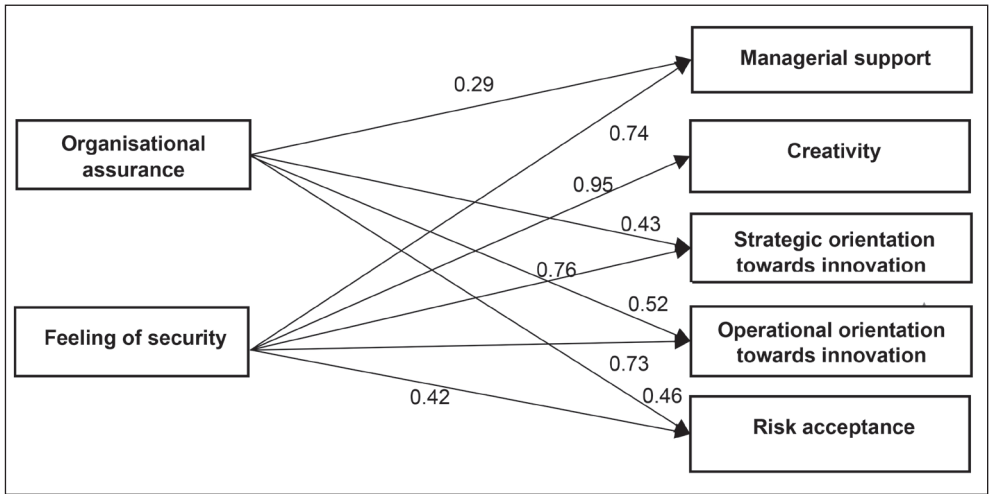
of mutual co-operation between managers and employees for innovative ventures. In addition, the stability is a guarantee of the effectiveness of activities which support innovation, provides favourable conditions for creating a set of values (sharing, collaboration, etc) that are necessary in an innovative organisation.

However, *H2* was not confirmed, i.e. the path between the organisational assurance and creativity was statistically insignificant.

The hypotheses related to feeling of security (*H6*, *H7*, *H8*, *H9* and *H10*) were verified positively. Feeling of security as a dimension of impersonal trust which has a positive impact on all the dimensions of innovative culture. Feeling of security, i.e. a belief that an organisation meets its employees' needs, providing them at the same time with a sense of security, encourages creativity, risky ventures, and ensures managerial support. What is more, it further enhances employees' awareness of their key role in innovation processes and the necessity of cooperation with external partners.

In addition, the power of the impact exerted by feeling of security is definitely higher than that of organisational assurance (regression factors are definitely higher than in the case of organisational assurance). Risk acceptance

Fig. 2: Model of relationship between impersonal trust and innovative culture



Source: own

Tab. 4: Standardized regression weights

		Estimate			Estimate
Managerial support	← Organisational assurance	0.29	Creativity	← Feeling of security	0.95
Strategic orientation towards innovation	← Organisational assurance	0.43	Strategic orientation towards innovation	← Feeling of security	0.76
Operational orientation towards innovation	← Organisational assurance	0.52	Operational orientation towards innovation	← Feeling of security	0.73
Risk acceptance	← Organisational assurance	0.46	Risk acceptance	← Feeling of security	0.42
Managerial support	← Feeling of security	0.74			

Source: own

is the only exception here. Both of these dimensions of impersonal trust have a relatively weaker impact on this aspect of innovative culture; and yet the impact of organisational assurance is stronger than the impact of feeling of security. The latter has the most powerful impact on employee creativity and strategic orientation towards innovation.

Discussion and Conclusion

Discussion

Search for innovation-stimulating factors in enterprises is an important issue for researchers and practitioners alike. Both these groups consider innovative culture and the degree of impersonal trust to be significant determinants. Approaching innovation as

an intraorganisational process related to employee attitudes and behaviour, with strong cultural influences, an attempt was made to prove that there is a relationship between the analysed constructs. Both of them are multi-dimensional, co-dependent and difficult to operationalise. In particular, the nature of innovative culture causes many doubts in the research process. The authors of this study assume that an innovative culture consists of five dimensions (Dobni, 2008), affected by both dimensions of impersonal trust: organisational assurance and feeling of security (Elonnen et al., 2008). Impersonal trust was recognized as a separate construct which determines the nature of innovative culture. The results of the study allowed to achieve the assumed goal. The structural modelling demonstrates that both of the studied dimensions of this kind of trust strongly affect different aspects of innovative culture but feeling of security exerts a stronger and more holistic impact, i.e. it influences all the dimensions of culture, albeit with a different power. Feeling of security has special significance for stimulating creativity of the personnel (*H6*), while it has a relatively weaker impact on their acceptance of risk (*H10*). Feeling of security at workplace, which guarantees stability, durability and openness in relations, enhances creativity of staff and gives them freedom to try non-conventional solutions to problems (Von Krogh et al., 2000). Many authors emphasize that a supportive and safe climate is important for creativity (Jia et al., 2014).

On the one hand, embarking on risky enterprises requires a feeling of security and assurance which comes with trust (Neves & Eisenberger, 2014) and, on the other hand, determination and self-confidence depend on certain personal factors along with risk propensity and perceived competence (Zuckerman & Kuhlman, 2000). For this reason, the impact of impersonal trust in both dimensions onto risk acceptance is weaker (*H5*, *H10*). These results are, to some degree, supported by other authors. In the literature, it is commonly believed that there is a relationship between the level of trust and risk perception (Colquitt et al., 2007; Baer et al., 2018), and that the level of risk acceptance is also connected with risk perception. Thus far, the link between trust and risk in intraorganisational relationships has been analysed only in the context of interpersonal relations (Meyer et al., 1995).

The authors point out that behaviour depends on the ratio of trust levels to the degree of perceived risk, which means that whenever the level of trust exceeds the threshold of perceived risk, the trustor is willing to take risks in the relationship. The obtained result suggests that a similar dependence exists for impersonal trust and propensity for risk taking in organisations.

Organisational assurance, i.e. a conviction about the clarity of rules and principles, open communication and making staff feel they are included in organisational processes, has a weaker impact on the dimensions of innovative culture when compared to feeling of security. Importantly, hypothesis *H2* about the impact of this dimension of trust on creativity was not confirmed. The literature does not fully support the result, as some authors point out that the system and structural solutions support creativity of staff members (Andriopoulos, 2001). However, the dependence requires further and deeper-reaching research.

Conclusion

This study gains understanding about how impersonal trust (both dimension: feeling of security and organisational assurance) influence on innovative culture. The main results is that trust strongly affect all aspects of innovative culture but feeling of security exerts a stronger and more holistic impact than organisational assurance. The feeling of security influences all the dimensions of culture, albeit with a different power. Whereas the impact of organisational assurance on creativity was not confirmed.

Theoretical Contribution

The present study addresses the question of the relationship between impersonal trust and innovative culture, which has been virtually ignored in the literature. As was indicated, the concept of innovative culture has not been widely discussed by researchers. There is, therefore, a cognitive gap regarding the factors that stimulate the development of such a culture.

Our study contributes to the elimination of this deficiency by indicating two dimensions of impersonal trust as their determinants.

The majority of studies search for determinants of innovation in enterprises. According to Škerlavaj et al. (2010), this complex issue is a combination of two constructs: (1) innovative culture and (2) innovations in

products, services (technical innovations) and processes. A comprehensive approach to this phenomenon can result in conclusions that are insufficiently precise because the studied sub-constructs have potentially varying strengths of links with the independent variables, e.g. trust and other determinants. Therefore, two possible solutions can be considered. The first one involves separating these two constructs (a culture of innovation and innovation as such) and attempting to identify the nature of the relationship that exists between each of them and the independent variables. However, the weakness of such an approach is that data regarding innovation are not readily available and that one must rely on opinion surveys, which merely gauge *perceived* innovation levels. The other solution involves creating a model including one of the constructs, e.g. innovation culture, in relation to independent variables. This is associated with the difficulty in distinguishing (in the opinions of respondents, without referring to hard data on innovation) between innovative culture which influences the conditions for innovative activity and the outcomes of these conditions. In this paper, the second of these two solutions is chosen. Omitting the remaining elements of innovativeness makes it possible to better understand the mechanism of the studied phenomenon, i.e. the impact of impersonal trust on innovative culture, because, as Neal and Shon (1976) observe, the choice of what to take into consideration or ignore in a model depends on the purpose of this model or, in other words, on the question which the model addresses.

Many authors have indicated the influence of perceived innovative culture on improvement of performance or its characteristics and on outcome-oriented issues (Jamrog et al., 2006). Therefore, identification of the determinants of innovative culture seems to be a significant challenge for researchers and business practitioners. This study offers an elaboration on the literature of the subject by documenting the influence of specific dimensions of impersonal trust on the particular dimensions of innovative culture. The obtained results also suggest a moderate impact of impersonal trust on the dimension of culture that stimulates employees to take risks. Unlike other research, the current study emphasises that no association exists between organisational assurance and creativity. The theoretical contribution of

the paper also involves identification of and differentiation between the dimensions of a culture of innovation and impersonal trust.

Managerial Implication

Trust is a phenomenon/value of exceptional importance in the contemporary business environment. For this reason, many authors point out to the need to deliberately build organisational cultures based on trust in order to keep the position of an enterprise oriented towards competing through innovation to fully deploy the power of human potential and obtain higher efficiency of companies, thus strengthening their competitive edges. In particular, it is important to build impersonal trust, which seems to have escaped the attention of researchers and practitioners. Similarly to the introduction of changes, building trust in an organisation should start from the 'top', i.e. from impersonal trust which would provide a basis for enhancing trust between people (Pennington et al., 2003; Nyhan, 1999). This paper offers guidelines on how to build the credibility of organisations in the eyes of employees. Therefore, it proposes a set of guidelines to form trust-based relations between employees and their organisations.

Impersonal trust represents a significant value for an organisation and, in addition, it contributes to creating innovative cultures. To exist and thrive, this kind of culture needs not only deeply rooted and clearly communicated values and standards but also tools that would support it, such as systems of rewards for innovators, organisational support for innovators, codes of ethics, training aimed at developing good relations and stimulating cooperation, procedures for solving conflicts or disputes in the workplace. What is more, it takes a long-term and well-planned effort to build an innovation-supporting culture. Therefore, the paper prepares managers for changes by identifying the dimension of impersonal trust that contributes to building a specific 'element' of innovative culture. Managers encouraging employees to innovate should first of all pay attention to the feeling of security as a dimension of impersonal trust. This dimension, apart from the fact that it strongly influences innovative culture as a whole, is particularly important in supporting creativity. Convincing employees that their interests are protected encourages them to be creative, which is connected with

the risk of failure and requires overcoming fear thanks to the feeling of security.

Limitations and Directions for Further Research

Undoubtedly, the limitation of the paper is the research sample, i.e. participation of large and medium-sized enterprises, which remained in the sample after small enterprises had been eliminated, in the research. Such an approach, while resulting from the objective of the research, does not guarantee that the sample is representative, thus making generalisation of the research results impossible.

Another obvious limitation is the fact of surveying employees' opinions, particularly about innovative culture. Firstly, in the literature on management, the terms: 'organisational culture' and 'organisational climate' are sometimes interchangeable (Barker, 1994). A lot of research on organisational climate was conducted in the 1980s and 1990s, but recently these topics have been far from popular. The relationships between these two constructs are not unambiguously defined and, to some extent, it is difficult to identify them precisely. Culture is interpreted as a set of assumptions, values and beliefs which give sense to an organisation and, consequently, it seems less distinctive (less prone to assumptions) than climate which comprises empirically available components such as behaviour or attitudes. Therefore, participants of an organisation find it much easier to identify its organisational climate since its elements are more accessible to experience. For the same reason, it is easier to measure.

Secondly, many researchers share the view that research with the pool of respondents recruited among employees of the researched organisation may only examine organisational climate, i.e. the external layer of a work culture (Bjerke, 2004). However, some scientists emphasise that, in fact, perceived corporate culture is analysed in qualitative research of organisational culture (Ortega-Parra & Sastre-Castillo, 2013). The construct 'perceived corporate culture' seems convergent with organisational climate. So the introduction of the term 'perceived corporate culture' may be partially deemed as an attempt to reconcile the above-presented positions. In this study, in spite of the doubts discussed above, the term 'innovative culture' was used after Dobni (2008)

and other contemporary researchers of the subject. As pointed out in the paper, there are a number of doubts as to the method used to analyse and study innovative culture and, more extensively, organisational culture. As a more correct solution, the authors would definitely suggest supplementing quantitative research with qualitative research. In addition, research into the matter could also go in the direction of analysing enterprises per sector.

References

- Ahmed, P. K. (1998). Culture and climate for innovation. *European Journal of Innovation Management*, 1(1), 30–43. <https://doi.org/10.1108/14601069810199131>
- Andriopoulos, C. (2001). Determinants of organisational creativity: a literature review. *Management Decision*, 39(10), 834–841. <https://doi.org/10.1108/00251740110402328>
- Alvesson, M. (1991). Organisational symbolism and ideology. *Journal of Management Studies*, 28(3), 207–226. <https://doi.org/10.1111/j.1467-6486.1991.tb00945.x>
- Armstrong, M. (2011). *Zarządzanie zasobami ludzkimi*. Warszawa: Wolters Kluwer Business.
- Atkinson, S., & Butcher, D. (2003). Trust in managerial relationships. *Journal of Managerial Psychology*, 18(4), 282–304. <https://doi.org/10.1108/02683940310473064>
- Baer, M., van der Werff, L., Colquitt, J., Rodell, J. B., Zipayand, K., & Buckley, F. (2018). Trusting the "Look and Feel": Situational Normality, Situational Aesthetics, and the Perceived Trustworthiness of Organisations. *Academy of Management Journal*, 61(5), 1718–1740. <https://doi.org/10.5465/amj.2016.0248>
- Bahman, R., & Ipken, A. C. (2011). Understanding Institutional-based Trust Building Processes in Inter-organizational Relationships. *Organization Studies*, 32(2), 281–301. <https://doi.org/10.1177/0170840610397477>
- Barker, R. (1994). Relative utility of culture and climate analysis to an organisational change agent: an analysis of general dynamics, electronics division. *International Journal of Organisational Analysis*, 2(1), 68–87. <https://doi.org/10.1108/eb028802>
- Bentler, P. (1995). *EQS Structural Equations Program Manual*. Encino, CA: Multivariate Software.
- Bentler, P. (2007). Can scientifically useful hypotheses be tested with correlations?

- American Psychologist*, 62(8), 772–782. <https://doi.org/10.1037/0003-066x.62.8.772>
- Bidault, F., & Castello, A. (2008). *Trust and Creativity: Identifying the Role of Trust in Creativity-Oriented Joint-Developments* (Working Paper No. 08-010). Berlin: ESMT. <https://doi.org/10.2139/ssrn.1436971>
- Bjerke, B. (2004). *Kultura a style przywództwa*. Kraków: Oficyna Ekonomiczna.
- Bogers, M. (2011). The Open Innovation Paradox: Knowledge Sharing and Protection in R&D Collaborations. *European Journal of Innovation Management*, 14(1), 93–117. <https://doi.org/10.1108/14601061111104715>
- Cameron, K. S., & Quinn, R. E. (2003). *Kultura organizacyjna – diagnoza i zmiana*. Kraków: Oficyna Ekonomiczna.
- Cameron, K. S., & Spreitzer, G. M. (2011). Introduction. What is positive about Positive Organisational Scholarship? In K. S. Cameron & G. M. Spreitzer (Eds.), *The Oxford Handbook of Positive Organisational Scholarship* (pp. 1–14). Oxford/New York, NY: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199734610.001.0001>
- Carolyn, L. (2009). Driving productivity, engagement and innovation by building trust. *Human Resources*, 13(5), 24–26.
- Chang, S. C., & Lee, M. S. (2007). A study on relationship among leadership, organisational culture, the operation of learning organisation and employees' job satisfaction. *The Learning Organisation*, 14(2), 155–185. <https://doi.org/10.1108/09696470710727014>
- Colquitt, J. A., Scott, B. A., & LePine, J. A. (2007). Trust, trustworthiness, and trust propensity: A meta-analytic test of their unique relationships with risk taking and job performance. *Journal of Applied Psychology*, 92(4), 909–927. <https://doi.org/10.1037/0021-9010.92.4.909>
- Colquitt, J. A., Noe, R. A., & Jackson, C. L. (2002). Justice in teams: Antecedents and consequences of procedural justice climate. *Personnel Psychology*, 55(1), 83–109. <https://doi.org/10.1111/j.1744-6570.2002.tb00104.x>
- Davenport, T. H., & Prusak, L. (2000). *Working knowledge: How organisations manage what they know*. Boston, MA: Harvard Business School Press.
- Davis, T. (1985). Managing Culture at the Bottom. In R. H. Kilmann, M. J. Saxton, & R. Serpa (Eds.), *Gaining Control of the Corporate Culture*. San Francisco, CA: Jossey-Bass.
- Deal, T. E. & Kennedy, A. A. (1982). *Corporate Cultures: The Rites and Rituals of Corporate Life*. London: Penguin Books.
- Dirks, K. T., & Ferrin, D. L. (2001). The role of trust in organizational settings. *Organization Science*, 12(4), 450–467. <https://doi.org/10.1287/orsc.12.4.450.10640>
- Dirks, K. T., & Ferrin, D. L. (2002). Trust in leadership: meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611–628. <https://doi.org/10.1037/0021-9010.87.4.611>
- Dobni, C. B. (2008). Measuring innovation culture in organisations. The development of a generalized innovation culture construct using exploratory factor analysis. *European Journal of Innovation Management*, 11(4), 539–559. <https://doi.org/10.1108/14601060810911156>
- Doney, P. M., Cannon, J. P., & Mullen, M. R. (1998). Understanding the Influence of National Culture on the Development of Trust. *Academy of Management Review*, 23(3), 601–620. <https://doi.org/10.5465/amr.1998.926629>
- Ellonen, R., Blomqvist, K., & Puumalainen, K. (2008). The role of trust in organisational innovativeness. *European Journal of Innovation Management*, 11(2), 160–181. <https://doi.org/10.1108/14601060810869848>
- Ford, D. P. (2004). Trust and knowledge management: the seeds of success. In C. W. Holsapple (Ed.), *Handbook on Knowledge Management* (pp. 553–575). Berlin, Heidelberg: Springer-Verlag. <https://doi.org/10.1007/978-3-540-24746-3>
- Gadomska-Lila, K. (2011). Metodologia badań kultury organizacyjnej. *Edukacja Ekonomistów i Menedżerów: problemy, innowacje, projekty*, 21(3), 11–25. <https://doi.org/10.5604/01.3001.0009.5746>
- García Rodríguez, N., José Sanzo Pérez, M., & Trespalacios Gutiérrez, J. A. (2007). Interfunctional trust as a determining factor of a new product performance. *European Journal of Marketing*, 41(5/6), 678–702. <https://doi.org/10.1108/03090560710737688>
- Glińska-Neweś, A. (2013). Employee interpersonal relationship. In M. J. Stankiewicz (Ed.), *Positive management Managing the Key Areas of Positive Organisational Potential for Company Success* (pp. 126–154). Toruń: TNOiK.
- Guiso, L., Sapienza, P., & Zingales, L. (2015). The value of corporate culture. *Journal of Financial Economics*, 117(1), 60–76. <https://doi.org/10.3386/w19557>

Hampden-Turner, C., & Trompenaars, F. (2001). *Riding the Waves of Culture*. London: John Murray Press.

Heyns, M., & Jearey, A. (2013). Dimensionality of interpersonal trust and its relationship to innovativeness. *The Journal for Transdisciplinary Research in Southern Africa*, 9(1), 159–170. <https://doi.org/10.4102/td.v9i1.223>

Hofstede, G. (1980). Attitudes, values and organisational culture: disentangling the concepts. *Organisation Studies*, 19(3), 477–493. <https://doi.org/10.1177/017084069801900305>

Hofstede, G. (1984). *Cultures Consequences. International Differences in Work Related Values*. London: Sage Publication Inc.

Jamrog, J. J. (2006). *The Quest for Innovation: A Global Study of Innovation 2006–2016*. New York, NY: American Management Association.

Jia, L., Show, J. D., Tsui, A. S., & Park T.-Y. (2014). A Social–Structural Perspective on Employee–Organisation Relationships and Team Creativity. *Academy of Management Journal*, 57(3), 869–891. <https://doi.org/10.5465/amj.2011.0147>

Katz, D., & Kahn, R. L. (1978). *The Social Psychology of Organisations*. New York, NY: John Wiley and Sons.

Kluckhohn, C. (1951). The Study of Culture. In D. Lerner & H. Dwight Lasswell (Eds.), *The Policy Science* (pp. 74–93). Stanford, CA: Stanford University Press.

Kramer, R. M. (1999). Trust and distrust in organisations: emerging perspectives and enduring questions. *Annual Review of Psychology*, 50(1), 569–598. <https://doi.org/10.1146/annurev.psych.50.1.569>

Krot, K. (2010). Zaufanie instytucjonalne jako społeczna determinanta innowacyjności przedsiębiorstw. In D. Lewicka (Ed.), *Wyzwania dla współczesnych organizacji w warunkach konkurencyjnej gospodarki*. Kraków: Wydawnictwo AGH.

Krot, K., & Lewicka, D. (2016). *Zaufanie w organizacji innowacyjnej*. Warszawa: C. H. Beck.

Lau, C. M., & Ngo, H. Y. (2004). The HR system, organisational culture, and product innovation. *International Business Review*, 13(6), 685–703. <https://doi.org/10.1016/j.ibusrev.2004.08.001>

Lewicka, D. (2010). The impact of HRM on creating proinnovative work environment.

International Journal of Innovation and Learning, 7(4), 430–449. <https://doi.org/10.1504/IJIL.2010.032932>

Lewicka, D., & Krot, K. (2015). The model of HRM-trust-commitment relationships. *Industrial Management & Data Systems*, 115(8), 1457–1480. <https://doi.org/10.1108/imds-12-2014-0388>

Lewicka, D., & Rakowska, A. (2017). Calculative and affective commitment – the case study of the best Polish employer Gaz Transmission Operator. *Argumenta Oeconomica*, 39(2), 213–235. <https://doi.org/10.15611/aoe.2017.2.09>

Lewis, J. D., & Weigert, A. (1985). Trust as a social reality. *Social Forces*, 63(4), 967–985. <https://doi.org/10.2307/2578601>

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organisational trust. *Academy of Management Review*, 20(3), 709–734. <https://doi.org/10.2307/258792>

McEvily, B., Perrone, V., & Zaheer, A. (2003). Trust as an Organizing Principle. *Organisation Science*, 14(1), 91–103. <https://doi.org/10.1287/orsc.14.1.91.12814>

McKnight, D. H., Choudhury, V., & Kacmar, C. (2002). Developing and Validating Trust Measures for e-Commerce: An Integrative Typology. *Information Systems Research*, 13(3), 334–359. <https://doi.org/10.1287/isre.13.3.334.81>

McKnight, D. H., & Chervany, N. L. (2001). Trust and Distrust Definitions: One Bite at a Time. In R. Falcone, M. Singh, & Y. H. Tan (Eds.), *Trust in Cyber-societies. Lecture Notes in Computer Science* (Vol. 2246, pp. 27–54). Berlin, Heidelberg: Springer. https://doi.org/10.1007/3-540-45547-7_3

Muñoz-van den Eynde, A., Cornejo-Cañamares, M., Diaz-Garcia, I., & Muñoz, E. (2015). Measuring Innovation Culture: Development and Validation of a Multidimensional Questionnaire. *Advances in Research*, 4(2), 122–141. <https://doi.org/10.9734/air/2015/15533>

Naranjo-Valencia, J. C., Valle, R. S., & Jimenez, D. J. (2010). Organisational culture as determinant of product innovation. *European Journal of Innovation Management*, 13(4), 466–480. <https://doi.org/10.1108/14601061011086294>

Neal, F., & Shone, R. (1976). *Economic Model Building*. London: Palgrave. https://doi.org/10.1007/978-1-349-15673-3_5

Neves, P., & Eisenberger, R. (2014). Perceived organisational support and risk

- taking. *Journal of Managerial Psychology*, 29(2), 187–205. <https://doi.org/10.1108/jmp-07-2011-0021>
- Nyhan, B. (1999). Building learning organisations: putting theory to the test – lessons from European companies. *The European Vocational Training Journal*, 16, 14–23.
- O'Reilly, C. A. (1989). Corporations, Culture and Commitment: Motivation and Social Control in Organisations. *California Management Review*, 31(4), 9–25. <https://doi.org/10.2307/41166580>
- Ortega-Parra, A., & Sastre-Castillo, M. A. (2013). Impact of perceived corporate culture on organizational commitment. *Management Decision*, 51(5), 1071–1083. <https://doi.org/10.1108/md-08-2012-0599>
- Pavlou, P. A., Tan, Y. H., & Gefen, D. (2002). The Transitional Role of Institutional Trust in Online Interorganisational Relationships. In *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03)*. Big Island, HI, USA. <https://doi.org/10.1109/hicss.2003.1174574>
- Pennington, R., Wilcox, H. D., & Grover, V. (2003). The Role of System Trust in Business-to-Consumer Transactions. *Journal of Management Information*, 20(3), 197–226. <https://doi.org/10.1080/07421222.2003.11045777>
- Robinson, S. L. (1996). Trust and breach of the psychological contract. *Administrative Science Quarterly*, 41(4), 574–599. <https://doi.org/10.2307/2393868>
- Rolland, N., & Chauvel, D. (2000). Knowledge transfer in strategic alliances. In C. Despres & D. Chauvel (Eds.), *Knowledge Horizons: The Present and the Promise of Knowledge Management* (pp. 225–236). Boston, MA: Butterworth Heinemann. <https://doi.org/10.1016/b978-0-7506-7247-4.50014-8>
- Schein, E. H. (1984). Coming to a New Awareness of Organisational Culture. *Sloan Management Review*, 25(2), 3–16.
- Schein, E. H. (1985). How Culture Forms, Develops and Changes. In R. H. Kilmann, M. J. Saxton, & R. Serpa (Eds.), *Gaining Control of the Corporate Culture*. (pp. 17–43). San Francisco, CA: Jossey-Bass.
- Schneider, B., Gunnarson, S. K., & Niles-Jolly, K. (1994). Creating the climate and culture of success. *Organisational Dynamics*, 23(1), 17–29. [https://doi.org/10.1016/0090-2616\(94\)90085-x](https://doi.org/10.1016/0090-2616(94)90085-x)
- Shapiro, S. P. (1987). The Social Control of Impersonal Trust. *American Journal of Sociology*, 93(3), 623–658. <https://doi.org/10.1086/228791>
- Shockley-Zalabak, P., Ellis, K., & Winograd, G. (2000). Organisational trust: What it means, why it matters. *Organisation Development Journal*, 18(4), 35–48.
- Semerciöz, F., Hassan, M., & Aldemir, Z. (2011). An Empirical Study on the Role of Interpersonal and Institutional Trust in Organisational Innovativeness. *International Business Research*, 4(2), 125–136. <https://doi.org/10.5539/ibr.v4n2p125>
- Smircich, L. (1983). Concepts of Culture and Organisational Analysis. *Administrative Science Quarterly*, 28(3), 339–358. <https://doi.org/10.2307/2392246>
- Six, F. (2005). *The Trouble with Trust: The Dynamics of Interpersonal Trust Building*. Cheltenham: Edward Elgar. <https://doi.org/10.4337/9781845426873>
- Škerlavaj, M., Song, J. H., & Lee, Y. (2010). Organizational learning culture, innovative culture and innovations in South Korean firms. *Expert Systems with Applications*, 37(9), 6390–6403. <https://doi.org/10.1016/j.eswa.2010.02.080>
- Sułkowski, Ł., & Sikorski, C. (2014). *Metody zarządzania kulturą organizacyjną*. Warszawa: Difin.
- Sydow, J., Schreyögg, G., & Koch, J. (2009). Organisational path dependence: Opening the black box. *Academy of Management Review*, 34(4), 689–709. <https://doi.org/10.5465/amr.34.4.zok689>
- Trompenaars, F., & Hampden-Turner, C., (2004). *Managing people across cultures*. London: Capstone Publishing.
- Trompenaars, F. (2010). *Kultura innowacji: kreatywność pracowników a sukces firmy*. Warszawa: Wolters Kluwer.
- Trunk Širca, N., Babnik, K., & Breznik, K. (2013). Towards organisational performance: Understanding human resource management climate. *Industrial Management & Data Systems*, 113(3), 367–384. <https://doi.org/10.1108/02635571311312668>
- Tschannen-Moran, M., & Hoy, W. K. (2000). A multidisciplinary analysis of the nature, meaning, and measurement of trust. *Review of Educational Research*, 70(4), 547–593. <https://doi.org/10.3102/00346543070004547>
- Tyler, T. R. (2003). Trust within organisations. *Personnel Review*, 32(5), 556–568. <https://doi.org/10.1108/00483480310488333>

Wallace, J., Hunt J., & Richards, C. (1999). The relationship between organisational culture, organisational climate and managerial values. *The International Journal of Public Sector Management*, 12(7), 548–564. <https://doi.org/10.1108/09513559910305339>

Vanhala, M., & Ahteela, R. (2011). The effect of HRM practices on impersonal organisational trust. *Management Research Review*, 34(8), 869–888. <https://doi.org/10.1108/01409171111152493>

Vanhala, M., Puumalainen, K., & Blomqvist, K. (2011). Impersonal trust. The development of the construct and the scale. *Personnel Review*, 40(4), 485–513. <https://doi.org/10.1108/00483481111133354>

Vanhala, M., & Ritala, P. (2016). HRM practices, impersonal trust and organisational innovativeness. *Journal of Managerial Psychology*, 31(1), 95–109. <https://doi.org/10.1108/jmp-03-2013-0084>

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling Knowledge Creation. How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation*. New York, NY: Oxford University Press.

Yilmaz, C., & Ergun, E. (2008). Organizational culture and firm effectiveness: An examination of relative effects of culture traits and the balanced culture hypothesis in an emerging economy. *Journal of World Business*, 43(3), 290–306. <https://doi.org/10.1016/j.jwb.2008.03.019>

Zeffane, R., & Connell, J. (2003). Trust and HRM in the new millennium. *The International Journal of Human Resource Management*, 14(1), 3–11. <https://doi.org/10.1080/09585190210158484>

Zuckerman, M., & Kuhlman, D. M. (2000). Personality and risk-taking: Common biosocial factors. *Journal of Personality*, 68(6), 999–1029. <https://doi.org/10.1111/1467-6494.00124>

ALTER EGO ONLY FOUR TIMES? THE CASE STUDY OF BUSINESS PROFITS IN THE VISEGRAD GROUP

**Katarína Valášková¹, Beáta Gavurová², Pavol Ďurana³,
Mária Kováčová⁴**

¹ University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics, Slovakia, ORCID: 0000-0003-4223-7519, katarina.valaskova@fpedas.uniza.sk;

² Tomas Bata University in Zlín, Faculty of Management and Economics, Center for Applied Economic Research, Czech Republic, ORCID: 0000-0002-0606-879X, gavurova@utb.cz;

³ University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics, Slovakia, ORCID: 0000-0001-5975-1958, pavol.durana@fpedas.uniza.sk;

⁴ University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics, Slovakia, ORCID: 0000-0003-2081-6835, maria.kovacova@fpedas.uniza.sk.

Abstract: The paper studies a new point of view and the approach to profit as an inherent part of business finance as well as a symbol of every healthy economy. The fundamental function of the profit is a stimulus; it means initial motivator of the business activity. The profit provides core resources for survival at the business start and after the stabilization, it is the synonym for progress. The aim of this paper is to detect significant change-points in times series of EBITDA during the analysed period in every country of the Visegrad Group to recognize the progress years in the monotonic development. We use a method of homogeneity test of time series that delivers significant robust results. We observe the variable EBITDA to eliminate different tax, interest and depreciation policies of these emerging countries. The original research of this article is based on empirical results of business profits of the sample of 3,853 enterprises covered by the broad theoretical review. Firstly, we identify missing values; and detect the outliers by Z-score and Grubbs test. EBITDA of 1,058 Slovak enterprises, 688 Czech enterprises, 1,376 Polish enterprises and 731 Hungarian enterprises is analysed during the period from 2010 to 2018. We eliminate the inconsistent observations and construct average values of EBITDA. Secondly, we prove normality by Jarque-Bera test, and support it by Shapiro-Wilk test, Anderson-Darling test, Lilliefors test to deliver reliable results. Thirdly, we find an independency of distribution that confirm randomness by the Box-Pierce test. And finally, we identify the years that affect heterogeneity of EBITDA in the countries of the Visegrad Four. We uncover some really surprising results. For all countries in the Visegrad Four, the year 2013 is detected as a change-point at a significance level of 0.05. This significant year shifts EBITDA between two homogeneous series with corresponding central lines and recognizes the similar annual development within the groups. In addition, we discuss the results to the areas and factors affecting the business risk. The adjustable area represented by the business dynamism has no significant impact on the development of EBITDA. The uncontrollable macroeconomic factors such as a GDP, unemployment rate, inflation rate, average monthly gross wage, and Ease of doing business index demonstrate the same development of Slovak, Czech, Polish and Hungarian enterprises. We connect our gained results to the undisputed influence of these factors and its derived components on monotonic development of EBITDA. Despite the fact, that the countries are not economically interconnected as they used to be in the past, in has to be underlined that their mutual relations are still very narrow and close and that might be the reason, why identical results are achieved in the countries with divergent development.

Keywords: Business finance, change-point, profit, uniformity, Visegrad Four.

JEL Classification: G30, G32.

APA Style Citation: Valášková, K., Gavurová, B., Ďurana, P., & Kováčová, M. (2020). Alter Ego Only Four Times? The Case Study of Business Profits in the Visegrad Group. *E&M Economics and Management*, 23(3), 101–119. <https://doi.org/10.15240/tul/001/2020-3-007>

Introduction

Globalization is the process of international integration arising from the interchange of world views, products, ideas and other aspects of the culture. Globalization brings together new opportunities also new threads (Vagner, 2016). Many studies have been published that assess business environment quality, risk, determinants, and influencing factors (Rowland, 2019). The enterprises must define the nature of the profit, the conditions of its creation, their importance for society, the legislative framework, the particular aim and also the financing conditions in the country (Vagner & Zadnanova, 2019) to be on the side of winners in the global market. The aim of this paper is to detect significant change-points in times series of EBITDA during the analysed period in every country of the Visegrad Group to recognize the progress years in the monotonic development. We identify the research gap in this issue because no studies focus on homogeneity of time series of business profit both in the area of Visegrad group and in the European Union. Detection of the change-points (break years within the development) in time series of profits in Visegrad Four has not been realized and the results of the analysis should be highlighted not only for the theoretical importance but also for the importance for business practice. To show the break point, when the changes in the profit development occurred – dividing the development into two homogenous series – and gain the causes of their existence could mean the starting point to understand them, used them and finally, even to force them to more change-points with positive consequences.

The results of the analysis play an important role in the research on the earnings management phenomenon in the selected European countries, where the incentive is to reveal the existence of earnings management by time series analysis. The investigation of the presence of manipulation with earnings in these countries may contribute to the justification of earnings management occurrence. As the issue of the manipulation with earnings in these countries is discussed by researchers and academicians only in Poland,

and the level of knowledge in other three countries remains unexplored, the significance of the analysis of unique country samples has to be underlined. Determination of earnings management practices has to be depicted as it is a significant factor of business partners' protection against risks which can appear if distorted and incomplete information is presented by the enterprises in their financial reports.

Our paper is structured as follows. Firstly, the theoretical background is presented, concentrating on the analyses of different aspects associated with the issue of business profits. Secondly, the materials used and methods applied in this research are portrayed. The next part of the paper presents the research results and analyses the results in detail. Finally, the limitations of the study, potential areas of further research as well as the conclusions are discussed.

1. Theoretical Background

The theoretical background of the paper focuses on four main domains which have significant effect on the success of the corporate transformation process. They reflect the basic functions of corporate earnings; to be able to make decisions about the crucial economic issues of an enterprise, to ensure key sources needed for the sustainable development of a company and its innovation policy and to redistribute the earnings achieved (e.g. corporate citizenship) in order to boost the performance of enterprises.

1.1 Maximization versus Ethics

Entrepreneurship is a process that recognizes opportunities in the environment or society which involves mobilizing resources in providing improved goods and services with the aim of profit maximization as a reward of risk-taking (Kowo et al., 2019; Belás & Sopková, 2016). Risk management represents a significant contribution to the increasing competitiveness of enterprises and their profits in changes of the business environment (Hudakova et al., 2018). Anand et al. (2019) solve the profit maximization problem by optimization of the

overall advertising duration and advertising take-off point. An algorithm to solve the optimal solution is also provided by Chuang and Wu (2019). They maximize the profit by determining the supplier's optimal process mean and investment amount, the retailer's optimal number of shipments, order and maximal backorder quantities. Shahriar et al. (2016) examine whether the profit orientation affects its decision to extend loans. According Rahman et al. (2017) risky borrowers need to pledge collateral and the reduction of asymmetric information can lower the incidence of collateral for firms. Rahman et al. (2018) show that service-oriented firms use less trade credit than manufacturing firms. Primeaux and Stieber (1994) and Primeaux (1997) propose a model for business ethics which arises directly from business practice. This model is based on a behavioural definition of the economic theory of profit maximization and situates business ethics within opportunity costs. Within that context, they argue that good business and good ethics are synonymous, that ethics is at the heart and centre of business, that profits and ethics are intrinsically related. The most successful enterprises are those which have realized that their greatest assets are their employees and therefore take special care of them (Angelova et al., 2017). Manish and Sutter (2016) oppose that entrepreneurs are motivated not only by the desire to maximize profits but also by the desire for mastery. The economy and the digital age have changed the nature of work and management. More people than ever before need to master ethical thinking skills (Friedman et al., 2019). The efficiency argument for the for-profit maximization says that corporations and their managers should maximize profits because this is the course of action that will lead to an 'economically efficient' or 'welfare maximizing' outcome (Jensen, 2001, 2002). Hussain (2012) criticizes these studies and argue that the fundamental problem with this argument is not that markets in the real world are less than perfect, but rather that the argument does not properly acknowledge the personal sphere. Morality allows each of us a sphere in which we are free to pursue our personal interests, even if these are not optimal from the social point of view. But the efficiency argument does not come to terms with this feature of social life. Singer (2013) argues that Hussain's strategy of seeing the corporation

as an extension of the private sphere is not a very effective way of challenging the profit-maximization norm, but Kristofik et al. (2019) and Robson (2019) reply Hussain (2012) and argue that even if firms are required to maximize their social welfare contributions, they are not necessarily required to maximize their profits. Anderson et al. (2018) examine the possible pathways to the profit; the impact of improvements in marketing skills relative to finance skills. These gains differ substantially between the two groups. The marketing group achieves greater profits by adopting a growth focus on higher sales, greater investments in stock and materials, and hiring more employees. The finance group achieves similar profit gains but through an efficiency focus on lower costs. Podhorska et al. (2019) connect these two groups. They investigate the correlation between profitability included in the category of financial-economic analysis and goodwill of enterprises represented by residual incomes. Significant dependence between these variables is detected. Managers are often caught between the expectations of ethical consumers and the profit-maximizing expectations of the investors (Kotek et al., 2018). It has been the traditional belief that profits and ethics are at odds with each other in the world of business. Corporate governance appears to be a hindrance or a drag on profit maximization (Ghosh et al., 2011). Ghosh et al. (2011) show that moral codes, public interest and social values pose no threat to profit maximization of any firm. Gazzola et al. (2019) explore various motivations and take into consideration both extrinsic and intrinsic drivers also monetary and nonmonetary benefits. The conceptual and structural model mainstreams a motivational continuum starting from profit maximization to development.

1.2 Sustainable Development to Industry 4.0

It was only in the 20th century, with the unification of large-scale industry and finance capital that the modern notion of profitability as return on capital employed finally developed (Toms, 2010). Aram and Cowen (1990) highlight the need of the development of effective management teamwork out of a planning process for increased profit and details the investment required in strategic process development which would guarantee

the critical five per cent difference to ensure the successful growth and adaptability of the company. The proposal of Altman and Dillon (2005) can be conceptualized as a profit-related loan scheme or as a form of capped public investment. It seeks to address key elements of the market failure that exist in relation to financing development. George and Kabir (2008) examine the phenomenon of profit redistribution in business groups and relate redistribution with the underperformance of group-affiliated firms relative to unaffiliated firms. The study also documents that profit redistribution is more pronounced in groups of large sizes and high levels of corporate control. The study of Leite et al. (2013) aimed to analyse and test the development of an alternative business performance metric: profit per employee (PE). An empirical study showed that the correlation between PE and share prices was higher and more significant than the correlation with traditional metrics for the firm most intensive in intellectual capital. For the other firms, traditional metrics presented higher correlation. The concept of Industry 4.0 marks a new phenomenon of modern business. Industry 4.0 and its other synonyms such as Smart Manufacturing, Smart Production or the Internet of Things have been identified as major contributors in the context of the digital and automated manufacturing environment. The term Industry 4.0 comprises a variety of technologies to enable the development of the value chain resulting in reduced manufacturing lead times, as well as improved product quality and organizational performance (Kamble et al., 2018). Felstead (2019) develops a conceptual framework based on a systematic and comprehensive literature review on systems in Industry 4.0 to keep the business profitable. Furnham (2019) performs reviews and advances existing literature concerning big data-driven algorithmic decision-making to estimate profits. Trigos and López (2019) add to these systems by design, capacity, maintenance and salvage value. Hayhoe et al. (2019) inspect the relevant literature on sustainable manufacturing in Industry 4.0, providing both quantitative evidence on trends and numerous in-depth empirical examples to being profitable in the context of Industry 4.0. Stanovcic et al. (2016) find that firms in which top management supports the development of employees' idea and have regular employees' meetings related

to innovative activities are likely to report higher profit generated by innovations. Authors' results underline the crucial role of human resource practices in the process of innovations that generates profitability for firms.

1.3 Innovations as a Driver

Modern economy is permanently evolving and becoming more interdependent, especially in the age of globalization (Krastev et al., 2020). The rapid reshaping of the global economic order requires fundamental shifts in international business scholarship and management practice (Petricevic & Teece, 2019). The response to these global phenomena may be the ability to understand and implement business innovations and profit from them. The final, third development stage of each country is also named Innovation-driven stage. Hallberg and Brattström (2019) show that knowledge revealing may have a positive effect on profits when there are strong indirect network effects; when firms are protected from imitation by causal ambiguity, complementary assets, and intellectual property; and when the innovating firm faces high technological uncertainty. Tuyls and Pera (2019) provide theoretical and empirical research on innovative data-driven systems. Capponi et al. (2019) investigate the use and perceived effectiveness of different appropriate strategies in the context of break through innovations. They find that firms consistently combine formal and informal intellectual property to prevent imitation and that their strategies can vary over time according to the phase of development of the innovation and lead to increasing business profit. Desyllas and Sako (2013) explicate the complex mechanism and dynamic capability for business profit from business model innovation. Their paper examines how an incumbent firm could increase profit from the approach of business model innovation and how long-term competitiveness depends on the specialized complementary asset. The study of Su et al. (2013a) examines the moderating effects of legal, marketing, and technological capabilities on the relationship between product innovation and firm performance in different environmental conditions in order to identify how a firm can leverage these capabilities to profit from product innovation. It is an addition of the previous study of Su et al. (2013b) in which they point out that R&D capability

and marketing capability are two important generators of business profit. Pinxterhuis et al. (2019) suggest that the key principles, enablers and barriers, sourced from literature, provide a framework for regular reflection that will help to maintain a co-innovation approach and to define interventions or adjustments of project activities to improve the profit. Lazonick et al. (2013) discuss that Apple is changing business model of large firms. By employing the theory of innovative enterprise to analyse how over the course of its history Apple became so profitable, they argue that there is no economic justification from a risk-reward perspective for this distribution to Apple's shareholders. Taxpayers and workers have superior claims on these profits. Vranceanu (2014) assesses that large firms manage to deliver positive profits even in the most competitive environments. They can do so, thanks to internal entrepreneurs, a subset of their employees able to drive change and develop innovation in the workplace. Krech et al. (2015, 2018) map profiting from the invention. Authors identify four groups of patent aggregating companies based on the profits provided to the original patent holders: the guardians, the shielders, the funders and the earners. Hu et al. (2017) differentiate technological leaders and latecomers. Their results demonstrate that innovations affect the profits of technological leaders as well as latecomers in different ways resulting in a relationship where the two play complementary roles. The study of Kim et al. (2019) try to ensure the genuine causality of profit and also it turns out practically useful. This paper develops a business model schema as a holistic two-dimensions multi-level tool/method for business model innovation based on the direct causal mechanisms of profit. Bogliacino and Pianta (2012) firstly, invest the ability of industries' R&D efforts to turn out successful innovations and secondly, the ability of innovations to lead to high profits and Janoskova and Kral (2019) mark innovative activity as an important source of competitiveness. Li et al. (2010) warn against R&D blindness because of the fact that innovating firms sometimes fail to obtain profits from product innovation. The multiple-case study of Garst et al. (2017) investigates the connecting motive of the responsibility besides the motive of the probability of the firms for product innovation. Their study highlights the

importance of having both profit and moral motives in the innovation process when aiming for socially responsible outcomes, and how both these motives contribute and interact.

1.4 Corporate Social Responsibility or Not?

Successful global companies in the 21st century have no doubts about the need to be socially responsible and developing a number of diverse activities that are involved in improving the business condition (Moravcikova & Krizanova, 2016). One common justification for the pursuit of profit by business firms within a market economy is that profit is not an end in itself but a mean to produce and allocate resources more efficiently (Smith, 2018). Jeon et al. (2020) argue with Jones (1995) that corporate social responsibility can contribute to a company's profits through the favourable influence of corporate social responsibility initiatives on its relationships with its stakeholders. This economic dimension is also included in Corporate Social Performance model proposed by Carrol (1979) and extended by Carrol (1998). Presented economic dimension explains generating profits for stakeholders, creating jobs, and promoting the creation of innovative services and products. Friedman (1970) highlights that the only social responsibility of business is to increase its profits. Mulligan (1986) deals with a critique of Friedman essay that the social responsibility of business is to increase its profits. Freeman (1984) provides a more inclusive stakeholder perspective. McWilliams and Siegel (2001a) create a model of profit-maximizing corporate social responsibility demonstrating that common ground exists between Friedman's agency theory perspective (shareholders only) and Freeman's more inclusive stakeholder perspective. They clarify some misconceptions regarding their model (McWilliams & Siegel, 2001b). If managers engage in the types of corporate social responsibility they identify, managers simultaneously satisfy shareholders and other primary stakeholders (i.e. consumers). Profit-maximizing corporate social responsibility also allows reconciling the conflicting empirical evidence of the impact of corporate social responsibility on financial performance (McWilliams & Siegel, 1997, 2000). Their model specifically demonstrates that, in equilibrium,

corporate social responsibility should have a neutral impact on performance. Furthermore, a model of profit-maximizing corporate social responsibility allows assessing the strategic implications of corporate social responsibility (Siegel, 2001). McWilliams et al. (2006) describe a variety of perspectives on corporate social responsibility, which they use to develop a framework for consideration of the strategic implications of corporate social responsibility. Blomgren (2011) investigates the relationship between corporate social responsibility and profits while avoiding the most important methodological pitfalls of the quantitative research and acknowledging the distinction between corporate social responsibility as a strategy for achieving average profits and as a strategy for achieving above-average profits. Socially responsible activities help create business profit, develop strategic resources, and insure against risks, but on the other hand, also cost money and distract management (Wang & Bansal, 2012). Gil Salmerón (2016) questions: Can the most responsible companies be more profitable? His study proves the higher level of corporate social responsibility used, the more profitable the companies are. These conclusions are determined from a linear regression analysis comparing the Return on Assets. The redistribution of part of business profit to the employees is a credible commitment on the part of companies to allow their employees to participate in any efficiency gain. The employees are motivated to share their specific information advantage on possibilities to optimize the production process and products with the management (Aerts, Kraft, & Lang, 2015). The survey of Krizanova et al. (2016) has shown that for employees, it is important to work for a socially responsible employer. Satisfied employees significantly contribute to the strengthening of the business profit.

2. Materials and Research Methodology

The secondary sources are observations of earnings before interest, taxes, depreciation and amortization (EBITDA) of Visegrad Four's enterprises. 1,347 Slovak enterprises, 859 Czech enterprises, 2,554 Polish enterprises and 880 Hungarian enterprises were extracted from the Amadeus database (provided by Moody's analytics company Bureau van Dijk) capturing years 2010 to 2018. The variable

EBITDA is chosen to eliminate different tax, interest and depreciation policies of these emerging countries. The enterprises have to meet three set criteria: the value of total assets at the minimal level of 3,000,000 EUR; the value of total sales at the minimal level of 2,000,000 EUR; the value of net income at least 100,000 EUR. These criteria were applied to recognize only the financial stable enterprises and to analyse business entities of the same economic and financial background to mitigate the problems of the classification by size, year of operation or turnover achieved. In the research, a purposive sampling was used, thus the sample of enterprise is considered representative. Purposive sampling is a sampling technique in which researcher relies on their own judgment when choosing members of population to participate in the study (e.g. Singh & Masaku, 2014). This type of sampling can be very useful in situations when there is a need to reach a targeted sample quickly, and where sampling for proportionality is not the main concern.

Following methodological steps were used:

1. *The detection of outliers:* Genuine outliers are typically treated in one of the following ways: keep the outlier and treat it like any other data point, winsorise it or eliminate it (Ghosh & Vogt, 2012). The winsorising and eliminating introduce statistical bias and may undervalue the outlier, while keeping it and treating it like the other points may overvalue it and cause the estimate to vary drastically from the true population value (Ghosh & Vogt, 2012). We prefer robust statistics and results insensitive to outliers, we decided for the third choice to drop all outliers from the sample.

Different techniques and tests exist to determine if some observations are outliers. Some visual methods are frequently used as a boxplot or adjusted boxplot. Z-scores are very popular method for labelling outliers (Garcia, 2012). The problem with Z-score may occur in a small data set, because of affecting the mean and the standard deviation by outliers and it is necessary to modify Z-score. We choose Z-score to detect outliers in this research. Our research contains great/huge samples from all the countries of the Visegrad Four that is way we may use not modified Z-score.

Nevertheless, it would be dangerous to blindly accept the result of only one technique without the judgment of another expert method (Garcia, 2012) we may support Z-score by

another test used to detect outliers. Shapiro-Wilk W test is quite widely used but Cochran test, Dixon test and Grubbs test provide better results in identification. Cochran test detects crude errors. It is designed based on simple statistics – the ratio of maximum (or minimum) variance to the sum of all variances (Komsta, 2006). Simple statistics was already used in Z -score, more sophisticated approach is needed. Garcia (2012) discusses the possibility of the occurrence of the situations of additional outliers by Dixon test. We must minimize the effect of outliers, thus we decided to support Z -score by Grubbs test. Grubbs test detects one outlier at a time assuming a normal distribution. This outlier is expunged from the dataset and the test is iterated until no outliers are detected. Testing if the minimum or maximum values are outliers or testing of two opposite outliers are possibilities of Grubbs test (Garcia, 2012). First test was selected and also Garcia (2012) notes that this test is also called Modified Thomson Tau or the maximum normed residual test.

2. *The normality proving:* Normality is often a maintained assumption in estimation and finite-sample inference (Bai & Ng, 2012). Basically, normality is checked using Q-Q plot, histogram, boxplot and steam-and-leaf-plot. These graphical methods are supported by numerical methods as a skewness and kurtosis. Formal normality test should be performed before any conclusion about the normality of the data. There are nearly 40 tests of normality in statistical literature (Dufour et al., 1998). The tests in question are e.g. Chi-squared, Kolmogorov-Smirnov, Anderson-Darling, Kuiper, Shapiro-Wilk, Ajne, modified Ajne, modified Kuiper, D'Agostino, modified Kolmogorov-Smirnov, Lilliefors test, Vasicek, and Jarque-Bera tests, etc (Yazici & Yolacan, 2007; Razali & Wah, 2011). Bai and Ng (2005) recommend to test the normality of time series data by Jarque-Bera test. We supported this test by Shapiro-Wilk W test, Anderson-Darling test, Lilliefors test. Shapiro and Wilk (1965) test was originally restricted for sample of less than 50 observations. Chen (1971) highlights the power of the Shapiro-Wilk W statistic demonstrated favourable sensitivity in testing normality under different contaminated normal distributions. Lilliefors test is a modification of the Kolmogorov-Smirnov test. It is preferred in the cases when it is difficult to initially or completely specify the parameters of the distribution is unknown, which is typical of our research. Grubbs test focuses on

outliers from the minimum or maximum values and we complementary performed Anderson-Darling test (modification of the Cramer-von Mises test) to give more weights to the tails of distribution by proving normality (Farrell & Rogers-Stewart, 2006; Razali & Wah, 2011). We do not also verify the constant variance over time because of the period of time series is very short.

3. *The indication of independency distribution:*

The occurrence of the autocorrelation means that the data are not independently distributed. The Box-Pierce and Ljung-Box tests are portmanteau tests generally used to test the independence in time series data. These tests can also be applied to the squares of the observations to detect independence (Warriyar et al., 2016). Box and Pierce (1970) perform test of the randomness at each distinct lag in their study. Ljung and Box (1978) modify this test to overall randomness. We prefer the robustness of the Box-Pierce statistic to test if the finite-sample performance of financial time series is uncorrelated without assuming statistical independence.

4. *The detection of homogeneity:*

Homogeneity tests enable to determine if time series may be considered as homogeneous over time, or if there is any point (in our case a year) at which a change occurs. Many methods have been proposed to test the homogeneity. We prefer nonparametric tests in our case of annual data that are robust to large data gaps (Meals et al., 2011). Kanovsky (2018) and Agha et al. (2017) recommend to select from Standard Normal Homogeneity test (SNHT), Buishand test (BR), Von Neumann (VNR) and Pettitt's test. We run Pettitt's test using 10,000 Monte Carlo simulations to test homogeneity because of this test is the non-parametric rank test that can reveal the single break point (month or year) at a continuous data (Pettitt, 1979). According to Pohlert (2020), Pettitt's tests the H_0 : The T variables follow one or more distributions that have the same location parameter (no change), against the alternative: A change point exists. The non-parametric statistic is defined as:

$$K_T = \max |U_{t,T}| \quad (1)$$

where:

$$U_{t,T} = \sum_{i=1}^t \sum_{j=t+1}^T \text{sgn}(X_i - X_j) \quad (2)$$

The change-point of the series is located at K_T , provided that the statistic is significant. The significance probability of K_T is approximated for p -value ≤ 0.05 with:

$$p \cong 2 \exp\left(\frac{-6 K_T^2}{T^3 + T^2}\right) \quad (3)$$

The analysis allows us to formulate the following hypotheses which are verified at the significance level alpha 0.05:

Hypothesis_{1A-D}: There is a date at which a change in the data of EBITDA of Slovak, Czech, Polish and Hungarian enterprises occurred.

3. Research Results

The first point of the research is to identify an amount and the existence of missing values in origin sample and remove them. After removal of incomplete data, the subsequent evaluation of the existence of outliers in observations of EBITDA of Slovak, Czech, Polish and

Hungarian enterprises is realized by Z-score and verified by Grubbs test. Their occurrence in the sample could cause changes in the results of statistical tests and procedures (Svabova & Durica, 2019).

H_0 : There is no outlier in the data of EBITDA.

H_1 : There is at least one outlier in the data of EBITDA.

As the computed p-value is lower than the significance level alpha, one should reject the null hypothesis H_0 , and accept the alternative hypothesis H_1 , based on Tab. 1. There is at least one outlier in the observations of EBITDA. This situation happened for all of the countries of Visegrad Four.

The existence of missing values and outliers caused the reduction of origin subsamples in all cases (Tab. 2). Together 289 missing values and outliers were identified in the Slovak sample; 171 in the Czech subsamples, the biggest reduction was in Polish observations (1,178 cases) and 149 in Hungary.

Tab. 1: Grubbs test

Grubbs test	Slovakia	Czechia	Poland	Hungary
G (Observed value)	23.298	24.187	35.059	27.116
G (Critical value)	4.076	3.952	4.131	3.970
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Source: own

Tab. 2: Numbers of observations

Samples	Slovakia	Czechia	Poland	Hungary
Origin	1,347	859	2,554	880
Outliers	289	171	1,178	149
Final	1,058	688	1,376	731

Source: own

Based on annual results of earnings before interest, taxes, depreciation and amortization of 1,058 Slovak enterprises, 688 Czech enterprises, 1,376 Polish enterprises and 731 Hungarian enterprises the last step was constructed considering the data preparation and it is the calculation of and annual average

of Visegrad group's enterprises during the analysed nine-year period (Tab. 3).

To provide reliability, robustness and consistency of the results, it is necessary to prove normality. For the importance of this analytical step, four normality tests were run to ensure the quality of the results: Jarque-Bera

Tab. 3: Average EBITDA [thousands EUR]

Year	Slovakia	Czechia	Poland	Hungary
2010	1,471.379	4,526.141	1,534.720	1,410.031
2011	1,499.398	4,649.366	1,531.875	1,430.479
2012	1,505.252	4,904.937	1,609.707	1,554.215
2013	1,551.384	4,645.056	1,753.624	1,857.260
2014	1,738.280	5,031.779	1,900.449	2,084.514
2015	1,917.288	5,458.817	2,083.086	2,365.801
2016	2,046.715	5,564.691	2,213.171	2,614.866
2017	2,132.926	5,949.365	2,448.194	2,836.100
2018	2,191.428	5,952.932	2,533.370	3,033.357

Source: own

Tab. 4: Normality tests

Test/Country	Slovakia	Czechia	Poland	Hungary
Jarque-Bera test (Two-tailed)	0.589	0.638	0.662	0.670
Shapiro-Wilk test (Two-tailed)	0.111	0.217	0.326	0.419
Jarque-Bera test (Two-tailed)	0.145	0.301	0.487	0.563
Lilliefors test (Two-tailed)	0.182	0.684	0.809	0.730

Source: own

test, Shapiro-Wilk test, Anderson-Darling test and last but not least Lilliefors test.

H_0 : The variable which the sample was extracted from follows a normal distribution.

H_1 : The variable which the sample was extracted from does not follow a normal distribution.

Running of four tests of normality proving is realized because each test has its own importance for the analysis. Firstly, we use the Lilliefors test because the distribution is unknown, and it is difficult to specify the parameters initially. Secondly, our sample consists of a nine-year period that is why we have to use Shapiro-Wilk test given for the sample that involves less than 50 observations. Thirdly, it is necessary to focus on the tails of distribution and it is proved by the Anderson-Darling test. Finally, we highlight the financial data of EBITDA in the time period and considering this fact, the Jarque-Bera test is recommended for time series modelling.

As the computed p-value is greater than the significance level alpha, one cannot reject the null

hypothesis H_0 , based on Tab. 4. The hypothesis that average Slovak, Czech, Polish and Hungarian earnings before interest, taxes, depreciation and amortization are normally distributed was not rejected for all cases as well as all tests.

After proving normality, one more statistical testing is to be done before searching the year of change in time series of EBITDA. We must confirm independency of distribution, it means, that there is no serial correlation in subsamples. This randomness of the sampling process is verified by Box-Pierce test.

H_0 : The data are independently distributed (the correlations in the population which the sample is taken from are zero, so that any observed correlations in the data result from the randomness of the sampling process).

H_1 : The data are not independently distributed (they exhibit serial correlation).

As the computed p-value is greater than the significance level alpha, one cannot reject the null hypothesis H_0 , based on Tab. 5. The hypothesis that average Slovak, Czech, Polish

Tab. 5: Box-Pierce test

Box-Pierce test	Slovakia	Czechia	Poland	Hungary
Value	10.570	8.287	9.228	9.500
P-value (Two-tailed)	0.103	0.218	0.161	0.147

Source: own

and Hungarian earnings before interest, taxes, depreciation and amortization are *independently distributed* was not rejected.

Finally, we tested the hypotheses to achieve the main aim of the paper. All of them are related to the detection of the existence of the “change-point” in EBITDA of Visegrad countries. Hypotheses were tested by Pettitt’s test using 10,000 Monte Carlo simulations.

H_0 : Data of EBITDA are homogeneous.

Hypothesis_{1A}: There is a date at which a change in the data of EBITDA of Slovak enterprises occurred.

Hypothesis_{1B}: There is a date at which a change in the data of EBITDA of Czech enterprises occurred.

Hypothesis_{1C}: There is a date at which a change in the data of EBITDA of Polish enterprises occurred.

Hypothesis_{1D}: There is a date at which a change in the data of EBITDA of Hungarian enterprises occurred.

As the computed p-value is lower than the significance level alpha, one should reject the null hypothesis H_0 , and accept the alternative hypothesis H_1 , based on Tab. 6. There is one year at which there is a change in the data of EBITDA. This is confirmed for all of the countries of Visegrad Four. The Pettitt’s test not only detected the occurrence of the change-points of EBITDA and also set the year that

was significant in the development of EBITDA of Slovak, Czech, Polish and Hungarian enterprises. Surprisingly identified fact of our result is that all the countries have the same significant year. It is the year **2013**, what is supported and demonstrated on Fig. 1. This year divides the development of the business profit into two homogeneous series, which values of the central lines are also shown. Identified significant year caused the positive change in monotonic development of time series of EBITDA. We might argue, based on our research that despite the fact that the countries are not in one bloc of controlled countries for three decades, but the influence is still so strong that the developments of Slovakia, Czechia, Poland and Hungary vary, but the final result is uniform.

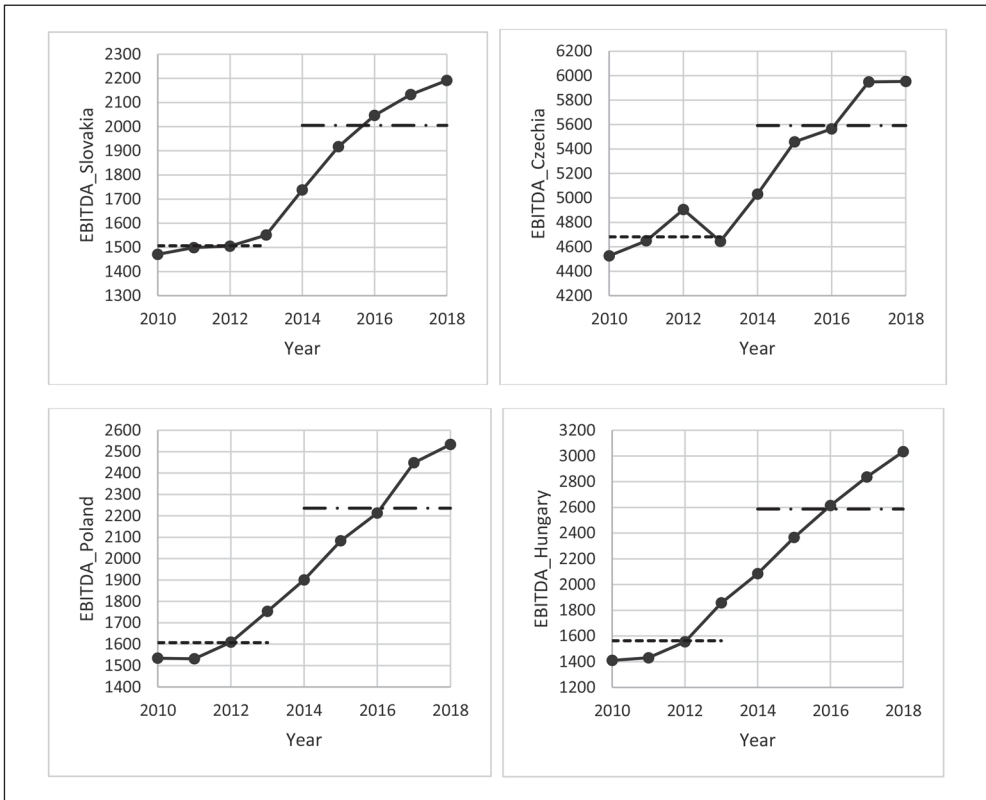
Fig. 1 does not only involve the indicated year 2013; this year divides the development of the business profit into two homogeneous series, which values of the central lines are also shown. The level of set central lines is 1,507,000 EUR to 2013 and 2,005,000 EUR for Slovak enterprises since 2013. The difference is 490,000 EUR between these fictionally calculated periods of development of EBITDA. In the Czech enterprises, the level of calculated central lines is 4,681,000 EUR to 2013 and 5,592,000 EUR since 2013. The difference between these calculated periods

Tab. 6: Pettitt’s test

Pettitt’s test	Slovakia	Czechia	Poland	Hungary
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1 [thousand EUR]	1,507	4,681	1,607	1,563
μ_2 [thousand EUR]	2,005	5,592	2,236	2,587
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Source: own

Fig. 1: Change-points in Visegrad Four



Source: own

Note: Dotted line EBITDA, dashed line μ_1 , dash-dotted line μ_2 .

of development of EBITDA is 911,000 EUR. In Poland, the level of set central lines is 1,607,000 EUR to 2013 and 2,236,000 EUR since 2013. The difference means 629,000 EUR between these fictionally calculated periods of the EBITDA development. The level of calculated central lines in Hungary is 1,563,000 EUR to 2013 and 2,587,000 EUR since 2013. The difference means 1,024,000 EUR. All the indicated differences in central lines oscillate from 490,000 EUR to 1,024,000 EUR, which does not reveal big discrepancies within the enterprises from our purposive sample and confirm that the same year 2013 was significant for the EBITDA developments but also the level of changes expressed in absolute values is approximately uniform.

Discussion

We discuss our presented results related to the business profit in Visegrad Group (every change-points in times series of EBITDA is detected in 2013) to the areas and factors that could affect them. We consider the development in these four countries as very similar (alternative but with the equal nature of the result). Schwab (2014) placed Slovakia, Hungary and Poland in the stage of development to the stage of Transition from stage 2 (Efficiency-driven) to stage 3 (Innovation-driven) and Czechia to stage 3. We support our discussion by data from the global competitiveness reports from 2010 to 2019 from World Economic Forum and EuroStat. Lemańska-Majdzik and Okręglička (2015) select based on comprehensive

Tab. 7: Pettitt's test of Adjustable area and Uncontrollable macroeconomic factors

	Slovakia	Czechia	Poland	Hungary
Business dynamism				
K_T	17	14	16	8
t (significant change-point)	–	–	–	–
μ	59.444	33.667	60.222	87.333
P-value (Two-tailed)	0.117	0.346	0.529	0.17
GDP				
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1 [million EUR]	71,269	159,984	381,539	100,384
μ_2 [million EUR]	82,301	181,724	446,353	117,267
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Unemployment rate				
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1 [%]	14.1	7	9.95	10.85
μ_2 [%]	9.8	4.06	6.3	5.5
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Inflation rate				
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1 [%]	2.5	2.325	2.3	4.25
μ_2 [%]	0	1.14	0.42	1.16
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Average monthly gross wage				
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1 [EUR]	796	965	889.75	761.5
μ_2 [EUR]	924	1,081	1,026	898.2
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Ease of doing business index				
K_T	20.000	20.000	20.000	20.000
t (significant change-point)	2013	2013	2013	2013
μ_1	45.75	69.25	53.5	56.5
μ_2	34.6	30.2	27.4	43.6
P-value (Two-tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Source: own

literature review factors most affecting success of the enterprises: type and size, profile of business activity conducted, character of the environment, economic cooperation on the market, adopted strategy of action, implementation of innovation and new technologies, staff satisfied with their jobs, competent leader. They argue that it is only fragment of a long list affected factors that is why we divide the list to the adjustable area and uncontrollable macroeconomic factors from the side of the enterprises. We confirm that both have the influence but the question is: *Do they both have significant impact on the business profit characterised by EBITDA?* We focus a priori on: (i) adjustable area by the enterprises that represents business dynamism; one of the crucial pillars of the global competitiveness index. It includes: cost of starting a business, time to start a business day, insolvency recovery rate, insolvency regulatory framework, attitudes toward entrepreneurial risk, willingness to delegate authority, growth of innovative companies, companies embracing disruptive ideas (Schwab, 2019); (ii) uncontrollable macroeconomic factors that represent GDP, unemployment rate, inflation rate, average monthly gross wage, and Ease of doing business index.

H_0 : *Data are homogeneous.*

H_1 : *There is a date at which there is a change in the data.*

As in previous part, we run Pettitt's test using 10,000 Monte Carlo simulations to test hypotheses.

As the computed p-value is greater than the significance level alpha, one cannot reject the null hypothesis H_0 , based on Tab. 7. There are no years where a change in the data occurred. This situation is unveiled when testing the influence of the business dynamism on EBITDA.

As the computed p-value is lower than the significance level alpha, one should reject the null hypothesis H_0 , and accept the alternative hypothesis H_1 , based on Tab. 10. There are significant years where there is a significant change in the data. This situation occurs by all of uncontrollable macroeconomic factors, and the results indicate that for all considered macroeconomic factors the most significant changes happened in 2013. We argue based on our results and the discussion that the change-point of positive monotonic development of EBITDA was not significantly caused by adjustable area, but it was definitely confirmed and demonstrated by uncontrollable

macroeconomic factors that the impact of them on the business profit represented by EBITDA is inalienable. The significant change of the monotonic development of EBITDA was positive since the year 2013, which is supported and corresponded with the significant growth of GDP, significant decrease of the unemployment rate, significant decrease of the inflation rate, significant growth of an average monthly gross wage and significant improvement of the Ease of doing business index in all countries of the Visegrad Four. This fact is confirmed by comparing the levels of identified central lines of chosen uncontrollable macroeconomic indicators from Tab. 7.

A limitation of our research is perceived by the focus of the research on the chosen factors affected the results related to the business profit, the research does not take into account the influences of macroeconomic factors as producer prices change, foreign direct investment, business confidence, etc. Another limitation might be the omission of the use of parametric tests that are considered more powerful and/or sensitive than nonparametric tests to detect significant trends, especially with a small sample number (Meals et al., 2011).

We consider the following areas as potential directions for further progress in the research: supporting results revealing the change point in times series of EBITDA by the use of SNHT test, Buishand's test and von Neumann's test; a completing of this case study in Soviet-controlled Eastern bloc counties to add Romanian results; an extension of the areas of the interest to formerly parts of the Soviet Union: Russia, Belarus, Ukraine, Estonia, Latvia, and Lithuania; an indication of trend existence in times series of EBITDA by Mann-Kendall trend test and Sen's slope as well as time series decomposition.

Conclusions

The objective of all business activities in a market environment is the long-term economic prosperity of business entities, which is determined by business profitability. The profit is considered to be the starting point for all other factors and an indispensable financial indicator that expresses the success and efficiency of business, especially in the relation to the invested capital. It is necessary for the enterprises to know which period of their business life was the break one considering the

business finance. Moreover, it is important also for the country represented by the government because it has the great chance to support enterprises to be successful by creating fair, positive and open competitive environment.

This research has several useful contributions. Firstly, it is the identification of the break point (year 2013), which indicates the significant change in the profit development, caused not only by the corporate development itself but also as a consequence of macroeconomic development in the countries. Secondly, the evidence was provided that enterprises in the Visegrad countries tend to manipulate earnings, and thus the importance of further research is unquestionable. This study provides important insights for state authorities, policymakers, auditors, consulting and accounting enterprises to develop possible measures and identify earnings management techniques and try to protect the market, banks, stakeholders and creditors from financial risks caused by distorted financial reports.

Acknowledgement: *This paper was supported by the Slovak Research and Development Agency under Grant number APVV-17-0546: Variant Comprehensive Model of Earnings Management in Conditions of the Slovak Republic as an Essential Instrument of Market Uncertainty Reduction.*

References

Aerts, K., Kraft, K., & Lang, J. (2015). Profit sharing and innovation. *Industrial and Corporate Change*, 24(6), 1377–1392. <https://doi.org/10.1093/icc/dtv009>

Agha, O. M. A. M., Bağçacı, S. Ç., & Şarlak, N. (2017). Homogeneity analysis of precipitation series in North Iraq. *IOSR Journal of Applied Geology and Geophysics*, 5(3), 57–63. <https://doi.org/10.9790/0990-0503025763>

Altman, J., & Dillon, M. (2005). Commercial development and natural resource management on the indigenous estate: A profit-related investment proposal. *Economic Papers: A Journal of Applied Economics and Policy*, 24(3), 249–262. <https://doi.org/10.1111/j.1759-3441.2005.tb00377.x>

Anand, A., Singhal, S., & Singh, O. (2019). Optimal advertising duration for profit maximization. *Journal of Management Analytics*, 1–23. <https://doi.org/10.1080/23270012.2019.1702904>

Anderson, S. J., Chandy, R., & Zia, B. (2018). Pathways to profits: The impact of marketing vs. finance skills on business performance. *Management Science*, 64(12), 5559–5583. <https://doi.org/10.1287/mnsc.2017.2920>

Angelova, G., Parvanov, P., Chetrafilov, G., Krasteva, N. Y., & Krastev, V. I. (2017). Sustainability in tourism cadre training and selection in Bulgaria perceptions of university students on their skills. *REVISTA INCLUSIONES*, 4(3), 144–156.

Aram, J. D., & Cowen, S. S. (1990). Strategic planning for increased profit in the small business. *Long Range Planning*, 23(6), 63–70. [https://doi.org/10.1016/0024-6301\(90\)90103-B](https://doi.org/10.1016/0024-6301(90)90103-B)

Bai, J., & Ng, S. (2005). Tests for skewness, kurtosis, and normality for time series data. *Journal of Business & Economic Statistics*, 23(1), 49–60. <https://doi.org/10.1198/073500104000000271>

Belás, J., & Sopková, G. (2016). A Model of Entrepreneurial Orientation. *Transformation in Business & Economics*, 15(2), 630–644.

Blomgren, A. (2011). Does corporate social responsibility influence profit margins? A case study of executive perceptions. *Corporate Social Responsibility and Environmental Management*, 18(5), 263–274. <https://doi.org/10.1002/csr.246>

Bogliacino, F., & Pianta, M. (2012). Profits, R&D, and innovation – A model and a test. *Industrial and Corporate Change*, 22(3), 649–678. <https://doi.org/10.1093/icc/dts028>

Box, G. E., & Pierce, D. A. (1970). Distribution of residual autocorrelations in autoregressive-integrated moving average time series models. *Journal of the American Statistical Association*, 65(332), 1509–1526. <https://doi.org/10.2307/2284333>

Capponi, G., Criscuolo, P., Martinelli, A., & Nuvolari, A. (2019). Profiting from innovation: Evidence from a survey of Queen's Awards winners. *Structural Change and Economic Dynamics*, 49, 155–169. <https://doi.org/10.1016/j.strueco.2019.02.002>

Carroll, A. B. (1979). A three-dimensional conceptual model of corporate performance. *Academy of management review*, 4(4), 497–505. <https://doi.org/10.5465/amr.1979.4498296>

Carroll, A. B. (1998). The four faces of corporate citizenship. *Business and society review*, 100/101(1), 1–7. <https://doi.org/10.1111/0045-3609.00008>

- Chen, E. H. (1971). The power of the Shapiro-Wilk W test for normality in samples from contaminated normal distributions. *Journal of the American Statistical Association*, 66(336), 760–762. <https://doi.org/10.1080/01621459.1971.10482342>
- Chuang, C.-J., & Wu, C.-W. (2019). Determining optimal process mean and quality improvement in a profit-maximization supply chain model. *Quality Technology & Quantitative Management*, 16(2), 154–169. <https://doi.org/10.1080/16843703.2017.1389124>
- Desyllas, P., & Sako, M. (2013). Profiting from business model innovation: Evidence from Pay-As-You-Drive auto insurance. *Research Policy*, 42(1), 101–116. <https://doi.org/10.1016/j.respol.2012.05.008>
- Dufour, J.-M., Farhat, A., Gardiol, L., & Khalaf, L. (1998). Simulation-based Finite Sample Normality Tests in Linear Regressions. *Econometrics Journal*, 1(1), 154–173. <https://doi.org/10.1111/1368-423X.11009>
- Farrell, P. J., & Rogers-Stewart, K. (2006). Comprehensive study of tests for normality and symmetry: extending the Spiegelhalter test. *Journal of Statistical Computation and Simulation*, 76(9), 803–816. <https://doi.org/10.1080/10629360500109023>
- Felstead, M. (2019). Cyber-physical production systems in Industry 4.0: Smart factory performance, innovation-driven manufacturing process innovation, and sustainable supply chain networks. *Economics, Management, and Financial Markets*, 14(4), 37–43. <https://doi.org/10.22381/EMFM14420195>
- Freeman, R. (1984). *Strategic Management: A Stakeholder Perspective*. Englewood Cliffs, NJ: Prentice-Hall.
- Friedman, H. H., Friedman, L. W., Frankel, M. R., & Amoo, T. (2019). Enhancing critical and ethical thinking with scenarios. *Psychosociological Issues in Human Resource Management*, 7(1), 7–29. <https://doi.org/10.22381/PIHRM7120191>
- Friedman, M. (1970, September 13). The social responsibility of business is to increase its profits. *The New York Times Magazine*, pp. 122–126. https://doi.org/10.1007/978-3-540-70818-6_14
- Furnham, P. (2019). Automation and autonomy of big data-driven algorithmic decision-making. *Contemporary Readings in Law and Social Justice*, 11(1), 51–56. <https://doi.org/10.22381/CRLSJ11120198>
- Garcia, F. A. A. (2012). *Tests to Identify Outliers in Data Series* (Doctoral dissertation). Rio de Janeiro: Pontifical Catholic University of Rio de Janeiro.
- Garst, J., Blok, V., Jansen, L., & Omta, O. (2017). Responsibility versus profit: The motives of food firms for healthy product innovation. *Sustainability*, 9(12), 2286. <https://doi.org/10.3390/su9122286>
- Gazzola, P., Vătămănescu, E.-M., Andrei, A. G., & Marrapodi, C. (2019). Users' motivations to participate in the sharing economy: Moving from profits toward sustainable development. *Corporate Social Responsibility and Environmental Management*, 26(4), 741–751. <https://doi.org/10.1002/csr.1715>
- George, R., & Kabir, R. (2008). Business groups and profit redistribution: A boon or bane for firms? *Journal of Business Research*, 61(9), 1004–1014. <https://doi.org/10.1016/j.jbusres.2007.12.002>
- Ghosh, D., & Vogt, A. (2012). Outliers: An evaluation of methodologies. In *JSM Proceedings, Survey Research Methods Section* (pp. 3455–3460). Alexandria, VA: American Statistical Association. Retrieved from http://www.asasrms.org/Proceedings/y2012/Files/304068_72402.pdf
- Ghosh, D., Ghosh, D. K., & Zaher, A. A. (2011). Business, ethics, and profit: Are they compatible under corporate governance in our global economy? *Global Finance Journal*, 22(1), 72–79. <https://doi.org/10.1016/j.gfj.2011.05.006>
- Gil Salmerón, A. M. (2016). The relationship of CSR and the business profit: can the most responsible companies be more profitable? *Revista FIR, FAEDPYME International Review*, 5(8), 60–71. Retrieved from <http://faedpyme.ojs.upct.es/index.php/revista1/article/view/107/162>
- Hallberg, N. L., & Brattström, A. (2019). Concealing or revealing? Alternative paths to profiting from innovation. *European Management Journal*, 37(2), 165–174. <https://doi.org/10.1016/j.emj.2018.04.003>
- Hayhoe, T., Podhorská, I., Siekelová, A., & Stehel, V. (2019). Sustainable manufacturing in Industry 4.0: Cross-sector networks of multiple supply chains, cyber-physical production systems, and AI-driven decision-making. *Journal of Self-Governance and Management Economics*, 7(2), 31–36. <https://doi.org/10.22381/JSME7220195>
- Hu, M.-C., Kang, J.-S., & Wu, C.-Y. (2017). Determinants of profiting from innovation activities: Comparisons between technological

- leaders and latecomers. *Technological Forecasting and Social Change*, 116, 223–236. <https://doi.org/10.1016/j.techfore.2016.10.013>
- Hudakova, M., Masar, M., Luskova, M., & Patak, M. R. (2018). The Dependence of Perceived Business Risks on the Size of SMEs. *Journal of Competitiveness*, 10(4), 54–69. <https://doi.org/10.7441/joc.2018.04.04>
- Hussain, W. (2012). Corporations, profit maximization and the personal sphere. *Economics & Philosophy*, 28(3), 311–331. <https://doi.org/10.1017/S0266267112000260>
- Janoskova, K., & Kral, P. (2019). An In-Depth Analysis of the Summary Innovation Index in the V4 Countries. *Journal of Competitiveness*, 11(2), 68–83. <https://doi.org/10.7441/joc.2019.02.05>
- Jensen, M. C. (2001). Value maximization, stakeholder theory, and the corporate objective function. *Journal of Applied Corporate Finance*, 14(3), 8–21. <https://doi.org/10.1111/j.1745-6622.2001.tb00434.x>
- Jensen, M. C. (2002). Value maximization, stakeholder theory, and the corporate objective function. *Business Ethics Quarterly*, 12(2), 235–256. <https://doi.org/10.2307/3857812>
- Jeon, M. M., Lee, S., & Jeong, M. (2020). Perceived corporate social responsibility and customers' behaviors in the ridesharing service industry. *International Journal of Hospitality Management*, 84, 102341. <https://doi.org/10.1016/j.ijhm.2019.102341>
- Jones, T. M. (1995). Instrumental stakeholder theory: A synthesis of ethics and economics. *Academy of Management Review*, 20(2), 404–437. <https://doi.org/10.5465/amr.1995.9507312924>
- Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, 117, 408–425. <https://doi.org/10.1016/j.psep.2018.05.009>
- Kanovský, M. (2018). The Research Effectivity of Slovak Universities: Quantitative Analysis of Trends 2008–2017. *Sociológia – Slovak Sociological Review*, 50(4), 429–447. <https://doi.org/10.31577/sociologia.2018.50.4.17>
- Kim, I.-H. S., Ku, T.-Y. D., & Lee, B.-Y. M. (2019). Business model schema: business model innovation tool based on direct causal mechanisms of profit. *Technology Analysis & Strategic Management*, 32(4), 379–396. <https://doi.org/10.1080/09537325.2019.1661988>
- Komsta, L. (2006). Processing data for outliers. *The Newsletter of the R Project*, 6(2), 10–14.
- Kotek, K., Schoenberg, A. M., & Schwand, C. (2018). CSR Behavior: Between Altruism and Profit Maximization. In R. Altenburger (Ed.), *Innovation Management and Corporate Social Responsibility* (pp. 159–169). Cham: Springer. https://doi.org/10.1007/978-3-319-93629-1_8
- Kowo, A. S., Sabitu, O. O., & Bola, K. (2019). An investigation of the role of entrepreneurship agencies for entrepreneurship development in Nigeria. *Ekonomicko-manazerske Spektrum*, 13(2), 68–80. <http://dx.doi.org/10.26552/ems.2019.2.68-80>
- Krastev, V., Koyundzhyska-Davidkova, B., & Atanasova, I. (2020). The impact of the corruption on the sustainable development of the businesses in South-West Bulgaria. In *Proceedings of the 19th International Scientific Conference Globalization and its Socio-Economic Consequences 2019 – Sustainability in the Global-Knowledge Economy* (SHS Web of Conferences Vol. 74, No. 06015). Rajecke Teplice, Slovakia. <https://doi.org/10.1051/shsconf/20207406015>
- Krech, C. A., Rüter, F., & Gassmann, O. (2015). Profiting from invention: Business models of patent aggregating companies. *International Journal of Innovation Management*, 19(03), 1540005. <https://doi.org/10.1142/S1363919615400058>
- Krech, C. A., Rüter, F., & Gassmann, O. (2018). Profiting from invention: Business models of patent aggregating companies. In J. Tidd (Ed.), *Exploiting Intellectual Property to Promote Innovation and Create Value* (pp. 361–391). Singapur: World Scientific Publishing Company. https://doi.org/10.1142/9781786343512_0016
- Kristofik, P., Horak, J., & Suler, P. (2019). Provision of trade credits in relation to corporate payment ability: A case study of the Visegrad four. *Ekonomicko-manazerske Spektrum*, 13(1), 96–108. <https://doi.org/10.26552/ems.2019.1.96-108>
- Krizanova, A., Moravcikova, K., & Rypakova, M. (2016). The social area of corporate social responsibility focusing on social policy. In G. Lee (Ed.), *ICASS 5th International Conference on Applied Social Science* (pp. 339–344). Bangkok, Thailand.
- Lazonick, W., Mazzucato, M., & Tulum, Ö. (2013). Apple's changing business model: What should the world's richest company

do with all those profits? *Accounting Forum*, 37(4), 249–267. <https://doi.org/10.1016/j.accfor.2013.07.002>

Leite, F. S. F., de Figueiredo, H. S., Hugo, S., & Crisóstomo, V. L. (2013). Applicability of the profit per employee as a measure of business performance. *Revista de Gestão, Finanças e Contabilidade*, 3(3), 75–93. Retrieved from <http://oaji.net/articles/2014/1191-1408982842.pdf>

Lemańska-Majdzik, A., & Okręglička, M. (2015). Determinants and areas of an organisations' success – literature review. In H. Kratochvílová & R. Kratochvíl (Eds.), *Proceedings of IAC-MEM 2015 in Vienna*. (pp. 32–42). Prague: Czech Institute of Academic Education.

Li, Y., Su, Z. F., & Liu, Y. (2010). Can strategic flexibility help firms profit from product innovation? *Technovation*, 30(5–6), 300–309. <https://doi.org/10.1016/j.technovation.2009.07.007>

Ljung, G. M., & Box, G. E. (1978). On a measure of lack of fit in time series models. *Biometrika*, 65(2), 297–303. <https://doi.org/10.1093/biomet/65.2.297>

Manish, G. P., & Sutter, D. (2016). Mastery versus profit as motivation for the entrepreneur: How crony policies shape business. *Journal of Entrepreneurship and Public Policy*, 5(1), 95–112. <https://doi.org/10.1108/JEPP-10-2015-0032>

McWilliams, A., & Siegel, D. (1997). Event studies in management research: Theoretical and empirical issues. *Academy of Management Journal*, 40(3), 626–657. <https://doi.org/10.5465/257056>

McWilliams, A., & Siegel, D. (2000). Corporate social responsibility and financial performance: correlation or misspecification? *Strategic Management Journal*, 21(5), 603–609. [https://doi.org/10.1002/\(SICI\)1097-0266\(200005\)21:5<603::AID-SMJ101>3.0.CO;2-3](https://doi.org/10.1002/(SICI)1097-0266(200005)21:5<603::AID-SMJ101>3.0.CO;2-3)

McWilliams, A., & Siegel, D. (2001a). Corporate social responsibility: A theory of the firm perspective. *Academy of Management Review*, 26(1), 117–127. <https://doi.org/10.2307/259398>

McWilliams, A., & Siegel, D. (2001b). Profit maximizing corporate social responsibility. *Academy of Management Review*, 26(4), 504–505. <https://doi.org/10.5465/amr.2001.5393880>

McWilliams, A., Siegel, D. S., & Wright, P. M. (2006). Corporate social responsibility: Strategic implications. *Journal of Management Studies*, 43(1), 1–18. <https://doi.org/10.1111/j.1467-6486.2006.00580.x>

Meals, D. W., Spooner, J., Dressing, S. A., & Harcum, J. B. (2011). Statistical analysis for monotonic trends. *Tech Notes*, 6, 1–23.

Moravcikova, K., & Krizanova, A. (2016). Impact of corporate social responsibility on the company's reputation. In H. Zhang (Ed.), *ICMIBI International Conference on Applied Social Science and Business* (pp. 20–25). Singapore: Singapore Management and Sports Science Institute.

Mulligan, T. (1986). A critique of Friedman, Milton essay the social-responsibility of business is to increase its profits. *Journal of Business Ethics*, 5(4), 265–269. <https://doi.org/10.1007/BF00383091>

Pettitt, A. N. (1979). A non-parametric approach to the change-point problem. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 28(2), 126–135. <https://doi.org/10.2307/2346729>

Petricevic, O., & Teece, D. J. (2019). The structural reshaping of globalization: Implications for strategic sectors, profiting from innovation, and the multinational enterprise. *Journal of International Business Studies*, 50(9), 1487–1512. <https://doi.org/10.1057/s41267-019-00269-x>

Pinxterhuis, I., Dirks, S., Bewsell, D., Edwards, P., Brazendale, R., & Turner, J. A. (2019). Co-innovation to improve profit and environmental performance of dairy farm systems in New Zealand. *Rural Extension & Innovation Systems Journal*, 14(2), 23–33.

Podhorska, I., Gajanova, L., Kliestikova, J., & Popescu, G. H. (2019). Analysis of Internally Generated Goodwill Indicators: A Case Study of the Slovak Republic. *Organizacija*, 52(4), 271–285. <https://doi.org/10.2478/orga-2019-0017>

Pohlert, T. (2020). *Non-parametric trend tests and change-point detection*. Creative Commons License (CC BY-ND 4.0). Retrieved from <https://cran.r-project.org/web/packages/trend/vignettes/trend.pdf>

Primeaux, P. (1997). Business Ethics in Theory and Practice: Diagnostic Notes B. A Prescription for Profit Maximization. *Journal of Business Ethics*, 16(3), 315–322. <https://doi.org/10.1023/A:1005715916297>

Primeaux, P., & Stieber, J. (1994). Profit maximization: The ethical mandate of business. *Journal of Business Ethics*, 13(4), 287–294. <https://doi.org/10.1007/BF00871675>

Rahman, A., Rozsa, Z., & Cepel, M. (2018). Trade Credit and Bank Finance – Evidence from the Visegrad Group. *Journal of*

Competitiveness, 10(3), 132–148. <https://doi.org/10.7441/joc.2018.03.09>

Rahman, A., Belas, J., Kliestik, T., & Tyll, L. (2017). Collateral requirements for SME loans: empirical evidence from the Visegrad countries. *Journal of Business Economics and Management*, 18(4), 650–675. <http://doi.org/10.3846/16111699.2017.1357050>

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics*, 2(1), 21–33.

Robson, G. (2019). To profit maximize, or not to profit maximize: For firms, this is a valid question. *Economics & Philosophy*, 35(2), 307–320. <https://doi.org/10.1017/S0266267118000329>

Rowland, Z. (2019). Business environment assessment based on profits: A comparative study of the Czechia and Slovakia. In D. Dukic, T. Studzieniecki, & J. Grzanic (Eds.), *Economic and social development: 49th International Scientific Conference on Economic and Social Development – “Building Resilient Society”* (pp. 569–578). Varazdin: Varazdin Development and Entrepreneurship Agency.

Schwab, K. (2014). *The Global Competitiveness Reports 2013–2014*. Geneva: World Economic Forum.

Schwab, K. (2019). *The Global Competitiveness Reports 2019*. Geneva: World Economic Forum

Shahriar, A. Z. M., Schwarz, S., & Newman, A. (2016). Profit orientation of microfinance institutions and provision of financial capital to business start-ups. *International Small Business Journal*, 34(4), 532–552. <https://doi.org/10.1177/0266242615570401>

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, 52(3/4), 591–611. <http://doi.org/10.2307/2333709>

Siegel, D. (2001). Do British companies really need a minister to make them socially responsible? *Parliamentary Brief*, 7, 7–8.

Singer, A. (2013). What is the best way to argue against the profit-maximization principle? *Business Ethics Journal Review*, 1(12), 76–81. <http://doi.org/10.12747/bejr2013.01.12>

Singh, A. S., & Masuku, B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. *International Journal of Economics, Commerce and Management*, 2(11), 1–22.

Smith, J. (2018). Efficiency and Ethically Responsible Management. *Journal of Business Ethics*, 150(3), 603–618. <https://doi.org/10.1007/s10551-016-3175-x>

Stanovicic, T., Bacovic, M., Pekovic, S., Jovanovic, J., & Savovic, I. (2016). The role of human resource practices on profits generated by the innovations: The role of top management support and regularity of employees meetings. *International Journal for Quality Research*, 10(4), 839–845. <https://doi.org/10.18421/IJQR10.04-13>

Svabova, L., & Durica, M. (2019). Being an outlier: A company non-prosperity sign? *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 14(2), 359–375. <https://doi.org/10.24136/eq.2019.017>

Su, Z. F., Peng, J. S., Shen, H., & Xiao, T. (2013a). Technological Capability, Marketing Capability, and Firm Performance in Turbulent Conditions. *Management and Organization Review*, 9(1), 115–137. <http://dx.doi.org/10.1111/j.1740-8784.2011.00280.x>

Su, Z. F., Xie, E., Liu, H., & Sun, W. (2013b). Profiting from product innovation: The impact of legal, marketing, and technological capabilities in different environmental conditions. *Marketing Letters*, 24(3), 261–276. <https://doi.org/10.1007/s11002-012-9214-1>

Toms, J. S. (2010). Calculating profit: A historical perspective on the development of capitalism. *Accounting, Organizations and Society*, 35(2), 205–221. <https://doi.org/10.1016/j.aos.2009.06.002>

Trading Economy. (2019). *Ease of Doing Business*. Retrieved from <https://tradingeconomics.com/country-list/ease-of-doing-business>

Trigos, F., & López, E. M. (2019). About tooling capacity for the vulcanising planning decision problem to improve strategic business profit. *International Journal of Production Research*, 1–12. <https://doi.org/10.1080/00207543.2019.1660820>

Tuyls, R., & Pera, A. (2019). Innovative data-driven smart urban ecosystems: Environmental Sustainability, Governance Networks, and the Cognitive Internet of Things. *Geopolitics, History, and International Relations*, 11(1), 116–121. <https://doi.org/10.22381/GHIR11120198>

Vagner, L. (2016). Controlling as a competitiveness tool in the global market. In *Globalization and Its Socio-economic Consequences: 16th International Scientific Conference, 5th–6th October 2016, Rajcecke*

Teplice, Slovak Republic: Proceedings (pp. 2260–2266). Žilina: University of Žilina.

Vagner, L., & Zadnanova, S. (2019). Non-profit organizations and their possibilities of measuring efficiency. In *8th International Scientific Symposium Economy of Eastern Croatia Vision and Growth. Osijek, Croatia* (pp. 1159–1165). Osijek: University of Osijek.

Vranceanu, R. (2014). Corporate profit, entrepreneurship theory and business ethics. *Business Ethics: A European Review*, 23(1), 50–68. <https://doi.org/10.1111/beer.12037>

Wang, T., & Bansal, P. (2012). Social responsibility in new ventures: Profiting from

a long-term orientation. *Strategic Management Journal*, 33(10), 1135–1153. <https://doi.org/10.1002/smj.1962>

Warriyar, K. V. V., Abraham, B., & Variyath, A. M. (2016). Robustness of Some Portmanteau Correlation Tests in Financial Time Series. *American Journal of Mathematical and Management Sciences*, 35(1), 67–76. <https://doi.org/10.1080/01966324.2015.1082451>

Yazici, B., & Yolacan, S. (2007). A comparison of various tests of normality. *Journal of Statistical Computation and Simulation*, 77(2), 175–183. <https://doi.org/10.1080/10629360600678310>

METHODOLOGY OF INDUSTRY STATISTICS: AVERAGES, QUANTILES, AND RESPONSES TO ATYPICAL VALUES

*Martin Boďa*¹, *Vladimír Úradníček*²

¹ Matej Bel University in Banská Bystrica, Faculty of Economics, Quantitative Methods and Information Systems Department, Slovakia, ORCID: 0000-0002-7503-6898, martin.boda@umb.sk;

² Matej Bel University in Banská Bystrica, Faculty of Economics, Quantitative Methods and Information Systems Department, Slovakia, ORCID: 0000-0001-5613-1964, vladimir.uradnicek@umb.sk.

Abstract: *The paper notices troublesome aspects of compiling industry statistics for the purpose of inter-enterprise comparison in corporate financial analysis. Whilst making a caveat that this issue is unbeknownst to practitioners and underrated by theorists, the goal of the paper is two-fold. For one thing, the paper demonstrates that financial ratios are inclined to frequency distributions characteristic of power-law (fat) tails and their typical shape precludes a simple treatment. For the other, the paper explores different approaches to compiling industry statistics by considering trimming and winsorizing cleansing protocols, and by confronting trimmed, winsorized as well as quantile measures of central tendency. The issues are empirically illustrated on data for a great number of Slovak construction enterprises for two years, 2009 and 2018. The empirical distribution of eight financial ratios is studied for troublesome features such as asymmetry and power-law (fat) tails that hamper usefulness of traditional descriptive measures of location without considering different possibilities of handling atypical values (such as infinite and outlying values). The confrontation of diverse approaches suggests a plausible route to compiling industry statistics that consists in reporting a 25% trimmed mean alongside 25% and 75% quantiles, all applied to trimmed data (i.e. data after discarding infinite values). The paper also highlights the sorely unnoticed fact that the key ratio of financial analysis, return on equity, may easily attain non-sense values and these should be removed prior to compiling financial analysis; otherwise, industry statistics is biased upward regardless of what measure of central tendency is made use of.*

Keywords: *Industry statistics, financial ratios, trimmed mean, winsorized mean, quantile, non-sense values, power law in the tail.*

JEL Classification: *C19, M10, M40.*

APA Style Citation: Boďa, M., & Úradníček, V. (2020). Methodology of Industry Statistics: Averages, Quantiles, and Responses to Atypical Values. *E&M Economics and Management*, 23(3), 120–137. <https://doi.org/10.15240/tul/001/2020-3-008>

Introduction

The paper studies the somewhat neglected and underestimated issue of constructing industry statistics for the purpose of inter-enterprise comparisons that are an indispensable ingredient for a sensible corporate financial analysis grounded in financial ratios. A comprehensive financial analysis requires that financial ratios computed for an enterprise being analyzed be compared to typical values of financial ratios

of enterprises in the same industry. Several approaches are available as to how to obtain typical values, e.g. averages, quantiles, robust measures of location; and, yet, none is generally accepted and widely used. Whereas in other countries it seems that average values are favoured to describe the financial image of an industry, in Slovak conditions the preferred methodology is making use of quantile values that are compiled from financial statements of

numerous Slovak enterprises. Whereas CRIF – Slovak Credit Bureau, Ltd. (henceforth referred to as CRIF) uses traditionally three quartile values (with a possibility of extending the report by averages), DataSpot, Ltd. (henceforth referred to as DataSpot) summarizes industries by second deciles, medians and eight deciles. At first glance, it may seem (and it does indeed) that it is an easy task with no methodological trouble that subsumes assembling financial statements from a number of enterprises in an industry, calculating financial ratios and summarizing them with one or a few descriptive measures. Many users of industry statistics (practitioners) as well as instructors of corporate financial analysis (theorists) are oblivious that this ostensibly simple procedure holds numerous pitfalls and the summary figures may be far from being representative of the financial situation in an industry. Several reasons may be singled out.

First, some input financial statements are erroneous (falsified on purpose, or affected by mistakes coming from errors in accounting records or arising in the process of preparing financial statements), and the financial ratios calculated from such statements are misleading. Unfortunately, that financial information disclosed even in audited statements is not free of errors is a notorious fact (e.g. Rezaee, 2005; Markham, 2006; Deloitte Forensic Center, 2009; Firth et al., 2011). Second, a portion of enterprises are not in good financial condition, their operations are atypical and they perhaps face financial distress (e.g. Konstantaras & Siriopoulos, 2011; Harada & Kageyama, 2011; Balcaen et al., 2012; Bhattacharjee & Han, 2014; Inekwe et al., 2018, 2019). In corporate comparisons, one should compare “healthy” enterprises with “healthy” enterprises and eschew comparisons with non-vital enterprises whose operations cast doubt on the faithfulness of the reality represented by financial ratios. Third, also non-sense values of financial ratios exist, and are symptomatic of many enterprises, so they cannot be ignored when the ambition is to give a general description of an industry. Such values arise owing to zero in the denominator (yielding an infinity) or whenever two negative values are divided (yielding a seemingly fortuitous economically favourable positive value). If existent, this signifies a highly non-standard situation to which a comparison should not be made. Fourth, even if the three

preceding issues are somehow mended, there still remains great heterogeneity of enterprises reflected in their financial statements, thanks to which the frequency distribution of any financial ratio is frequently heavily-skewed and displays power-law (fat) tails on account of the preponderance of outlying values on either side. The proneness to asymmetry and fat-tailedness casts doubts about an ability of simple descriptive measures to deliver a faithful representation of the situation in an industry.

With a few exceptions, industry statistics is traditionally processed and proffered on a commercial basis by different vendors (credit bureaus and other agencies specialized in keeping business registers), and each vendor has a different approach to tackling these problems. The procedure starts with preliminary screening for anomalous financial statements and mistakes, and then different (sometimes undisclosed) protocols are followed in calculating summary measures. Of course, there are inevitable differences in the way that vendors define financial ratios, but they are of no import to the user granted that he is familiar with the definition.

Odd as it may be, the described issues are overlooked in the academic community, although they do merit attention. This paper is an effort to make amends, it strives to incite discussion amongst practitioners and theorists in this regard by bringing to the forefront of their attention the fact that it matters how industry statistics is calculated. More specifically, the goal of the paper is to demonstrate that the (typical) empirical distribution of financial ratios is too complicated to allow a simple treatment, and to explore different approaches to representing the financial situation of an industry. The reason being, the first ambition follows from the fact that the typical frequency distributions of a financial ratio is inclined to (asymmetric) power-law tails, which mars the usefulness of simple descriptive metrics. This in turn motivates the second ambition and a search for suitable remedies to the situation. Hence, the exploration of fat-tailed properties of financial ratios has its non-negligible role in this paper. To a great extent, the paper takes form of a case study centred upon Slovak corporate conditions. Nonetheless, the lessons learned from this case study are fully transferable to any other economic milieu since the difficulties with the quality of accounting information and

heterogeneity of enterprises are shared across all economies.

The paper uses raw financial statements of a great number of Slovak enterprises provided by FinStat, Ltd. (henceforward referred to as FinStat) for two years, 2009 and 2018. Whereas the year 2018 was a period of economic tranquillity, in the year 2009 the Slovak economy was affected by the global economic crisis (e.g. Tóth, 2017; Buček, 2012). For selected industries, eight representative financial ratios defined in line with the methodology of CRIF are considered, and several approaches to calculating industry summaries are compared. Before that, however, the empirical distribution of the eight ratios and its properties are studied to prove the point that these “ugly” properties make common descriptive measures less useful and unsuited. The studied approaches include averages and quantiles used in conjunction with different possibilities of handling atypical values (infinite and outlying values) such as simple removal, trimming or winsorization.

The rest of the paper is organized into five parts. Whilst Section 1 acts as a short literature review and proves the currency of the issue, Section 2 describes the set-up of the case study including the data, the definition of the financial ratios, and approaches to calculating industry summaries. Section 3 presents the results, and is followed by Section 4 that discusses the findings and presents the limitations of the study. Finally, the last part of the paper concludes.

1. Contextual Background

Financial analyses of the enterprise and competitive environment oftentimes require analytical procedures that are based upon average or other typical industry values of selected financial indicators. Sometimes industry values are not needed as an input to the analysis, but are given full appreciation in the interpretations when the position of an industry, or of an enterprise in the industry, is to be assessed. Examples of such financial analyses include Leuz and Verrechia (2000), Serrano Cinca et al. (2005), Sedláček (2007), Bradshaw (2012), Prášilová (2012), Koráb and Poměnková (2014), Skokan and Pawliczek (2014) or Lesáková et al. (2019). There are unavoidable questions regarding the quality of data that are available to analysts for industry comparisons. The heavily used industry

characteristics (such as averages, quartiles, deciles) are affected by the methodology adopted in processing financial statements at the level of an industry. Unawareness about the nuances of compiling industry statistics is a pitfall that may lead to erroneous results and unsound conclusions.

In Slovakia, the tradition of industry statistics dates back to 1993 and originated under the umbrella of Bankové a zúčtovacie centrum Slovenska, a. s. (Banking and Clearing Center of Slovakia, Plc.), which was later transformed eventually to CRIF – Slovak Credit Bureau, Ltd. The inspiration for instituting the standards of industry statistics in Slovak conditions came from the USA, where similar standards had been adopted and implemented by the American Bankers Association (Profini, 2018, p. 7). CRIF publishes industry statistics for 20 selected financial ratios in printed form in its annual report called *Stredné hodnoty finančných ukazovateľov ekonomických činností v SR* (or *Central values of financial ratios of economic activities in the Slovak Republic*). In addition, more detailed information is available on its web site <https://www2.cribis.sk> and pertains to another 11 financial ratios. Every financial ratio is represented by three quartile values, the average, and a synthetic indicator called “mental view”. The “mental view” for a given financial ratio is obtained by applying the traditional definition of the financial ratio to the aggregated financial statements arising from summing all financial statements in that particular industry. Details on procedures followed by CRIF in detection and removal of false and erroneous financial statements are not divulged. Yet, the definitional formulas referring to particular items of financial statements are fully available to the authors of this study, and are obeyed to the letter in the applicational part. In the case that there is a preponderance of non-defined cases when calculating a financial ratio requires dividing two zeros, CRIF reports a #NA# sign for quartile values. This only reveals that non-defined values enter calculations of quartiles and no trimming or winsorizing procedure protocol is adhered to. A new-comer to the market of business registers is DataSpot, which maintains *Index Podnikateľa* (or *Entrepreneurial Index*). Although the business register operated by DataSpot offers for a selected enterprise a variety of financial ratios, only 10 financial ratios are benchmarked against the second

decile, median and eight decile in the industry. Unfortunately, FinStat may also service an extensive business register, provide a collection of raw unprocessed financial statements in a convenient format and calculate for enterprises a number of financial ratios, but it does not occupy itself with compiling industry statistics. This omission is at the cost of a loss in competitive advantage. Needless to say, the definitions of financial ratios implemented by CRIF, DataSpot and FinStat are not identical, although those by CRIF could be righteously deemed for their longevity and tradition as authoritative.

Owing to the relatively small size of the Slovak economy, it is possible to develop and maintain a sort of “national standards”, but outside Slovakia the situation may be much more complicated. An example is the USA where there are several vendors of industry statistics. One of them, the Risk Management Association (formerly Robert Morris Associates), publishes its Annual statement studies that provide ratios for a total of 723 manufacturing, wholesale, retail, and selected service industries in the USA, and are available after the paid registration at <https://www.rmahq.org/annual-statement-studies>. Selected industry statistics and financial ratios for benchmarking are available for sole proprietorships, S corporations, and corporations from BizStats at <http://www.bizstats.com>. Another such vendor, IndustriousCFO, provides at <http://www.industriouscfo.com> benchmarking industry metrics summarized by first deciles, quartile values and last deciles. Finally, industry summaries and scoring by Bizminer at <http://www.bizminer.com> are developed for various financial ratios and other metrics by dint of averages. Another source is the *Almanac of business and industrial financial ratios*, a printed compendium assembled originally by Leo Troy and later by Philip Wilson, who also authored the latest edition (Wilson, 2016). The almanac gives performance data for 50 operating and financial factors in 199 industries. All these vendors or sources vary in manifold aspects such as the coverage of industries, the population of financial statements, the variety and definition of financial ratios, the procedures necessary to ensure integrity of summary statistics, the selection of measures of central tendency etc. Frequently, methodological details are difficult to track.

A not well-known initiative is BACH (standing for *Bank for the Accounts of Companies Harmonized*), launched in 1985 in order to analyze the financial condition of European enterprises, but harmonized and enhanced in 2010. The BACH project provides industry summaries for 13 European countries (inclusive of Slovakia), and reports industry summaries for 29 financial ratios in addition to numerous balance-sheet and income statements. In step with the agencies that keep business registers for Slovak enterprises, i.e. CRIF, DataSpot and FinStat, the source of input financial statements is the Registry of Financial Statements maintained by the Ministry of Finance of the Slovak Republic. The BACH database is available at <https://www.bach.banque-france.fr> and for 2018 represents as many as 8.6% of all enterprises (see ECCBSO, 2019, p. 16). The methodology is fairly detailed and described in ECCBSO (2019). The three quartiles and “mental view” are computed to represent financial ratios in an industry (although the term “weighted mean” is used instead of “mental view”). The administration of the BACH database is entrusted to the *Banque de France* (Bank of France) that also maintains the ERICA database of aggregated and harmonised accounting data based on IFRS consolidated financial statements for 8 European countries (exclusive of Slovakia).

Of course, there are many other vendors of financial information outside Slovakia such as Bureau van Dijk (the AMADEUS database), Bisnode (the Albertina enterprise monitor), but in a vein similar to FinStat, they do not compile industry statistics.

The typical empirical distribution of a financial ratio is unsightly and suffers for four chief reasons: (1) Some financial statements are erroneous. (2) Some enterprises tackle financial difficulties and their operations show abnormal values of financial ratios. (3) Non-sensical values of an indicator can arise naturally when both the numerator and denominator are zero, and they do arise. More frequently, only the denominator is zero, in which case a plus or minus infinity is the result. Likewise, a very small value in the denominator makes the financial ratio explode and causes an extreme value. (4) Enterprises even in the same industry are often very dissimilar and so the empirical distribution of otherwise normal values has a tendency towards asymmetry and

fat tails. All in all, calculated values of a financial indicator compiled for sundry enterprises in an industry are always to some degree contaminated by errors and their distribution is not well-behaved, typically evincing asymmetric power-law (Paretian) tails. Hence, it transpires that descriptors of classical statistics (averages, or even quantiles) must fare poorly in giving a snapshot of the situation in an industry and robust descriptors must be equal to the task. Indeed, robust methods are devised for use in situations when there are extreme values or where the distribution is highly atypical (highly asymmetric or fat-tailed).

In addition to conventional quantiles, this paper considers two simple robust approaches useful in characterizing the financial situation in an industry: the trimmed (truncated) mean, and the winsorized mean. Despite the existence of a plethora of robust measures of central tendency, these two methods are effective, and conceptually simple with the construction easy and graspable to a layman. They fall into the broad category of L-estimators of location, and have a high breakdown point (Jurečková & Picek, 2006, pp. 66–69). The trimmed mean is a mean applied to the central (trimmed) mass of data that remain after discarding equal portions of data from both endpoints. Similarly, the winsorized mean is a mean applied to the whole (winsorized) mass of data obtained by replacing equal portions of data at both endpoints with the most extreme remaining values. The former is notably used in Olympic judging to prevent impact of a single judge on the overall score (Gaynor et al., 2005), or in calculation of the LIBOR rate (ICE Benchmark Administration, 2019), and both perform well when the contamination at both endpoints is below the set trimming percentage (Wilcox & Keselman, 2003). Nonetheless, the winsorized mean is recommendable for universal situations with no information available about the underlying distribution (Bieniek, 2016).

2. Methodology

As pointed out in the introduction, the paper is built-up as a case study that demonstrates issues in compiling industry statistics with the use of Slovak data. In order to prove more convincingly the point that industry statistics must be related to the empirical distribution of financial ratios, data on Slovak enterprises for two years are employed as the distributional properties of financial ratios vary with business

cycles. The year 2009 can be described as turbulent since Slovak corporate financial ratios of that time bore a signature of the erstwhile Great Recession, whereas the year 2018 is a standard year with satisfactory economic growth, low unemployment and normal inflation (National Bank of Slovakia, 2016, p. 15, 2019, p. 16). For either year, the input data represented financial statements of Slovak enterprises collected and provided by FinStat. This analytic agency processes financial statements sourced from web page of the Registry of Financial Statements maintained by the Ministry of Finance of the Slovak Republic (<http://www.registeruz.sk>). Financial statements for 2009 were mostly scanned and ran through an OCR (optical character recognition) data extraction, and for 2018 were simply downloaded in a structured format from the Registry. In addition to omnipresent commonplace typos and errors in financial statements, the data set of financial statements for 2009 is less trustworthy owing to the digitalization by OCR technology. The input data sets were screened for errors and financial statements with apparent inconsistencies were dropped (the criteria being as follows: the balance sheet identity is violated; either asset or liability components do not add up to declared totals; the numerators or denominators of the financial ratios considered are not non-negative when they must be).

For simplicity, only 8 ratios were considered respecting the definition and method of computation of CRIF two per each of the four major categories. Their classification, shorthand definitions and abbreviations are provided in Tab. 1.

Note that out of the definitional categories in the numerators and denominators only income before taxes, net income and equity can take negative values, otherwise all the quantities must be non-negative. Note also that L3, ATO, INVDAY, D2ASS must be non-negative or plus infinity, and that WC2INV, INTCOV, ROE and OROS are supported on the real axis or take a value of negative or positive infinity. In addition, with ROE pathological situations may easily happen when both the numerator and denominator are strictly negative, in which case a positive value arises with no economic meaning or sense whatsoever. Unconditionally, such non-sensible values cannot be taken into account when compiling business statistics. A correct approach is to eliminate them in the data set and report that a certain percentage of

Tab. 1: Financial ratios considered in the study

Financial ratio	Code	Notional definition	Category
Liquidity tier 3	L3	$\frac{\text{current assets}}{\text{current liabilities}}$	liquidity
Inventory by net working capital funding ratio	WC2INV	$\frac{\text{current assets} - \text{current liabilities}}{\text{inventory}}$	liquidity
Asset turnover (in sales)	ATO	$\frac{\text{sales}}{\text{assets}}$	activity
Days' sales in inventory	INVDAY	$\frac{\text{inventory}}{\text{sales}} \cdot 360$	activity
Debt to assets ratio	D2ASS	$\frac{\text{debt}}{\text{assets}} \cdot 100$	leverage
Interest coverage	INTCOV	$\frac{\text{income before taxes} + \text{interest expense}}{\text{interest expense}}$	leverage
Return on equity	ROE	$\frac{\text{net income}}{\text{equity}} \cdot 100$	profitability
Operating return on sales	OROS	$\frac{\text{operating income}}{\text{sales}} \cdot 100$	profitability

Source: own

enterprises reported both negative net income and equity and state this percentage alongside the industry representative. It is not known how vendors of business statistics cope with the technical circumstance that emerges with ROE and perhaps with other indicators.

Given the space available, the demonstration is limited merely to one industry recognized according to the industry classification NACE Rev 2 as. "F41.2 – Construction of residential and non-residential buildings". The choice fell upon this industry to allow a sufficient number of observations on enterprises. Whereas 2018 was rich in the number of available financial statements, 2009 was sparse in terms of effective financial statements. For most industries at the third level of the nomenclature (groups) there were only a few observations in 2009. In truth, all computations were accomplished also for the industry "Q86.2 – Medical and dental practice activities" with findings to a fault similar, but – as the output doubled and became extensive – the analysis for this industry goes unreported.

Eventually, for the two years 2009 and 2018 and the eight financial ratios summarized in Tab. 1 the analysis concentrated upon the following: (i) visual exploration of the frequency

distribution of ratios, (ii) demonstration that the frequency distribution of ratios is susceptible to anomalous (outlying) values, and (iii) comparison of different measures of location of the frequency distribution. These aspects are further clarified in the ensuing subsections. Points (i) and (ii) correspond to the goal to demonstrate undesirable empirical properties of the typical distribution of financial ratios with an emphasis upon skewness and asymmetric power-law (Paretian) tails. Points (iii) answers to the goal to explore possible remedial approaches to this situation when a summary measure of location is to be constructed. Whilst elements (i) and (ii) help to prove the assertion that compilation of industry statistics is a complicated task and deserves deeper insights that are obtained through point (iii).

2.1 Visualization of the Frequency Distribution

A visual display of the frequency distribution gives immediate insights into the credibility of simple measures of location upon which the industry statistics is based. For example, it may reveal that the frequency distribution is heavily skewed or is a mixture of distributions,

and these are cases in which averages and quantile measures are barely ideal. Financial ratios can be handled as continuous random variables; whereas WC2INV, INTCOV, ROE and OROS are with support on the real axis, the other four ratios L3, ATO, INVDAY, D2ASS are bounded from below at zero. In addition, there are frequent instances when the ratio attains an infinite value owing to zero in the denominator. Values of financial ratios thus resemble censored data and must be treated in this manner, wherein negative and positive infinite values are replaced by the observed finite minimums and maximums, respectively. The knot deletion algorithm of Kooperberg and Stone (1992) is applied to estimate the density of financial ratios by using splines that allows possible boundeness from below at zero (for L3, ATO, INVDAY, D2ASS) and right and left censoring (for all the ratios). Sometimes, additional censoring was needed to assure that the algorithm converges and gives an accurate representation of the frequency distribution. This is implemented symmetrically on both tails of the distribution and the censoring percentages are reported with the censoring percentages arising from the presence of infinite values.

2.2 Power-law (Fat) Tails of the Frequency Distribution

The argument is that the frequency distribution of a typical financial ratio has a tendency towards tails that decay slowly, and is exposed to the occurrence of values extraordinarily distant from the location of the distribution. As the terminology across the statistical community in this respect is not settled, the view adopted here is that a distribution with distribution function $F(x)$ that exhibits a power law in its right tail is a distribution whose complementary cumulative distribution function $S(x) = 1 - F(x)$ can be expressed as $S(x) = L(x) \cdot x^{-\alpha}$ with a small value of $\alpha > 0$ and $L(x)$ such that $\lim_{x \rightarrow \infty} L(x)$ equals to a constant. Whereas $L(x)$ is called a slowly varying function, α is positive and required $\alpha < 3$. In such a case, the distribution has a right tail that is heavier than that of an exponential distribution (fat tails) and the probability of extreme values is higher than imposed by the Gaussian law. A similar definition can be adopted for the left tail. The underlying coefficient α is the tail index, and may be employed as a measure of fat-tailedness: the smaller α , the heavier tails a distribution

displays. For more details and formal treatment, it is possible to consult Bryson (1974), Nair et al. (2013), Sornette (2006) and Mikosch (2009).

Since in principle a power can be fitted and estimated in the tail of any distribution, it is necessary to inspect whether the data exhibit power-law tail behaviour. Besides informal approaches, there are formal methods for testing rigorously that the frequency of data diminishes in the tail in accordance with the power-law hypothesis. Clauset et al. (2009) recommend a goodness-of-fit test based on the Kolmogorov-Smirnov statistic implemented by dint of a bootstrapping procedure. When a power law is established (and the null hypothesis claiming its presence is not refuted), it is then appropriate to estimate the tail index. Several approaches have been devised to estimate the tail index that captures the magnitude with which the power law presents itself. This paper reports the results of 3 approaches to estimation: the maximum likelihood method (Newman, 2005), and two methods that extend the Hill estimator (Hill, 1975) by an automatic criterion for selecting the cut-off starting off the power-law tail, the method of Danielsson et al. (2016) and of Hall and Welsh (1985). The usefulness of the first method is limited by its reliance on the assumption of Pareto distributed data, whereas the last two Hill-based methods are more general as they only necessitate that the power-law behaviour is exhibited (only) by the tail. Since every method for estimating the tail index has its advantages and drawbacks (Munasinghe et al., 2019), it is prudent to make a comparative use of various methods. The analysis also made use of 3 other methods that are in nature grossly similar to maximum likelihood: the weighted least squares (Nair et al., 2019) alongside the percentile and geometric mean percentile method (Bhatti et al., 2018). These are for the sake of the size limit unreported, and their results are in agreement with the chief 3 methods.

2.3 Measures of Location to Represent the Situation in an Industry

A crucial obstacle to any attempt to characterize the industry situation by a measure of central tendency is the existence of non-defined or infinite values of the financial indicator. The former happens when both the numerator and denominator coincide at a zero amount. An example is when an enterprise is fresh

in the business, in which case it may have neither inventory nor sales. The latter arises when only the denominator is zero. Alas, both cases do happen and with some indicators are somewhat frequent. To deal with this issue, the following protocol is adopted: (1) Non-defined values are removed because they appertain to enterprises that do not qualify as a basis for benchmarking and industry comparison. (2) Infinite values are handled in two different ways: either by trimming (truncation) or by winsorization (censoring). Upon trimming, all positive or negative infinities are simply discarded and removed from the calculated values of a financial ratio. In contrast, upon winsorizing, the maximum finite value is substituted for positive infinities, and the minimum value is used instead of negative infinities. Note that whilst an error or inconsistency discovered in the preliminary screening leads to the discarding the erroneous financial statement and affects all the eight financial ratios, the described trimming and winsorization protocol is implemented afterwards for each financial ratio individually.

The following measures of location are applied to both the trimmed and winsorized data on the eight financial ratios in the years 2009 and 2018: (1) the simple non-robust mean, (2) the trimmed (truncated) mean with 5%, 10%, 15%, 20% and 25% observations discarded from both endpoints of the data sample, (3) the winsorized mean with observations 5%, 10%, 15%, 20% and 25% censored at both endpoints of the data sample, in addition to (4) the quantiles at probabilities 10%, 25%, 50%, 75% and 90%. Owing to the presence of extreme observations that trouble data on a typical financial ratio, there is a need to suppress the effect of observations at the endpoints. Hence, trimmed and winsorized means are preferable over the non-robust mean. Note that 25% trimmed mean is the mid-mean advocated by Tukey (1970) and that the 50% quantile is the median. In addition, the 25% and 75% quantiles define the interquartile range, and indicate the central half of the data that participates in computing the 25% trimmed and winsorized means.

The analysis was in full implemented in program R, version 3.6.0, using the functionalities of the packages `psych`, `logspine`, `ptsuite`, `tea` and `powerLaw`.

3. Results

After the dismissal of financial statements with obvious errors during the preliminary screening, a total of 101 and 1,109 financial statements were left for enterprises associated with the “construction” industry F41.2. The top parts of Tabs. 2 and 3 identify for the scrutinized financial indicators the frequency of pathological cases when a financial ratio was not defined (“# NA values”), cases when an infinity value was calculated (“# $\pm\text{Inf}$ values”) and standard cases with finite values. In addition to the eight indicators catalogued in Tab. 1 – L3, WC2INV, ATO, INVDAY, D2ASS, INTCOV, ROE, and OROS – Tabs. 2 and 3 encompass also ROE*, which is return on equity with economically non-sensical values suppressed and designated as non-defined. By comparing the number of NA values for ROE and ROE*, it becomes apparent that there were $18 - 3 = 15$ such values ($15 / 101 \approx 14.85\%$) in 2009 and $124 - 0 = 124$ such values ($124 / 1,109 \approx 11.18\%$) in 2018. This is a fairly high proportion to be simply ignored. As highlighted in Section 2, the non-defined and infinity values were either trimmed, or winsorized. The tables report industry statistics for both versions of data, and label trimmed and winsorized means as “trim mean” and “wins mean”, respectively.

The summaries in Tabs. 2 and 3 point out several notable aspects that appear universal regardless of whether the trimming or winsorizing protocol is adhered to.

- First, to all intents and purposes, the conventional arithmetic mean seems to produce values that are beyond credibility as they are apparently severely affected by extreme values and are overtly distant from values yielded by other metrics. In addition, simple mean values are also less believable from an economic point of view, perhaps with the exception of ATO.
- Second, estimates of central tendency react rather sensitively to the amount of trimming or winsorizing implemented in both endpoints of the distribution. The mean in itself is a 0% trimmed mean as well as 0% winsorized mean, and both the trimmed and winsorized mean in most cases exhibit a strictly monotone trajectory with the increasing trimming or winsorizing factor. Slight exceptions happen with indicators awash with non-defined or infinite values (L3, INVDAY, INTCOV, OROS in 2008,

and WC2INV, INVDAY, INTCOV for 2018). For example, a good many construction enterprises do not report interest expense (and they finance their assets by equity), which renders INTCOV negative. It is perhaps the issue with small entities. There are also situations that are more difficult to explain. For example, 5 enterprises in 2009 reported neither inventory nor sales, and as many as 52 enterprises did not declared sales, which resulted in 5 non-defined and 52 infinite values for INVDAY in 2009. Certainly, a few enterprises may be fresh in the business, but this does not explain why there are so many enterprises with odd values. A similar situation can be detected with other indicators as well, especially with WC2INV for 2018. Nonetheless, this is a snapshot of corporate reality that only proves the point that there will always be a proportion of financial statements liable to be erroneous and that robust or resistant methods are of the utmost appeal to compile industry statistics.

- Third, it is evident that some amount of cutting-off values is desirable. Whereas 5% trimming or winsorizing seems insufficient, 25% trimming or winsorizing aligns calculated values more with median values. The latter is but natural, and implied by the definition.
- Fourth, the presence of odd values is also manifested in quantiles, and especially first and ninth deciles (10% and 90% quantiles) are scourged by values that are not typical and obviously non-representative of the industry situation. Only quartiles (25%, 50% and 75% quantiles) seem to possess some information value.
- Fifth, the trimming protocol may be viewed as more reliable as it produces values that are economically more acceptable and useful for the purpose of comparison. Having said that, the output presented in Tabs. 2 and 3 does not warrant the assertion that the industry statistics compiled by using trimmed data conforms to the true empirical distribution of the scrutinized financial ratios (more closely than the one produced by winsorized data).
- Sixth, the industry statistics for ROE is considerably more favourable than for ROE* when non-sensical values are eliminated. The industry statistics for ROE in both years is artificially biased upward by the presence

of non-sensical positive values.

The frequency distributions estimated by logspline are visualized for both years in Figs.1 and 2. The estimated densities are produced with winsorized (censored) data with allowance for the lower bound 0 with L3, ATO, DAYINV, and D2ASS. In some cases, in addition to the trimming owing to the presence of infinite cases, some other additional trimming was sometimes necessary at both ends of the distribution to make the logspline method converge. The needed amounts of trimming are reported with density plots. Figs.1 and 2 display somewhat atypical shapes of frequency distributions and prove the self-evident fact that frequency distributions of financial indicators are not time-invariant, but they change and shift over time. In some cases they are bimodal, and frequently extremely skewed. They depart substantially from the Gaussian paradigm and serve to illustrate glaringly situations where there is an objective need to employ robust metrics of location. The prolonged tails are suggestive of fat tails consistent with a power law.

Indeed, the evidence that in many a case visualized in Figs.1 and 2 a power law is at work is submitted in Tab. 4. The table first reports the results of testing for power-law behaviour in the right tail and (if appropriate also) the left tail for estimates of the tail index α obtained with the aid of maximum likelihood and the Hill estimator combined with the recommendation by Danielsson et al. (2016) and Hall and Welsch (1985). These estimation methods are labelled as "ML", "Hill_Dan", and "Hill_HW". The testing is carried out at the 5% level of significance, and only in a situation when a power law is detected, the respective tail index is reported as a measure of fat-tailedness. This substantiates the claim that financial ratios are naturally exposed to values distant from the centre of their distribution, and tallies with the display of Figs.1 and 2.

4. Discussion

It is very difficult, if not impossible, to formulate a definite instruction concerning how to proceed in compiling industry statistics for the sake of corporate comparisons. Indeed, the ambition of this study is to draw attention to the fact that accounting data from which industry statistics are compiled are not free of mistakes (and are frequently erroneous) and that even errorless financial statements may yield values that are

Tab. 2: Indicators of industry statistics compiled for 2009 for the “construction” industry F41.2

	L3	WC2INV	INVDAY	ATO	D2ASS	INTCOV	ROE	ROE*	OROS
# NA values	1	1	5	0	0	20	3	18	14
# ±Inf values	39	5	52	0	0	71	8	8	43
# finite values	61	95	44	101	101	10	90	75	44
Trimmed data									
Mean	25.39	-11.24	776.37	4.51	1,597.04	49.67	-81.93	-104.70	7.55
5% trim mean	12.04	0.29	262.08	1.39	155.07	49.67	-1.08	-9.09	-18.29
10% trim mean	9.27	1.36	98.14	0.89	89.47	29.87	-1.21	-7.01	-4.47
15% trim mean	7.66	1.59	81.23	0.48	67.96	29.87	-0.74	-5.01	-1.98
20% trim mean	6.69	1.66	70.11	0.32	63.62	2.40	-0.17	-3.44	-1.12
25% trim mean	5.91	1.69	57.87	0.18	64.34	2.40	0.11	-2.54	0.28
5% wins mean	14.60	-0.52	466.94	1.87	270.59	48.18	-1.48	-11.19	-32.28
10% wins mean	12.17	0.99	124.21	1.53	124.79	46.68	-1.11	-10.20	-8.21
15% wins mean	9.72	1.35	102.47	0.82	82.58	31.14	-1.75	-8.35	-3.65
20% wins mean	8.97	1.57	87.75	0.66	65.84	11.57	-0.60	-6.33	-2.93
25% wins mean	7.44	1.60	71.44	0.44	59.15	2.62	0.06	-4.57	-1.79
10% quantile	0.01	-3.15	8.70	0.00	0.00	-12.50	-52.01	-63.58	-70.27
25% quantile	0.43	1.00	27.08	0.00	7.95	0.21	-7.44	-15.28	-11.68
50% quantile	4.87	1.81	45.48	0.00	71.55	1.75	0.00	0.00	0.63
75% quantile	17.62	2.00	142.94	1.42	99.77	6.12	7.46	1.75	3.98
90% quantile	48.03	2.00	483.99	8.27	535.66	240.38	50.67	15.19	19.40
Winsorized data									
Mean	155.62	-38.00	7,330.57	4.51	1,597.04	29.17	-681.29	-810.18	-432.16
5% trim mean	152.95	-12.87	7,411.58	1.39	155.07	18.25	-422.06	-512.81	-582.30
10% trim mean	149.61	0.53	7,535.49	0.89	89.47	4.63	-16.02	-133.36	-582.59
15% trim mean	145.31	1.37	7,694.82	0.48	67.96	-12.81	-6.21	-13.26	-580.97
20% trim mean	139.53	1.59	7,908.17	0.32	63.62	-35.95	-3.77	-8.83	-578.70
25% trim mean	131.36	1.64	8,209.73	0.18	64.34	-58.03	-2.02	-6.18	-575.47
5% wins mean	155.62	-38.80	7,330.83	1.87	270.59	29.17	-686.84	-817.54	-581.45
10% wins mean	155.62	-1.43	7,332.04	1.53	124.79	29.17	-33.77	-669.36	-584.23
15% wins mean	155.67	0.81	7,333.17	0.82	82.58	29.17	-11.31	-26.50	-585.30
20% wins mean	155.82	1.36	7,334.87	0.66	65.84	29.17	-8.57	-15.79	-585.79
25% wins mean	155.98	1.54	7,335.90	0.44	59.15	-45.52	-4.85	-11.48	-585.92
10% quantile	0.07	-20.50	24.37	0.00	0.00	-68.00	-272.11	-6,017.79	-1,195.49
25% quantile	1.88	0.90	47.69	0.00	7.95	-68.00	-22.51	-35.66	-1,195.49
50% quantile	26.15	1.77	12,876.43	0.00	71.55	-68.00	0.00	-1.86	-201.29
75% quantile	359.31	2.00	12,876.43	1.42	99.77	2.58	6.82	1.09	1.25
90% quantile	359.31	2.00	12,876.43	8.27	535.66	325.77	35.07	14.36	12.53

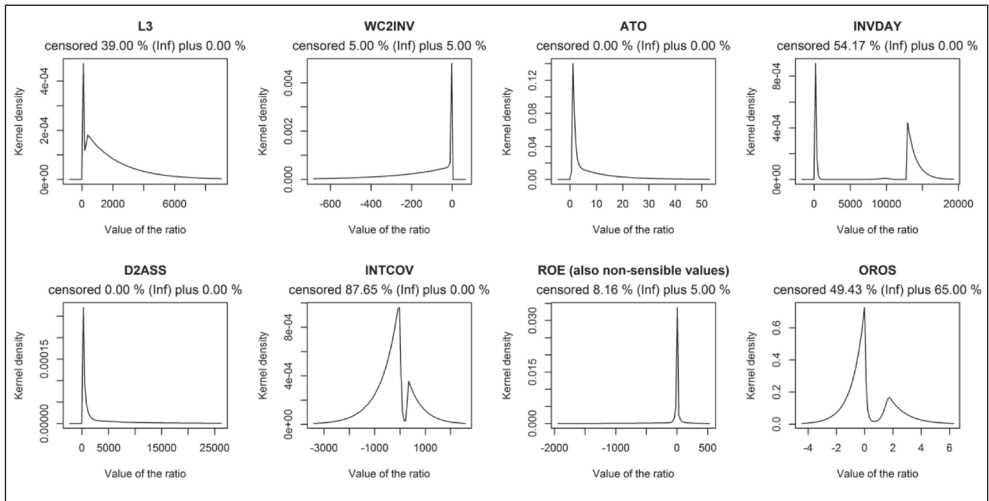
Source: own

Tab. 3: Indicators of industry statistics compiled for 2018 for the “construction” industry F41.2

	L3	WC2INV	INVDAY	ATO	D2ASS	INTCOV	ROE	ROE*	OROS
# NA values	1	1	160	0	0	57	0	124	70
# ±Inf values	49	521	53	0	0	532	0	0	143
# finite values	1,059	587	896	1,109	1,109	520	1,109	985	896
Trimmed data									
Mean	30.18	114.79	517,861	2.11	146,859	-145.98	-303.89	-368.52	3,537.93
5% trim mean	2.49	10.14	54.63	1.24	69.24	20.07	11.65	6.69	1.88
10% trim mean	1.75	3.07	22.04	1.13	66.98	13.48	11.18	7.74	3.29
15% trim mean	1.49	1.50	12.94	1.06	67.84	9.34	10.16	7.54	3.50
20% trim mean	1.36	1.12	8.30	1.00	69.26	6.72	8.97	6.73	3.42
25% trim mean	1.29	0.90	5.37	0.97	70.41	5.29	7.71	5.83	3.25
5% wins mean	3.62	25.95	124.37	1.36	74.89	29.58	10.51	3.83	-0.56
10% wins mean	2.28	8.07	44.39	1.26	66.85	20.62	12.59	7.33	2.41
15% wins mean	1.83	2.81	24.98	1.19	64.95	16.30	12.63	8.83	3.59
20% wins mean	1.57	1.78	17.12	1.11	66.20	11.95	11.80	8.91	3.67
25% wins mean	1.43	1.42	11.23	1.02	68.01	7.61	10.55	7.95	3.72
10% quantile	0.22	-14.99	0.00	0.00	5.52	-24.45	-33.53	-40.53	-26.83
25% quantile	0.69	-0.98	0.00	0.04	35.78	0.21	-1.29	-2.74	-0.15
50% quantile	1.15	0.54	0.72	0.93	71.56	3.65	4.81	3.24	2.67
75% quantile	2.46	4.89	34.19	2.12	95.46	19.65	28.09	22.88	8.52
90% quantile	8.68	71.70	269.19	3.60	127.19	122.87	70.10	51.90	24.56
Winsorized data									
Mean	363.82	4,009.80	24,894,390	2.11	146,859	-6,126.42	-303.89	-368.52	-134,274
5% trim mean	9.06	3,888.11	3,609,331	1.24	69.24	-5,185.00	11.65	6.69	-157,067
10% trim mean	2.41	3,736.27	65.39	1.13	66.98	-3,986.17	11.18	7.74	-52,790
15% trim mean	1.76	3,537.44	23.80	1.06	67.84	-2,475.26	10.16	7.54	-3.83
20% trim mean	1.52	3,077.57	13.86	1.00	69.26	-423.59	8.97	6.73	0.94
25% trim mean	1.39	1,690.02	8.77	0.97	70.41	1,240.24	7.71	5.83	1.99
5% wins mean	38.78	4,009.80	24,894,390	1.36	74.89	-6,126.42	10.51	3.83	-239,059
10% wins mean	4.11	4,009.80	239.81	1.26	66.85	-6,126.42	12.59	7.33	-239,062
15% wins mean	2.45	4,009.80	57.57	1.19	64.95	-6,126.42	12.63	8.83	-27.34
20% wins mean	1.92	5,756.33	29.08	1.11	66.20	-6,126.42	11.80	8.91	-3.22
25% wins mean	1.60	5,841.50	18.87	1.02	68.01	7,580.91	10.55	7.95	0.81
10% quantile	0.23	-9,765.62	0.00	0.00	5.52	-57,516.00	-33.53	-40.53	-1,984,600
25% quantile	0.72	-7.42	0.00	0.04	35.78	-257.15	-1.29	-2.74	-8.65
50% quantile	1.22	1.09	1.47	0.93	71.56	4.34	4.81	3.24	2.14
75% quantile	2.88	19,993.40	57.98	2.12	95.46	28,100.33	28.09	22.88	7.89
90% quantile	21.71	19,993.40	1,892.64	3.60	127.19	28,100.33	70.10	51.90	25.93

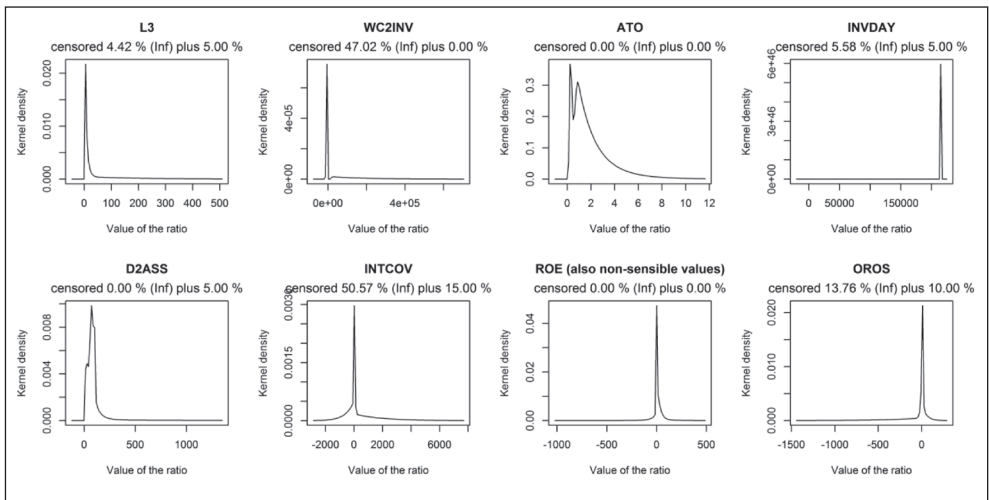
Source: own

Fig. 1: Estimated densities of financial ratios for 2009 for the “construction” industry F41.2



Source: own

Fig. 2: Estimated densities of financial ratios for 2018 for the “construction” industry F41.2



Source: own

Tab. 4:

Presence of power laws in financial indicators for the “construction” industry F41.2 and tail indices for cases where a power law cannot be rejected

	L3	WC2INV	INVDAY	ATO	DZASS	INTCOV	ROE	ROE*	OROS
Year 2009: the right tail									
ML	0.00	0.68 $\alpha = 0.451$	0.00	0.15 $\alpha = 0.216$	0.49 $\alpha = 0.201$	0.28 $\alpha = 0.479$	0.08 $\alpha = 0.366$	0.44 $\alpha = 0.390$	0.15 $\alpha = 0.359$
Hill_Dan	0.83 $\alpha = 0.946$	0.00	0.68 $\alpha = 1.269$	0.76 $\alpha = 0.541$	0.81 $\alpha = 0.646$	0.00	0.24 $\alpha = 1.386$	0.39 $\alpha = 1.052$	0.49 $\alpha = 0.469$
Hill_HW	0.87 $\alpha = 0.924$	NA	0.33 $\alpha = 0.996$	0.73 $\alpha = 0.508$	0.72 $\alpha = 0.560$	NA	0.23 $\alpha = 0.680$	0.39 $\alpha = 1.052$	NA
Year 2009: the left tail									
ML	bounded from below by zero	0.53 $\alpha = 0.306$	bounded from below by zero	bounded from below by zero	bounded from below by zero	NA	0.37 $\alpha = 0.184$	0.37 $\alpha = 0.184$	0.14 $\alpha = 0.251$
Hill_Dan		0.00				NA	0.84 $\alpha = 0.788$	0.84 $\alpha = 0.788$	0.74 $\alpha = 0.705$
Hill_HW		NA				NA	0.83 $\alpha = 0.566$	0.83 $\alpha = 0.566$	0.69 $\alpha = 0.431$
Year 2018: the right tail									
ML	0.00	0.00	0.00	1.00 $\alpha = 0.123$	1.00 $\alpha = 0.136$	0.00	0.00	0.00	0.25 $\alpha = 0.163$
Hill_Dan	0.46 $\alpha = 0.702$	0.48 $\alpha = 0.922$	0.18 $\alpha = 1.765$	1.00 $\alpha = 0.408$	1.00 $\alpha = 0.410$	0.54 $\alpha = 0.784$	0.57 $\alpha = 0.743$	0.00	0.95 $\alpha = 0.751$
Hill_HW	0.11 $\alpha = 0.747$	0.70 $\alpha = 1.175$	0.04	NA	1.00 $\alpha = 0.559$	0.34 $\alpha = 1.075$	0.07 $\alpha = 1.259$	0.00	0.96 $\alpha = 0.815$
Year 2018: the left tail									
ML	bounded from below by zero	0.00	bounded from below by zero	bounded from below by zero	bounded from below by zero	0.00	0.21 $\alpha = 0.138$	0.21 $\alpha = 0.138$	1.00 $\alpha = 0.184$
Hill_Dan		0.30 $\alpha = 1.013$				0.34 $\alpha = 0.535$	0.52 $\alpha = 0.754$	0.52 $\alpha = 0.754$	1.00 $\alpha = 0.594$
Hill_HW		0.64 $\alpha = 1.741$				0.26 $\alpha = 0.516$	0.51 $\alpha = 0.734$	0.51 $\alpha = 0.734$	1.00 $\alpha = 0.426$

Source: own

difficult to grasp (infinities) and non-sensical (non-defined). In the experience of the authors of this study, many do not realize that industry measures do not come easy, but necessitate a number of subjective decisions whose purpose is to isolate the frequency distribution of financial ratios and capture its central tendency or other characteristics. The task is not a simple empirical exercise or a mere statistical analysis by reason of the absence of information about the underpinning frequency distribution. In fact, this must be reconstructed from available data, and the plausibility of the measures of location chosen to represent the situation in an industry must be assessed through economic judgement as an inevitable input to the entire process. Such economic judgement provides guidance in adjudging which of the explored

elements of the methodological procedure are sound and preferable.

Albeit the empirical demonstration focuses on an only industry of the Slovak economy, it is both the contention and experience of the authors, that the results of the previous section are universal and do not deviate in troubles from the patterns identifiable in other industries and in industries of other economies. The references made in the introduction prove that issues with financial statements or usefulness in corporate comparisons are not particular only to Slovak economic conditions, but are international. The results proved firmly that analysis of financial ratios requires a robust methodology as data – even after addressing the problem with infinite values (either by trimming or winsorization) – teem with extreme

values that make the arithmetic mean useless. Each of the examined financial ratios showed a tendency towards a power law at least in one tail, or in other words, towards at least one Paretian tail, which signalizes the failure of standard measures of central tendency. In spite of using more common sense and subjective reasoning than objective knowledge as explained afore, the recommendation is to stick to the trimming protocol and to summarize the remaining data through the interquartile range and 25% trimmed mean, possibly in conjunction with the 50% quantile. On the one hand, winsorization may be deemed as more friendly in regard to the information encompassed in infinite values since the information about the direction of data is preserved by clipping the infinite values off to the nearest finite values. On the other hand, the results obtained after the winsorization protocol still display less credible values that cannot be reasonably employed in industry comparisons. The trimming protocol is in this respect more suitable as it produces more interpretable and credible values of financial ratios. Hence, it transpires that there is no benefit in trying to spare information that may be recoverable from infinite values. The interquartile range applied to such trimmed data then specifies the boundaries of the middle half of data, the 25% trimmed mean is their arithmetic average, and the 50% quantile is their mid. The recommendation advanced for discussion is thus to use only the middle half of the ordered data rid of infinite values, and to apply a measure of central tendency to them. The 25% trimmed mean is also called the midmean or interquartile mean, whereas the 50% quantile is the median.

In one respect, the recommendation to employ the three quartile measures, i.e. the 25%, 50% and 75% quartiles, is no improvement over the methodology of CRIF. In another respect, it is a confirmation of the soundness of the methodology they use. That being said, also their quartile summaries suffer from extreme values as is apparent in too frequent an occurrence of $-\#INF\#$ or $\#INF\#$ signs that are used in place of values of a ratio lower than $-100,000$ or greater than $100,000$. Nonetheless, the firm does not disclose the measures taken to ensure integrity of their summary numbers, how they deal with infinite values or to what extent they cleanse input financial statements. That thorough cleansing

is needed is corroborated by the fact that the number of erroneous financial statements is not negligible. For instance, Profini (2018, p. 33) reports for 2015 to 2017 from 12.48% to 13.22% erroneous financial statements published for enterprises that keep accounts on a double-entry basis. For both years, 2009 and 2018, Tab. 5 contrasts the summary statistics provided by CRIF and the summary statistics recommended in this study. There is a huge disproportion in the numbers of financial statements out of which these summaries were calculated. Whereas CRIF calculated their statistics using 2,229 and 7,082 financial statements for 2009 and 2018, this study employed respectively 101 and 1,109 financial statements that remained after the preliminary screening for errors. It is not clear whether the counts 2,229 and 7,082 appertain to the effective number of financial statements or the input data set before any removal of dubious financial statements. In addition, CRIF does not report any adjustment regarding non-sensical values of ROE. The differences between the summary statistics are striking and unsettling. On the one hand, the quartile measures and arithmetic mean reported by CRIF emerged from a considerably higher sample of financial statements (yet, they still do not represent the full population of construction enterprises), which might be suggestive of better accuracy or cogency. On the other hand, the method of disposing of erroneous or suspicious financial statements and the approach to coping with infinite values is not communicated. The glaring discrepancies between mean and median (50% quantile) values indicate extremely skewed frequency distributions, in which case the mean is of little avail to corporate comparisons since it fails to capture the central tendency. Obviously, the methodology recommended here for the sake of compiling industry statistics seems more coherent as there are petit differences between 25% trimmed mean and median (50% quantile) values in comparison to the preceding commented discrepancies. Nonetheless, it is not possible to state which one is more relevant. Yet, the point is made. Note that it is not possible to add into this comparison the industry statistics prepared by DataSpot since their definitional convention differs.

A methodological issue that remains is that, if an enterprise shows a non-sense value in one financial ratio, only this particular value should

Tab. 5: Comparison of the industry statistics using the methodology of CRIF and the recommended methodology for the “construction” industry F41.2

	L3	WC2INV	INVDAY	ATO	D2ASS	INTCOV	ROE	ROE*	OROS
Year 2009									
Year 2009: methodology of CRIF									
25% quantile	0.59	-3.20	0.00	0.07	12.00	-#INF#	-4.77		-5.93
50% quantile	1.10	0.11	0.00	0.99	56.75	15.51	2.93		1.51
75% quantile	2.38	4.08	8.62	2.27	90.98	#INF#	26.55		6.34
Mean	15.78	18.24	159.60	5.67	320.09	6,872.04	-44.10		-117.24
Year 2009: recommended methodology									
25% quantile	0.43	1.00	27.08	0.00	7.95	0.21	-7.44	-15.28	-11.68
50% quantile	4.87	1.81	45.48	0.00	71.55	1.75	0.00	0.00	0.63
75% quantile	17.62	2.00	142.94	1.42	99.77	6.12	7.46	1.75	3.98
25% trim mean	5.91	1.69	57.87	0.18	64.34	2.40	0.11	-2.54	0.28
Year 2018: methodology of CRIF									
25% quantile	0.91	-1.54	0.00	0.01	19.23	-7.53	-9.53		-8.99
50% quantile	1.72	#INF#	0.00	1.13	69.30	2.08	3.01		2.30
75% quantile	8.90	#INF#	4.82	2.36	97.11	16.51	29.45		11.28
Mean	26.64	32.44	9,098.47	5.83	212.83	-101.48	-246.52		-241.52
Year 2018: recommended methodology									
25% quantile	0.69	-0.98	0.00	0.04	35.78	0.21	-1.29	-2.74	-0.15
50% quantile	1.15	0.54	0.72	0.93	71.56	3.65	4.81	3.24	2.67
75% quantile	2.46	4.89	34.19	2.12	95.46	19.65	28.09	22.88	8.52
25% trim mean	1.29	0.90	5.37	0.97	70.41	5.29	7.71	5.83	3.25

Source: own, CRIF – Slovak Credit Bureau, Ltd.

be dropped from the database or the values for all financial ratios should be discarded. At present, the cleansing procedure is applied for every financial ratio separately. The cleansing procedure must include also cases when a financial ratio attains not so obviously incorrect values. Such an issue arises with the frequently used and popular return on equity, ROE, which indicates a positive (desirable) value even in economically distressed situations when both net income and equity are negative. A snapshot provided by the empirical demonstration is alarming as it proves that these unacceptable situations are rather common and their disregard is at the risk of putting the profitability in an industry into a more positive light.

An obvious shortcoming shared by the discussed approaches to compiling industry statistics is unidimensionality. This paper, CRIF, DataSpot and other vendors consider every financial ratio individually and separately from

others at the expense of ignoring simultaneous links that exist between different financial ratios at a time. An avenue worthy of exploration is consideration of these relationships, e.g., in the spirit of multivariate medians (and similarly multivariate measures of location). Small (1990) surveys different definitions of the median in a multivariate case, and Chaudhuri (1996) and Hallin et al. (2010) exemplify multivariate extensions of the concept of quantiles.

Finally, industry statistics should encompass not only information about the central tendency of financial ratios, but also about their variability. A proper interpretation should take into account also the level of dispersion of a financial ratio in the industry. Given the noted and observed heterogeneity of enterprise values, conventional non-robust measures will scarcely be useful. Nonetheless, a robust measure of variability can be easily extracted from 25% and 75% quantile values as their difference (the

interquartile range) or half their difference (the quartile deviation). In the methodology of CRIF and the recommended methodology, 25% and 75% quantile values are immediately available.

Conclusion

Motivated by the practical needs of corporate financial analysis when it comes to benchmarking and comparison with an industry, the paper studies methodological subtleties of compiling industry statistics. In this respect, the paper contributes to the methodology of financial analysis in no less than three ways. First, it challenges the semblance that compiling industry statistics is a simple task that leads to trustworthy figures to which an enterprise can be compared. The converse is true for input data are drawn from financial statements with varying veracity and financial ratios have distributions with power-law (fat) tails to say nothing of the existence of relatively frequent infinite or non-defined values. Second, it explores different methodological choices underlying compilations of industry statistics and suggests that after the preliminary screening for errors in financial statements data should first be trimmed (truncated) in order to rid them of infinite values and then summarized by three quartiles (especially the 25% and 75% quantiles) as well as the 25% trimmed mean. It seems that with typical frequency distributions of financial ratios winsorization is substantially inferior to trimming, in both suppressing infinite values and representing the central tendency of a financial ratio. Albeit quartile values are conventional metrics of industry statistics in Slovakia in the methodology of CRIF, their methodology does not appreciate the trimming protocol and does not make use of a trimmed mean. Third, the paper calls attention to the defective feature of return on equity, ROE, which is the ultimate indicator of accounting profitability and of somewhat obligatory use. ROE becomes positive, which is interpreted as a good situation, also when both net income in the numerator and equity in the denominator are negative. Yet, this is the worst possible scenario. If this is not reflected in the trimming protocol before values of ROE are summarized, the calculated metrics of central tendency are biased upward.

The study has implications not only for the methodology of industry statistics, but also for corporate and banking analysts as end users

of financial information compiled for different industries. Whereas in Anglophone countries there is an inclination to averages, in Slovakia the golden standard instituted by CRIF prefers quantiles. Although any such descriptive gives a snapshot of where an industry stands in terms of its financial position, its computation requires a set of steps associated with cleansing data and ensuring that computed values are usable, at least at first glance. An analyst should understand that a particular value of an industry statistic actually does not appertain to all firms in a given industry, but to those whose financial ratios are well-behaved to some degree. Thus, comparability is inevitably limited, and a reasonable approach to analysis is to use quartiles rather than (traditional) averages to assess the position of a firm for the former are less sensitive to atypical values thanks to their resistance. That said, this only testifies the prudence of the quartile-based approach of CRIF.

A seeming limitation of the initiative is that the point is made through a case study oriented upon Slovak enterprises falling into the "construction" industry F41.2 for two years, 2009 and 2018. Nonetheless, in no manner is this orientation restrictive since lessons are of universal validity all over the financial world. The reason being, financial statements are full of errors, enterprises vary in operations and are extremely heterogeneous, and some of them find themselves in financial distress. The caveat placed upon the methodology of industry statistics is of concern elsewhere, and the raised issues deserve special attention on the agenda of international management.

Acknowledgement: *The paper arose in partial fulfilment of VEGA project No. 1/0767/18 and would not have come into existence without the encouragement of the late prof. Ing. Mária Uramová, PhD. The authors regret her sudden demise and are grateful to her for the idea to write this paper.*

References

- Balcaen, S., Manigart, S., Buyze, J., & Ooghe, H. (2012). Firm exit after distress: differentiating between bankruptcy, voluntary liquidation and M&A. *Small Business Economics*, 39(4), 949–975. <https://doi.org/10.1007/s11187-011-9342-7>
- Bhattacharjee, A., & Han, J. (2014). Financial distress of Chinese firms: Microeconomic,

macroeconomic and institutional influences. *China Economic Review*, 30, 244–262. <https://doi.org/10.1016/j.chieco.2014.07.007>

Bhatti, S. H., Hussain, S., Ahmad, T., Aslam, M., Aftab, M., & Raza, M. A. (2018). Efficient estimation of Pareto model: Some modified percentile estimators. *PLoS ONE*, 13(5), 1–15. <https://doi.org/10.1371/journal.pone.0196456>

Bieniek, M. (2016). Comparison of the bias of trimmed and winsorized means. *Communications in Statistics – Theory and Methods*, 45(22), 6641–6650. <https://doi.org/10.1080/03610926.2014.963620>

Bradshaw, M. T. (2012). Discussion of “Analysts’ industry expertise”. *Journal of Accounting and Economics*, 54(2–3), 121–131. <https://doi.org/10.1016/j.jacceco.2012.09.003>

Bryson, M. (1974). Heavy-Tailed Distributions: Properties and Tests. *Technometrics*, 16(1), 61–68. <https://doi.org/10.1080/00401706.1974.10489150>

Buček, J. (2012). Crisis in Slovakia 2009–2010: from saving the economy to saving public finance. In G. Gorzelak, K. Fazekas, & C.-C. Goh (Eds.), *Adaptability and change: the regional dimensions in Central and Eastern Europe* (pp. 334–359). Warszawa: Wydawnictwo Naukowe Scholar.

Chaudhuri, P. (1996). On a Geometric Notion of Quantiles for Multivariate Data. *Journal of the American Statistical Association*, 91(434), 862–872. <https://doi.org/10.2307/2291681>

Clauset, A., Shalizi, C. R., & Newman, M. E. J. (2009). Power-law distributions in empirical data. *SIAM Review*, 51(4), 661–703. <https://doi.org/10.1137/070710111>

Danielsson, J., Ergun, L. M., de Haan, L., & de Vries, C. G. (2016). *Tail index estimation: quantile driven threshold selection* (Discussion Paper Series 58). London: London School of Economics and Political Science. <https://doi.org/10.2139/ssrn.2717478>

Deloitte Forensic Center. (2009). *Ten things about financial statement fraud: A review of SEC enforcement releases, 2000–2008* (3rd ed.). London: Deloitte Development. Retrieved December 31, 2019, from <https://assets.corporatecompliance.org/Portals/1/Users/169/29/60329/10%20Things%20about%20financial%20statement%20fraud.pdf>

ECCBSO [European Committee of Central Balance-Sheet Data Offices]. (2019). *BACH userguide summary*. BACH Working Group. Retrieved December 31, 2019, from

https://www.bach.banque-france.fr/index.php?page=telechargementFile&file=Summary_Userguide.pdf

Firth, M., Rui, O. M., & Wu, W. (2011). Cooking the books: Recipes and costs of falsified financial statements in China. *Journal of Corporate Finance*, 17(2), 371–390. <https://doi.org/10.1016/j.jcorpfin.2010.09.002>

Gaynor, J., Engel, J., Long, L., Auxier, S., & Goldman, L. (2005). *Judges training manual for the ISU Judging System*. Colorado Springs, CO: US Figure Skating. Retrieved December 31, 2019, from <https://www.usfsa.org/content/module4pgs30-34.pdf>

Hall, P., & Welsh, A. H. (1985). Adaptive estimates of parameters of regular variation. *The Annals of Statistics*, 13(1), 331–341.

Hallin, M., Paindaveine, D., & Šiman, M. (2010). Multivariate quantiles and multiple-output regression quantiles: From L_1 optimization to halfspace depth. *The Annals of Statistics*, 38(2), 635–669. <https://doi.org/10.1214/09-AOS723>

Harada, N., & Kageyama, N. (2011). Bankruptcy dynamics in Japan. *Japan and the World Economy*, 23(2), 119–128. <https://doi.org/10.1016/j.japwor.2011.01.002>

Hill, B. (1975). A simple general approach to inference about the tail of a distribution. *The Annals of Statistics*, 3(5), 1163–1174.

ICE Benchmark Administration. (2019). *ICE LIBOR methodology (Approved July 9, 2019)*. London: ICE Benchmark Administration. Retrieved December 31, 2019, from https://www.theice.com/publicdocs/ICE_LIBOR_Methodology.pdf

Inekwe, J. N., Jin, Y., & Valenzuela, M. R. (2018). The effects of financial distress: Evidence from US GDP growth. *Economic Modelling*, 72, 8–21. <https://doi.org/10.1016/j.econmod.2018.01.001>

Inekwe, J. N., Jin, Y., & Valenzuela, M. R. (2019). Financial conditions and economic growth. *International Review of Economics & Finance*, 61, 128–140. <https://doi.org/10.1016/j.iref.2019.02.001>

Jurečková, J., & Picek, J. (2016). *Robust statistical methods with R*. Boca Raton, FL: Chapman & Hall/CRC.

Konstantaras, K., & Siriopoulos, C. (2011). Estimating financial distress with a dynamic model: Evidence from family owned enterprises in a small open economy. *Journal of Multinational Financial Management*, 21(4), 239–255. <https://doi.org/10.1016/j.mulfin.2011.04.001>

- Kooperberg, C., & Stone, C. J. (1992). Log-spline density estimation for censored data. *Journal of Computational and Graphical Statistics*, 1(4), 301–328. <https://doi.org/10.2307/1390786>
- Koráb, P., & Poměnková, J. (2014). Financial crisis and financing constraints of SMEs in Visegrad countries. *Ekonomický časopis*, 62(9), 887–902.
- Leuz, C., & Verrecchia, R. (2000). The economic consequences of increased disclosure. *Journal of Accounting Research*, 38, 91–124. <https://doi.org/10.2307/2672910>
- Lesáková, L., Ondrušová, A., & Vinczeová, M. (2019). Factors determining profitability of small and medium enterprises in selected industry of mechanical engineering in the Slovak Republic – the empirical study. *E&M Economics and Management*, 22(2), 144–160. <https://doi.org/10.15240/tul/001/2019-2-010>
- Markham, J. W. (2006). *A Financial History of Modern U.S. Corporate Scandals: From Enron to Reform*. Abingdon: Routledge.
- Mikosch, T. (2009). *Non-Life Insurance Mathematics: An Introduction with the Poisson Process* (2nd ed.). Berlin: Springer. <https://doi.org/10.1007/978-3-540-88233-6>
- Munasinghe, R., Kossinna, P., Jayasinghe, D., & Wijeratne, D. (2019). *Fast Tail Index Estimation for Power Law Distributions in R (Vignette to the R package ptsuite)*. Retrieved December 31, 2019, from https://cran.r-project.org/web/packages/ptsuite/vignettes/ptsuite_vignette.pdf
- Nair, J., Wierman, A., & Bert, Z. (2013). The fundamentals of heavy-tails: properties, emergence, and identification. *ACM SIGMETRICS Performance Evaluation Review*, 41(1), 387–388. <https://doi.org/10.1145/2465529.2466587>
- National Bank of Slovakia. (2016). *NBS monthly bulletin: March 2016*. Bratislava: National Bank of Slovakia. Retrieved December 31, 2019, from https://www.nbs.sk/_img/Documents/_MonthlyBulletin/2016/mb0316en.pdf
- National Bank of Slovakia. (2019). *NBS monthly bulletin: March 2019*. Bratislava: National Bank of Slovakia. Retrieved December 31, 2019, from https://www.nbs.sk/_img/Documents/_MonthlyBulletin/2019/mb0319en.pdf
- Newman, M. E. J. (2005). Power laws, Pareto distributions and Zipf's law. *Contemporary Physics*, 46(5), 323–351. <https://doi.org/10.1080/00107510500052444>
- Prášilová, P. (2012). Determinants of capital structure within Czech companies. *E&M Economics and Management*, 15(1), 89–104.
- Profíni. (2018). *Analýza súčasného stavu odvetvových štandardov na Slovensku a ich využitie na zefektívnenie verejných politík* (Research report on Project NFP314011L717). Bratislava: Profíni. Retrieved December 31, 2019, from <http://www.profíni.sk/informacie-o-projekte-nfp314011l717>
- Rezaee, Z. (2005). Causes, consequences, and deterrence of financial statement fraud. *Critical Perspectives on Accounting*, 16(3), 277–298. [https://doi.org/10.1016/S1045-2354\(03\)00072-8](https://doi.org/10.1016/S1045-2354(03)00072-8)
- Sedláček, J. (2007). Analysis of the development of financial efficiency of enterprises in the Czech Republic. *Ekonomický časopis*, 55(1), 3–18.
- Serrano Cinca, C., Mar Molinero, C., & Gallizo Larraz, J. L. (2005). Country and size effects in financial ratios: a European perspective. *Global Finance Journal*, 16(1), 26–47. <https://doi.org/10.1016/j.gfj.2005.05.003>
- Skokan, K., & Pawliczek, A. (2014). Lifecycle dynamics of Czech and Slovak enterprises in selected regions. *Ekonomický časopis*, 62(7), 728–742.
- Small, C. G. (1990). A Survey of Multidimensional Medians. *International Statistical Review*, 58(3), 263–277. <https://doi.org/10.2307/1403809>
- Sornette, D. (2006). *Critical Phenomena in Natural Sciences: Chaos, Fractals, Selforganization and Disorder: Concepts and Tools* (2nd ed.). Berlin: Springer. <https://doi.org/10.1007/3-540-33182-4>
- Tóth, P. (2017). When are we in recession? Estimating recession probabilities for Slovakia. *Biatec*, 25(4), 31–35.
- Tukey, J. W. (1970). Some Further Inputs. In D. F. Merriam (Ed.), *Geostatistics: Computer Applications in the Earth Sciences* (pp. 163–174). New York, NY: Plenum Press. https://doi.org/10.1007/978-1-4615-7103-2_12
- Wilcox, R. R., & Keselman, H. J. (2003). Modern robust data analysis methods: measures of central tendency. *Psychological Methods*, 8(3), 254–274. <https://doi.org/10.1037/1082-989X.8.3.254>
- Wilson, P. (2016). *2017 Almanac of Business & Industrial Financial Ratios* (48th annual edition). Chicago, IL: Wolters Kluwer.

IMPACT OF STOCK MARKETS ON THE ECONOMY IN THE V4 COUNTRIES

Radmila Krkošková¹

¹ Silesian University in Opava, School of Business Administration in Karviná, Department of Informatics and Mathematics, ORCID: 0000-0002-4977-0060, krkoskova@opf.slu.cz.

Abstract: *The performance of the economy should generally reflect the performance of stock markets. Production increases, prices rise, and companies' profits increase if the economy grows. And the shares should naturally make the profits (which means among other things, higher dividends) even more attractive. But is that really true? The aim of the article is to find out the relationship between the development of stock markets and the economic growth in Visegrad Group countries (V4). The subject of the survey is both the long-term relationship and the short-term relationship in the course of economic cycles. The article uses the tools of time series econometrics, especially VECMs, including corresponding diagnostics, Granger causality and block ergogeneity. The relationships between the variables examined vary from country to country. The long-term relationship between the development of stock markets and the economic growth was confirmed in Slovakia and Hungary. It was confirmed that the GDP growth rate influenced the growth rate of stock indices in all V4 countries. The opposite relationship (the stock index growth rate influences the GDP growth rate) was not confirmed only in the Czech Republic. Quarterly data for the period from 2005/Q1 to 2018/Q4 was used for the analysis. This period was selected because all of the V4 countries have been members of the European Union since 2004. The EViews software version 9 was used for the calculations. Variables used in this research are: the GDP, the stock exchange index of the country and stock trading volume. The PX, SAX, BUX and WIG20 stock indices are considered to be the crucial representatives of individual stock markets in this work.*

Keywords: *ADF test of stationarity, Granger causality, impulse-response analysis, stock market, VECM, V4.*

JEL Classification: *C19, C50, D53.*

APA Style Citation: Krkošková, R. (2020). Impact of Stock Markets on the Economy in V4 Countries. *E&M Economics and Management*, 23(3), 138–154. <https://doi.org/10.15240/tul/001/2020-3-009>

Introduction

The objectives and common interests of the V4 countries were described in the Visegrad Declaration (1991). One of the objectives was to create favorable conditions for direct cooperation between enterprises, for foreign capital investment, for the development of financial and stock markets. And this is the reason why the countries of V4 were selected for the analysis. The paper could confirm the relationship between the development of stock markets and the economic growth in the V4. Following the admission of the V4 countries to the European Union in 2004, Visegrad Four's

foreign-policy activities increased significantly and the group focused on promoting cooperation and stability in the wider Central European region. The article dealt with the effects of the stock market on the economy in individual countries and discusses the relationship between the GDP, the stock trading volume and the index rate. The goal of this paper is to find if exists the long-term relationship and the short-term relationship between variables. Why is the mutual dependence of the GDP and income from shares different in the V4 countries?

The relation between macroeconomic variables and the movement of stock prices

has been documented well in the literature over the last several decades. It is often argued that stock prices are determined by some fundamental macroeconomic variables. This work is based on the fact that stock quotes respond to events that affect the equity and economic markets before GDP. The long-term relationship between the development of stock markets and the economic growth was not confirmed in all countries.

This article is divided into five parts. The introduction explains why the V4 countries were selected for the analysis. The first chapter contains a review of literature. The second part describes the econometric methods used. The third part describes the economic development and development of individual the V4 markets in the period from 2005 to 2018. The core of this article is the fourth chapter dealing with modelling for each country which is performed here separately. The results of the work are presented in the conclusion.

1. Literature Review

Most authors currently believe that financial markets positively contribute to the economic growth as discussed in the work by, for example, Bekaert and Harvey (1998) of financial markets.

There are different views of Arestis, Demetriades and Luintel (2001) and others. According to them, the economic growth rate can be maintained without the existence of technological development, mainly due to the influence and the importance of financial markets for the economic growth. Bekaert and Harvey (1998) are of the opinion that authors who assert that the existence of stock markets is of little importance for real economic growth, forget the several roles that equity markets hold. One of these roles is the ability to diversify.

Olweny and Kimani (2011), Wanzala, Muturi and Olweny (2017) attach importance to stock markets in combination with the economic growth because they enable corporations and governments to accumulate long-term capital and hence fund new projects.

Arestis, Demetriades and Luintel (2001) show in their empirical analysis that stock markets can contribute to the long-term economic growth, but their impact is only part of the influence of the banking system. The authors examined quarterly time series from 1968 to 1998 in the fully developed economies of the following countries: the USA, the United

Kingdom, France, Germany, and Japan. The results differed for each country.

In their articles, Caporale, Howells and Soliman (2004), Dritsaki and Bargiota (2004) deal with the causal relationship between stock and credit markets and economic developments in the Greek economy. They use the VAR model for monthly data from 1988 to 2002, along with the Granger causality tests and the Johansen cointegration test. The results show that there is one cointegrated vector among the variables examined.

Caporale, Howells and Soliman (2004) use the VAR model to study the relationships between stock markets, investment and the economic growth for seven selected countries: Argentina, Chile, Greece, Korea, Malaysia, Philippines and Portugal, with quarterly data from 1977 to 1998. The aim of the work was to find out whether earlier works not including the stock market had misleading results.

Ndako (2010) examines the relationship between equity markets, banks and economic growth with the VECM model on the quarterly time series from 1983 to 2007 for South Africa. His results indicate the presence of bi-directional causality and the importance of the role of financial sector in the South African economy.

Vazikidis and Adamopoulos (2009) use the VECM model to analyse the economy of France in the 1965–2007 period. They are primarily concerned with the question whether stock market development causes the economic growth or vice versa.

The paper by Megaravalli, Sampagnaro and Murray (2018) emphasizes the impact of macroeconomic variables on the stock market performance of a developing economy (India and China) and a developed economy (Japan). In the short run, there is no statistically significant relationship between macroeconomic variables and stock markets. Erdem and Arslan (2005) study effects of macroeconomic variables on Istanbul stock exchange indexes and Pal and Mittal (2011) deal with the impact of macroeconomic indicators on Indian capital markets. Hsing and Hsieh (2012) deal with impacts of macroeconomic variables on the stock market index in Poland. Ho, Odhiambo and Millan (2018) analyse the macroeconomic drivers of stock market development in the Philippines, Pilinkus (2010) evaluates macroeconomic indicators and their impact on stock market performance in the short and long run in the case of the Baltic countries.

Marques et al. (2013) analyse this relationship in the case of Portugal. Cherif and Gazdar (2010) explore the institutional determinants for financial development in the countries of the Middle East and North African region.

Other articles dealing with V4 issues are, for example, the following. Růčková (2015) evaluates whether there is a functional dependency between the used financial sources and the reported rate of return on equity. The relationship between the real gross domestic product and the unemployment rate during the economic crisis in the countries of V4 is analysed in the paper Tvrdou (2016). The stock market integration of V4 and G7 countries is examined in the paper Baumöl (2014). The research showed that during the recent financial crisis, conditional correlations between the states of V4 have increased more significantly than after the entry of the states of V4 into the European Union. The paper by Nežinský and Baláž (2016) examines the predictive power of the confidence indicators for developments in industrial output, producer prices and employment in the V4 countries. The Granger Causality tests are used for establishing potential causation between the confidence indicators and real economic data.

It is not always true that the stock market reflects the true state of the economy. While it is expected that the stock markets should fall in times of recession, they can grow as well. There are several reasons for it. The stock markets do not take into account the present, but the future. This was also demonstrated by the latest financial crisis, which appeared to happen a bit earlier in the stock markets in the USA than in the real economy. However, this does not apply to the V4 countries where there is a demonstrable correlation between the performance of the economy and the performance of stock markets. During the crisis in the V4 countries, both the performance of the economy and the performance of the stock markets declined. Stock markets can only differ from the real economy for a limited time. For example, Poland's economy (as the only country in the European Union) was not in recession during the crisis years. The growth of Slovakia's economy during the boom period is also worth attention. Moreover, the Slovak economy returned to a growth trend after the crisis. On the other hand, the economy of Hungary and the Czech Republic stagnated

from 2008 to 2014. The current state of the GDP development shows that all economies have been able to restore the growth trend.

2. Method

2.1 VAR/VECM Model

The Vector Autoregressive Model (VAR) and the Vector Error Correction Model (VECM) make it possible to express and analyse a simultaneous relation between the variables. Arlt (1999) states that VAR analysis is based on the idea that all the variables used to analyse a selected dependency are random and simultaneously dependent. This means that the model structure contains only endogenous variables (except the deterministic components of the model), with their maximum delay time being the same (Juselius, 2006).

Time series can be analysed based on their short-term and long-term relations. If there is only a short-term relation between the time series, the VAR model is a sufficient tool for analysing this relation. If a long-term relation exists between selected time series, the VECM model can be used for the analysis. The VECM model simultaneously captures and expresses both short-term and long-term relations. The VECM model is based on a cointegration approach that models non-stationary time series the long-term relation of which is expressed through the error correction mechanism.

2.2 Cointegration Analysis

The cointegration analysis is based on the integrated processes that were first comprehensively addressed by Box and Jenkins. The cointegration analysis examines short-term dynamics and long-term relations between variables. Each system is subject to constant shocks, so it does not reach equilibrium in the short run (Johansen & Juselius, 1990). Nevertheless, there may be a relation between the time series that can be considered as equilibrium in the long run. Arlt (2003) states, that Engle and Granger developed a simple cointegration test based on a residual stationarity test. The Engle and Granger approach can be described as a classic approach.

2.3 Impulse-response Analysis

Impulse-response analysis allows the of both the short-term and long-term relations between

the analysed variables based on the derived model. Arlt (1999) states that the impulse-response analysis is related to the question of what reaction in one time series will be caused by an impulse in another time series within a system that contains multiple time series. This is the study of the relation between two one-dimensional time series in a multidimensional system.

3. Development of V4 Countries

The Visegrad Group is an alliance of four Central European countries: the Czech Republic, Slovakia, Poland and Hungary. Quarterly data for the period from 2005/Q1 to 2018/Q4 was used for the analysis. This period was selected because all of the V4 countries have been members of the European Union since 2004. The global fundamental analysis examines the impact of the economy and the market on the value of the share. It uses global macroeconomic indicators such as: interest rates, inflation, the gross domestic product, money supply, movement of international capital, movement of foreign exchange rates, political and economic shocks. This article discusses the relationship between the GDP, the stock trading volume and the index rate.

3.1 Czech Republic

This chapter uses data from analyzes of the Czech Statistical Office, the Ministry of Industry and Trade, the Ministry of Finance of the Czech Republic and the Prague Stock Exchange (2018).

Economic Development

The year 2004 is considered as the turning point when the transformed economy became a market economy. Previous reforms and the EU accession helped to develop export-oriented businesses. This trend lasted until 2008. The trend was halted only in the last quarter of 2008, when the global crisis broke out. The economy slowed significantly and fell into a deep recession. Growth in private consumption was negative in the third quarter of 2009, as households responded to rising unemployment and a decline in the wage growth. However, compared to other affected countries, the effects of the crisis were not so sky-high, as the very financial crisis causing the recession did not excessively affect the economy of the Czech Republic. The economy's performance

improved and the recovery was stronger in 2014, when the Czech Republic's GDP growth of 2% equalized the decline of the previous two years to move the country out of recession. The economy has been growing since then.

Stock Market

The year 2004 was the most successful year of stock markets in the Czech Republic. The PX 50 index reached a sharp appreciation at the beginning of 2004 and continued its long-term growth trend with an overall year-on-year increase of 56.6%. The year 2005 interrupted the growth of the PX 50 index, but there was again the overall appreciation in the course of the year. This development corresponded to the situation on the world financial markets responding to high prices of energy commodities, interest rate developments, etc. The index development in 2006 and 2007 was unstable and it was marked by strong fluctuations affected by the situation in the US stock markets in 2007, where the effects of the mortgage crisis began to appear. These consequences were fully reflected in 2008, causing the global financial collapse which led to the collapse of all stock indices on world stock exchanges. Compared to 2007, the PX 50 index was 53% lower. There was a slight recovery in 2009 and the Czech stock market started to grow again. The PX index for the 2014–2015 showed a growing trend in 2016 the highest value fell PX index to 954 points in 2017 and increased to the highest value of 1,087 points (Wikipedia, 2019).

3.2 Slovakia

In the following, the development of the economy and stock market in Slovakia will be presented. The source of information is data from the OECD, the Slovak National Bank and the Bratislava Stock Exchange (2018).

Economic Development

Thanks to Slovakia's accession to the EU in 2004, the real GDP grew by 4% YOY, exports increased and domestic demand was strong. The growth continued until 2009. The Slovak government tried to meet the Maastricht convergence criteria with a view to joining the Monetary Union and adopting the euro as a currency in 2009. The beginning of 2009 brought one of the highest real GDP declines among the OECD countries as a result of the financial crisis and the subsequent decline

in world trade volumes on which the Slovak economy was dependent. The economy began to recover relatively quickly, and even surpassed its pre-crisis record by 2013. The GDP growth rate was increasing in the 2014–2018 period.

Stock Market

At the beginning of the 21st century the Slovak stock market was characterized by small volumes and insufficient liquidity. There was a rise in private share investment, but direct trades still prevailed over stock trades in 2004. Stock trading volumes decreased by 60.6% compared to 2003. The SAX index grew by 84% in this period. The index developed experienced a number of fluctuations in 2007. The value increased by 7.23%. There were other large declines in stock trading volumes in 2012 and 2013. The SAX index fell by 10.79% in 2012, but it broke down declining trends and slightly increased in 2013. The SAX index rose by 12.42% in 2014. The SAX index had a growing trend, and the stock trading volume had a declining trend.

3.3 Hungary

The data in the following paragraph are based on the OECD, the Budapest Stock Exchange and the Hungarian Statistical Office.

Economic Development

At the turn of the millennium, the Hungarian economy was relatively strong and the country was one of the leading candidates for the EU membership. The GDP growth rates ranged between 4% and 5% in 2005 and 2006. The breakthrough occurred with the advent of the 2006 elections when the centre-left coalition was re-elected. Its government announced a financial consolidation plan. The government introduced new fiscal measures and structural reforms in the area of public spending, which exerted pressure on households, businesses and the public sector, and the pace of the GDP growth slowed significantly. Just before the outbreak of the crisis in September 2008, the Hungarian economy was able to meet its fiscal consolidation targets. Hungary was one of the countries heavily hit by the 2008 crisis, despite foreign aid. Thanks to a large amount of foreign investment, many households and companies got into debt, just like the country itself, the indebtedness of which amounted to 120% of the GDP. Year-on-year the GDP growth

was negative (–6.8%) in 2009. There was an improvement and the year-on-year growth was 1.1% in 2010. This trend continued in 2011. After the crisis in 2012, Hungary returned to the growth trend of the year-on-year GDP growth. Improvements were seen in rising exports, increasing domestic demand and the domestic investment growth. The GDP growth rate was increasing in the 2014–2018 period.

Stock Market

The Budapest Stock Exchange was one of the most liquid in Central and Eastern Europe until 2000. The turn of the millennium brought problems to the stock exchange and the financial markets in Hungary. The BUX index grew by 19.5% in 2006. The stock market continued in its positive development until 2008, when the Hungarian economy was hit by the financial crisis. This affected the value of the BUX index, which decreased by 53.3%. The stock market had gradually begun to recover since 2009. There was a slight improvement, but the stock market was still below its pre-crisis performance in 2012 and 2013. There were further declines and the Hungarian stock market moved away from the other stock markets of the region in 2014. The situation improved in the 2014–2018 period, and both the BUX and the stock trading volume showed a growing trend.

3.4 Poland

The data in the following paragraph is based on the OECD, the Warsaw Stock Exchange (2018) and the National Bank of Poland.

Economic Development

Together with other EU countries, Poland joined the EU in 2004. The EU accession was accompanied by a strong acceleration in the GDP growth. It declined to 3.2% in 2005. However, the Polish economy recorded a 6% GDP growth over the next two years. Since 2007, the Polish economy had been the most powerful of the OECD countries in the real GDP growth. The 2008 crisis hit Poland less than other European countries, thanks to the stability of its financial system. The GDP growth accelerated in 2010 and 2011, with a sharp downturn in 2012 and 2013. The GDP growth fell to a year-on-year increase of 1.4% in 2013. This development is attributable to the collapse of public investment after 2012. The GDP growth rate was increasing in the 2014–2018 period.

Stock Market

The period at the end of the millennium marked a downward trend for the WIG index, the official index of the Warsaw Stock Exchange. 2005 was marked by very low interest rates, which contributed to the development of the stock market. The stock market became the fastest growing segment of the capital market in Poland. The WIG index reached its peak, with a year-on-year increase of 33.7%. This trend continued in 2006 and 2007. It made the fall in 2008 even worse, as the development was heavily influenced by the financial crisis. It caused a strong outflow of capital from the stock market, resulting in a sharp fall in stock prices. The stock market started to positively develop in 2010, when all indicators grew. There was another drop in prices in 2011 and the decline continued in 2012. 2013 was favourable for the Polish stock market, the WIG index rose by 26.2%. The WIG index and the stock trading volume declined in the 2014–2016 period, but both the WIG index value and the stock trading volume have had a growing trend since 2016.

4. Relationships between Economic Development and Stock Markets

Quarterly data for the period from 2005/Q1 to 2018/Q4 was used for the calculations. All values were seasonally adjusted and were considered in logarithmic terms. The EViews software version 9 was used for the calculations.

Variables used in this research are: the GDP, the stock exchange index of the country, and the stock trading volume. The GDP is the variable representing the economic development of the countries studied. Data for the Czech Republic and Slovakia were obtained from the statistical offices, for Hungary and Poland from the Eurostat database. The PX, SAX, BUX and WIG20 stock indices are considered to be the crucial representatives of individual stock markets in this work. The

stock market is also represented by the Amount Traded (AT) variable, which represents the volume of all traded shares for the given period. Time series were obtained from the Bloomberg database.

The modelling structure is similar for all the countries studied and consists of the following steps: testing the presence of unit roots, the VECM model estimation, impulse responses, Granger causality and block exogeneity. The similar procedure is listed by Stoklasova (2018).

The variables (CR_GDP , CR_PX , CR_AT), (SR_GDP , SR_SAX , SR_AT), (HU_GDP , HU_BUX , HU_AT), (PL_GDP , PL_WIG20 , PL_AT) for the VAR model exhibit the properties of first-order non-stationarity, i.e. $I(1)$; therefore, the long-run cointegration relationships may exist between these variables. Using the Johansen's method, as shown in Johansen (1995), the existence of 1 cointegration relationship for the VECM(1) was confirmed. The result is the same for all states of V4.

4.1 Czech Republic

The preparatory phase of estimating the VAR model is testing the stationarity of variables included in the model or their first differences. The test results for all variables are provided in Tab. 1. The Dickey-Fuller test (ADF) was used to test the stationarity. The last column includes the result of testing: N = non-stationary (H_0 not rejected), S = stationary (H_0 rejected).

Existence of one long-term bond can be specified by a cointegration equation:

$$EQ_CR = CR_GDP_t - 0.371CR_PX_t + 0.465CR_AT_t \quad (1)$$

A cointegration vector expressing the equilibrium relationship between CR_GDP , CR_PX and CR_AT is (1.000; -0.371; 0.465). This means that a 1% increase in CR_PX will cause an increase in CR_GDP by 0.371%, and

Tab. 1: Testing the unit root of the variables in levels and their first differences

Variable	n/c/c+t	T-stat	P-value	Result	Variable	n/c/c+t	T-stat	P-value	Result
CR_GDP	c+t	-1.06	0.925	N	D(CR_GDP)	c+t	-4.88	0.001	S
CR_PX	n	-0.84	0.343	N	D(CR_PX)	c+t	-4.42	0.005	S
CR_AT	c	2.31	0.999	N	D(CR_AT)	c	-4.99	0.001	S

Source: own

Tab. 2: Estimates VECM (1)

Error correction	D(CR_GDP)	D(CR_PX)	D(CR_AT)
CointEq1	-0.022991	-0.010164***	-0.041996***
	(0.04436)	(0.00167)	(0.00261)
	[-0.51826]	[-6.09233]	[-16.0863]
D(CR_GDP(-1))	0.062902	-0.014651**	0.042799***
	(0.14932)	(0.00562)	(0.00879)
	[0.42126]	[-2.60897]	[4.87042]
D(CR_PX(-1))	-0.084028	0.869893***	-0.493121***
	(0.88386)	(0.03324)	(0.05202)
	[-0.09507]	[26.1702]	[-9.48031]
D(CR_AT(-1))	0.207937	-0.000283	1.047954***
	(0.14828)	(0.00558)	(0.00873)
	[1.40235]	[-0.05069]	[120.093]
C	0.014800	-0.000582***	-0.003004***
	(0.00375)	(0.00014)	(0.00022)
	[3.94838]	[-4.12812]	[-13.6189]
R-squared	0.342855	0.998777	0.999635

Source: own

1% increase in CR_AT will cause an decrease in CR_GDP by 0.465%. This conclusion is in line with the assumption, because a positive relationship is assumed between the variables CR_GDP , CR_PX .

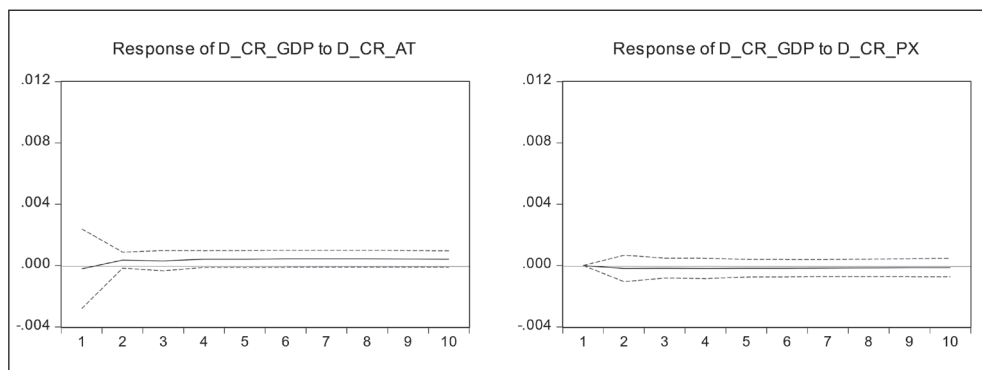
The results of the VECM(1) estimate did not demonstrate the statistical significance of the GDP correction component, as shown in Tab. 2. The model does not sufficiently explain the convergence to the long-term equilibrium defined by the cointegration equation. The residual component is not correlated, residual component heteroscedasticity and residual component non-normality were not demonstrated.

Impulse-responses trace the effects of structural shocks on the endogenous variables. Each response includes the effect of a specific shock on one of the variables of the system at impact t , the on $t+1$, and so on. The results are explained in graphics on the Fig. 1, which shows the impulse response functions. This article deals with the response of the GDP growth rate variable to shocks in the change in the PX index growth rate and the AT stock

trading volume. There is no GDP response to the PX index shock or the AT shock.

This part deals with the testing of short-term relationships (Granger causality). The hypothesis tested is that the series in question does not act in Granger's sense against an alternative hypothesis that denies the hypothesis tested. We consider the 5% significance level. When evaluating Granger causality, it is necessary to work with stationary time series. The results of the series 1 delay test are shown in Tab. 3.

Based on the significance, the zero hypothesis cannot be rejected: the PX growth rate neither affects the GDP growth rate nor the zero hypothesis: the stock trading volume does not affect the GDP growth rate. It was only demonstrated that the GDP growth rate is influenced by the PX index growth rate. The results of block exogeneity (Tab. 4) show that together the variables representing the stock market affect the development of the economic growth. If we consider the PX and AT variables separately, the Granger test result is confirmed, i.e. the effect of PX development and the impact

Fig. 1: Response to Cholesky One S. D. Innovations

Source: own

Tab. 3: Pairwise Granger causality tests (Lag 1)

Null hypothesis	F-Statistic	P-value	Results for $\alpha = 0.05$
D(CR_PX) does not Granger Cause D(CR_GDP)	1.24245	0.2703	NO
D(CR_GDP) does not Granger Cause D(CR_PX)	6.98069	0.0110	YES
D(CR_AT) does not Granger Cause D(CR_GDP)	3.57698	0.0644	NO
D(CR_GDP) does not Granger Cause D(CR_AT)	0.58899	0.4464	NO
D(CR_AT) does not Granger Cause D(CR_PX)	565.447	6.E-29	YES
D(CR_PX) does not Granger Cause D(CR_AT)	1,618.70	9.E-40	YES

Source: own

Tab. 4: Block Exogeneity Wald tests – dependent variable D(CR_GDP)

Excluded	Chi-sq	df	Prob.
D(CR_PX)	0.009038	1	0.9243
D(CR_AT)	1.966591	1	0.1608
All	13.04737	2	0.0015

Source: own

of stock trading volume do not play a significant role in the development of the economic growth.

4.2 Slovakia

The variables (SR_GDP , SR_SAX , SR_AT) for the VAR model exhibit the properties of first-order non-stationarity, i.e. $I(1)$. It shows Tab. 5.

Existence of one long-term bond can be specified by a cointegration equation:

$$EQ_SR = SR_GDP_t + 1.216SR_SAX_t + 0.144SR_AT_t \quad (2)$$

A cointegration vector expressing the equilibrium relationship between SR_GDP , SR_SAX and SR_AT is (1.000; 1.216; 0.144). This means that a 1% increase in SR_SAX will cause a decrease in SR_GDP by 1.216%, and a 1% increase in SR_AT will cause

Tab. 5: Testing the unit root of the variables in levels and their first differences

Variable	n/c/c+t	T-stat	P-value	Result	Variable	n/c/c+t	T-stat	P-value	Result
SR_GDP	c+t	-3.11	0.115	N	D(SR_GDP)	c+t	-5.041	0.001	S
SR_SAX	n	-0.51	0.491	N	D(SR_SAX)	c+t	-3.656	0.035	S
SR_AT	c+t	-3.19	0.097	N	D(SR_AT)	c	-2.071	0.038	S

Source: own

an decrease in *SR_GDP* by 0.144%. This conclusion is not in line with the assumption, because a positive relationship is assumed between the variables.

The results of the VECM(1) estimate demonstrated the statistical significance of the GDP correction component, as shown in Tab. 6. The model sufficiently explains the convergence to the long-term equilibrium defined by the cointegration equation. The CointEq1 value (0.045) indicates that this time series is adjusted by 4.5% in the first quarter in the case of long-term instability of the dependent variable. In other words, complete elimination of instability would last approximately 22 months (1/0.045),

it means almost 2 years. Regarding regression coefficients, it can be argued that the GDP is negatively related to the rise in the SAX stock index and the stock trading volume, with quarterly delays. Model assumptions are met.

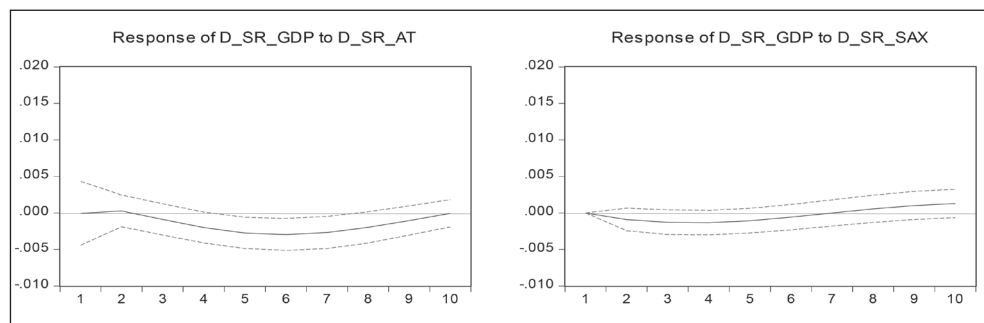
Fig. 2 shows the impulse response functions. This article deals with the response of the GDP growth rate variable to shocks in the change in the SAX index growth rate and the AT stock trading volume. There is an immediate reaction in the case of AT, the effect of which persists for several periods. An immediate response is also triggered by the SAX index shock, but this shock is absorbed faster than in the case of AT.

Tab. 6: Estimates VECM

Error correction	D(SR_GDP)	D(SR_SAX)	D(SR_AT)
CointEq1	0.044835***	-0.016073***	0.067268'
	(0.01492)	(0.00224)	(0.03776)
	[3.00534]	[-7.16767]	[1.78154]
D(SR_GDP(-1))	0.042170	0.027676	0.495568
	(0.14409)	(0.02166)	(0.36470)
	[0.29266]	[1.27784]	[1.35885]
D(SR_SAX(-1))	-0.197066**	0.880563***	0.717930***
	(0.09752)	(0.01466)	(0.24682)
	[-2.02078]	[60.0723]	[2.90866]
D(SR_AT(-1))	-0.095667***	-0.018677***	1.034930***
	(0.02583)	(0.00388)	(0.06537)
	[-3.70434]	[-4.81132]	[15.8330]
C	0.006515***	-0.001197***	0.000730'
	(0.00256)	(0.00038)	(0.00648)
	[2.54436]	[-3.11092]	[0.11261]
R-squared	0.328278	0.995912	0.953314

Source: own

Fig. 2: Response to Cholesky One S. D. Innovations



Source: own

Tab. 7: Pairwise Granger causality tests (Lag 1)

Null hypothesis	F-Statistic	P-value	Results for $\alpha = 0.05$
D(SR_SAX) does not Granger Cause D(SR_GDP)	4.03415	0.0441	YES
D(SR_GDP) does not Granger Cause D(SR_SAX)	9.23387	0.0038	YES
D(SR_AT) does not Granger Cause D(SR_GDP)	4.86803	0.0320	YES
D(SR_GDP) does not Granger Cause D(SR_AT)	0.47592	0.4935	NO
D(SR_AT) does not Granger Cause D(SR_SAX)	113.680	2.E-14	YES
D(SR_SAX) does not Granger Cause D(SR_AT)	18.3562	8.E-05	YES

Source: own

This part deals with the testing of short-term relationships (Granger causality). The results of the series 1 delay test are shown in Tab. 7.

It was shown that the stock trading volume affects the GDP growth rate. Furthermore, it was shown that the change in the GDP growth rate causes a change in the SAX index growth rate. The results of block exogeneity (Tab. 8) show that together the variables representing the stock market affect the development of the

economic growth. We give the same result if we consider the SAX and AT variables separately. The effect of SAX development and the impact of stock trading volume play a significant role in the development of the economic growth.

4.3 Hungary

The variables (HU_GDP , HU_BUX , HU_AT) for the VAR model exhibit the properties of first-order non-stationarity, i.e. $I(1)$. It shows Tab. 9.

Tab. 8: Block Exogeneity Wald tests – dependent variable D(SR_GDP)

Excluded	Chi-sq	df	Prob.
D(SR_SAX)	4.083538	1	0.0433
D(SR_AT)	13.72210	1	0.0002
All	14.41164	2	0.0007

Source: own

Tab. 9: Testing the unit root of the variables in levels and their first differences

Variable	n/c/c+t	T-stat	P-value	Result	Variable	n/c/c+t	T-stat	P-value	Result
HU_GDP	c+t	-1.17	0.904	N	D(HU_GDP)	c+t	-4.73	0.002	S
HU_BUX	n	0.84	0.889	N	D(HU_BUX)	c+t	-3.45	0.045	S
HU_AT	n	0.22	0.747	N	D(HU_AT)	n	-2.12	0.034	S

Source: own

Existence of one long-term bond can be specified by a cointegration equation:

$$EQ_{HU} = HU_GDP_t - 0.171HU_BUX_t - 0.479HU_AT_t \quad (3)$$

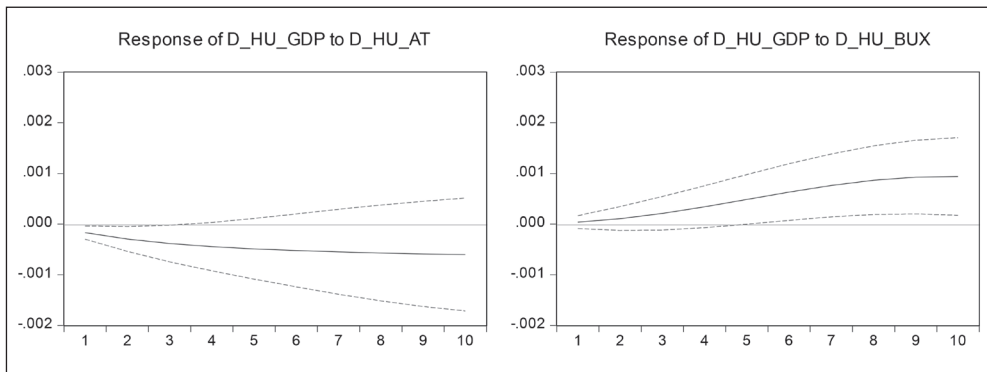
A cointegration vector expressing the equilibrium relationship between *HU_GDP*, *HU_BUX* and *HU_AT* is (1.000; -0.171; -0.479). This means that a 1% increase in *HU_BUX* will cause an increase in *HU_GDP* by 0.171%, and 1% increase in *HU_AT* will cause an increase in *HU_GDP* by 0.479%. This conclusion is in line with the assumption, because a positive relationship is assumed between the variables.

The results of the VECM(1) estimate demonstrated the statistical significance of the GDP correction component, as shown in Tab. 10. The model sufficiently explains the convergence to the long-term equilibrium defined by the cointegration equation. The CointEq1 value (0.043) indicates that this time series is adjusted by 4.3% in the first quarter in the case of long-term instability of the dependent variable. In other words, complete elimination of instability would lasted approximately 23 months (1/0.043), it means almost 2 year. Regarding regression coefficients, it can be argued that the GDP is positively related to the rise in the BUX stock index and negatively

Tab. 10: Estimates VECM

Error correction	D(HU_GDP)	D(HU_BUX)	D(HU_AT)
CointEq1	0.04301**	0.050867***	0.054329***
	(0.0186)	(0.01030)	(0.00678)
	[2.31236]	[4.93676]	[8.01858]
D(HU_GDP(-1))	0.912854***	-0.846498***	-0.201845
	(0.04165)	(0.23026)	(0.15141)
	[21.9198]	[-3.67632]	[-1.33310]
D(HU_BUX(-1))	0.026600***	1.043974***	-0.047021
	(0.00785)	(0.04343)	(0.02856)
	[3.38647]	[24.0382]	[-1.64651]
D(HU_AT(-1))	0.020922***	0.017581	0.991229***
	(0.00420)	(0.02321)	(0.01526)
	[-4.98441]	[0.75755]	[64.9524]
C	0.000475**	0.004611***	0.001655***
	(0.00024)	(0.00131)	(0.00086)
	[2.00238]	[3.51268]	[1.91749]
R-squared	0.987846	0.971734	0.992469

Source: own

Fig. 3: Response to Cholesky One S. D. Innovations

Source: own

Tab. 11: Pairwise Granger causality test (Lag 1)

Null hypothesis	F-Statistic	P-value	Results for $\alpha = 0.05$
D(HU_BUX) does not Granger Cause D(HU_GDP)	5.67299	0.0062	YES
D(HU_GDP) does not Granger Cause D(HU_BUX)	39.3713	9.E-11	YES
D(HU_AT) does not Granger Cause D(HU_GDP)	17.5322	2.E-06	YES
D(HU_GDP) does not Granger Cause D(HU_AT)	2.81491	0.0700	NO
D(HU_AT) does not Granger Cause D(HU_BUX)	0.56836	0.5703	NO
D(HU_BUX) does not Granger Cause D(HU_AT)	3.99899	0.0249	YES

Source: own

related to the stock trading volume, with quarterly delays. Model assumptions are met.

Fig. 3 shows the impulse response functions. This article deals with the response of the GDP growth rate variable to shocks in the change in the BUX index growth rate and the AT stock trading volume. There is an immediate reaction in both the BUX and the AT variable, the effect of which persists for several periods.

This part deals with the testing of short-term relationships (Granger causality). The results of the series 1 delay test are shown in Tab. 11.

It was shown that the stock trading volume affects the GDP growth rate. Furthermore, it was shown that the change in the BUX index growth rate causes a change in the GDP growth rate. And the change in the GDP growth rate causes a change in the BUX index growth

Tab. 11: Pairwise Granger causality test (Lag 1)

Excluded	Chi-sq	df	Prob.
D(HU_BUX)	11.46815	1	0.0007
D(HU_AT)	24.84439	1	0.0000
All	30.46638	2	0.0000

Source: own

rate. The results of block exogeneity (Tab. 12) show that together the variables representing the stock market affect the development of the economic growth. We give the same result if we consider the BUX and AT variables separately. The effect of BUX development and the impact of stock trading volume play a significant role in the development of the economic growth.

4.4 Poland

The variables (PL_GDP , PL_WIG20 , PL_AT) for the VAR model exhibit the properties of first-order non-stationarity, i.e. $I(1)$. It is shown in Tab. 13.

Existence of one long-term bond can be specified by a cointegration equation:

$$EQ_PL = PL_GDP_t - 5.564PL_WIG20_t + 2.303PL_AT_t \quad (4)$$

A cointegration vector expressing the equilibrium relationship between PL_GDP , PL_WIG20 and PL_AT is (1.000; -5.564; 2.303). This means that a 1% increase in PL_WIG20 will cause an increase in PL_GDP by 5.564%, and 1% increase in PL_AT will cause an decrease in PL_GDP by 2.303%. This conclusion is in line with the assumption, because a positive relationship is assumed between the variables PL_GDP , PL_WIG20 .

The results of the VECM(1) estimate did not demonstrate the statistical significance of the

Tab. 13: Testing the unit root of the variables in levels and their first differences

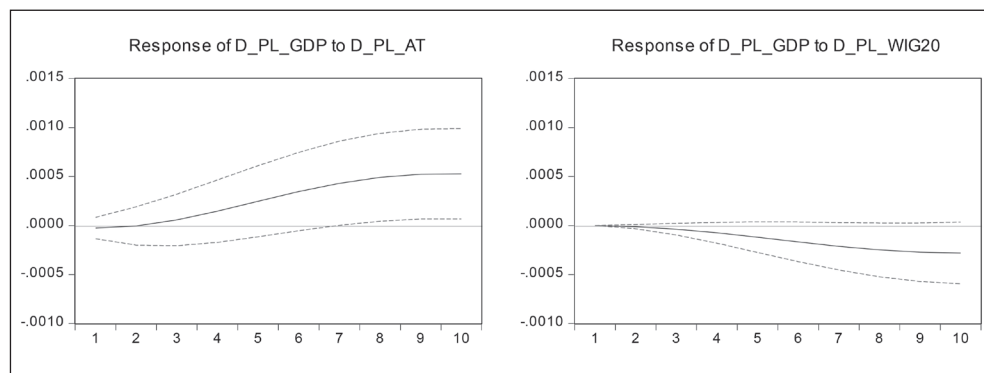
Variable	n/c/c+t	T-stat	P-value	Result	Variable	n/c/c+t	T-stat	P-value	Result
PL_GDP	c+t	-3.13	0.111	N	D(PL_GDP)	c+t	-4.13	0.012	S
PL_WIG20	n	-0.39	0.537	N	D(PL_WIG20)	c+t	-3.97	0.016	S
PL_AT	c+t	-0.66	0.971	N	D(PL_AT)	c+t	-4.93	0.001	S

Source: own

Tab. 14: Estimates VECM

Error correction	D(PL_GDP)	D(PL_WIG20)	D(PL_AT)
CointEq1	-9.03E-05	0.010316***	0.000290
	(0.00027)	(0.00130)	(0.00201)
	[-0.34048]	[7.90625]	[0.14416]
D(PL_GDP(-1))	0.943906***	-0.094725	-0.203663
	(0.04163)	(0.20489)	(0.31603)
	[22.6732]	[-0.46232]	[-0.64445]
D(PL_WIG20(-1))	4.80E-5	0.949977***	-0.098242**
	(0.00622)	(0.03061)	(0.04721)
	[0.00772]	[31.0362]	[-2.08089]
D(PL_AT(-1))	-0.001689	0.042039*	0.932205***
	(0.00474)	(0.02333)	(0.03599)
	[-0.35620]	[1.80188]	[25.9048]
C	0.000471	9.18E-05***	-0.000244
	(0.00050)	(0.00246)	(0.00379)
	[0.94329]	[0.03737]	[-0.06425]
R-squared	0.962842	0.974624	0.978716

Source: own

Fig. 4: Response to Cholesky One S. D. Innovations

Source: own

Tab. 15: Pairwise Granger causality tests (Lag 1)

Null hypothesis	F-Statistic	P-value	Results for $\alpha = 0.05$
D(PL_WIG20) does not Granger Cause D(PL_GDP)	0.79152	0.3779	NO
D(PL_GDP) does not Granger Cause D(PL_WIG20)	10.2153	0.0024	YES
D(PL_AT) does not Granger Cause D(PL_GDP)	36.1890	2.E-07	YES
D(PL_GDP) does not Granger Cause D(PL_AT)	80.3058	6.E-12	YES
D(PL_AT) does not Granger Cause D(PL_WIG20)	6.73700	0.0124	YES
D(PL_WIG20) does not Granger Cause D(PL_AT)	10.4137	0.0022	YES

Source: own

GDP correction component, as shown in Tab.14. The model does not sufficiently explain the convergence to the long-term equilibrium defined by the cointegration equation. Model assumptions are met.

There is an immediate reaction in the GDP growth rate in the case of both the WIG20 and the AT variables.

This part deals with the testing of short-term relationships (Granger causality). The results of the series 1 delay test are shown in Tab. 15.

It was shown that the stock trading volume affects the GDP growth rate. Furthermore, it was shown that the change in the GDP growth rate causes a change in the WIG20 growth rate and also a change in the AT growth rate. The results

Tab. 16: Block Exogeneity Wald tests – dependent variable D(PL_GDP)

Excluded	Chi-sq	df	Prob.
D(PL_WIG20)	5.96E-05	1	0.9938
D(PL_AT)	0.126881	1	0.7217
All	0.182432	2	0.9128

Source: own

of block exogeneity (Tab. 16) show that together the variables representing the stock market do not affect the development of the economic growth. The effect of WIG20 development and the impact of stock trading volume do not play a significant role in the development of the economic growth if we consider the variables separately.

Conclusions

It is not always true that the stock market accurately reflects the true state of the economy. While it is expected that the stock markets should fall in times of recession, uncertainty or political upheaval, they can fall, as well as grow. How is it possible? There are several reasons for it. The stock markets do not take into account the present, but the future. Therefore, they may be through an ongoing economic downturn, and now they are expecting a recovery. This was also demonstrated by the latest financial crisis, which appeared to happen a bit earlier in the stock markets than in the real economy.

The correlation between the economy performance and the stock market performance is evident. The theoretical model of the economy predicts that income from shares should reflect the economic growth but, in fact, these two figures are very different. During the 2008 financial crisis, stock markets across the globe fell by 40 to 60%, but no economy experienced such a sharp drop, as reported by Wise-Owl.com (2018).

The long-term relationship between the development of stock markets and the economic growth was confirmed in Slovakia and Hungary. For Slovakia, this series will be adjusted by 4.5% in the first quarter in the case of the long-term GDP instability. In other words, complete elimination of instability would last approximately for almost 2 years. Cointegration equation (2) shows that the GDP is negatively affected in the long run by the growth rate of the SAX stock index and the stock trading volume. For Hungary, this series will be adjusted by 4.3% in the first quarter in the case of the long-term GDP instability. In other words, complete elimination of instability would last approximately for almost 2 years. Cointegration equation (3) shows that the GDP is positively affected in the long run by the growth rate of the SAX stock index and the stock trading volume.

It was confirmed that the income from shares reflects the economic growth in all V4

countries, coinciding with the theoretical model. The changes in the GDP growth rate affect the changes in the growth rate of stock indices in the Granger sense. Conversely, the hypothesis that the changes in the stock trading volume do not affect the changes in the GDP growth rate in the Granger sense was not rejected only for the Czech Republic. Therefore, it is true for the other countries that the economic growth reflects the income from shares in the short-term.

Typically, stock market and economic performance will often be aligned. Thus, when the stock market is performing well it is usually a function of a growing economy. When GDP is growing, individual businesses are producing more and usually expanding. Expanding business activity usually increases valuations and leads to stock market gains. Historically, the steep market also declines preceded during the financial crisis 2007–2009. Some experts believe markets predict what the economy will be doing in about six months.

The stock market contributes to the nation's economy. Stocks affect the economy in three critical ways. The first way is that the stocks allow individual investors to own part of a successful company. Without stocks, only large investors could profit. The second way is that the stocks provide the capital for companies to gain a competitive advantage. The last way is that falling stock prices mean investors have lost confidence in the company's ability to increase its profit margins.

Naturally, there is a positive relationship between economic growth and the stock growth – as demonstrated by the fact that there is no prosperous economy without a capital market anywhere in the world. However, it is not possible to rely on any simple rule or elegant mathematical model that would clarify the relationship between the income from shares and the economic growth.

New macroeconomic data confirmed that the dynamics of the world economy is further slowing slightly. However, stock market developments were above expectations. And what were the financial markets in 2019? Government bonds of all V4 countries continued to grow.

The article dealt with the effects of the stock market on the economy in individual countries. Why is the mutual dependence of the GDP and income from shares different in

the V4 countries? The reason is the statistical behaviour of stock indices and the economic growth. The long-term growth trend, which adds to the effects of short-term fluctuations, plays a major role in both cases. However, short-term fluctuations are not very important either for the development of the economy or for long-term income from the stock market.

The global financial crisis may be a factor in this investigation because during the economic crisis (2007–2008), the external economic equilibrium was not favorable. Suggestions for further research: comparison of the relationship between the development of stock markets and the economic growth in V4 before and after the financial crisis. Further research can be extended to these countries: the United States of America, Japan and the European Union.

Acknowledgement: *This paper was supported by the project no. SGS/19/2019, Application of Customer Relationship Management Systems in Small and Medium-sized Enterprises accepted in 2019.*

References

- Arestis, P., Demetriades, P. O., & Luintel, K. B. (2001). Financial Development and Economic Growth: The Role of Stock Markets. *Journal of Money, Credit and Banking*, 33(1), 16–41. <https://doi.org/10.2307/2673870>
- Arlt, J. (1999). *Moderní metody modelování ekonomických časových řad*. Prague: Grada Publishing.
- Arlt, J. (2003). Statistikům a ekonometrům byla udělena Nobelova cena za ekonomii za rok 2003. *Informační bulletin České statistické společnosti*, 3(14).
- Baumöhl, E. (2014). Determinanty integrácie akciových trhov krajín V4. *Politická ekonomie*, 62(3), 347–365. <https://doi.org/10.18267/j.polek.955>
- Bekaert G., & Harvey, C. R. (1998). Capital Markets: An Engine for Economic Growth. *The Brown Journal of World Affairs*, 5(1), 33–53.
- Bratislava Stock Exchange. (2018). Retrieved March 30, 2019, from <http://www.bsse.sk/default.aspx>
- Budapest Stock Exchange. (2014). *An Eventful Year for Stock Exchanges – the Summary of Last Year at the Budapest Stock Exchange*. Retrieved March 30, 2019, from https://bse.hu/data/cms188918/BSE_summary_2014.pdf
- Caporale, G. M., Howells, P. G., & Soliman, A. M. (2004). Stock Market Development and Economic Growth: The Causal Linkage. *Journal of Economic Development*, 29(1), 33–50. Retrieved December 10, 2018, from http://www.jed.or.kr/full-text/29-1/02_J665_.PDF
- Cherif, M., & Gazdar, K. (2010). Macroeconomic and Institutional Determinants of Stock Market Development in MENA Region: New Results from a Panel Data Analysis. *International Journal of Banking and Finance*, 7(1), 139–159. <https://doi.org/10.32890/ijbf2010.7.1.8403>
- Czech Statistical Office of the Czech Republic. (2018). Retrieved March 20, 2019, from <http://www.czso.cz/>
- Dritsaki, Ch., & Dritsaki-Bargiota, M. (2005). The Causal Relationship between Stock, Credit Market and Economic Development: An Empirical Evidence for Greece. *Economic Change and Restructuring*, 38(1), 113–127. <https://doi.org/10.1007/s10644-005-4525-3>
- Erdem, C., Arslan, C. K., & Sema Erdem, M. (2005). Effects of Macroeconomic Variables on Istanbul Stock Exchange Indexes. *Applied Financial Economics*, 15(14), 987–994. <https://doi.org/10.1080/09603100500120365>
- Ho, S.-Y., Odhiambo, N. M., & McMillan, D. (2018). Analysing the Macroeconomic Drivers of Stock Market Development in the Philippines. *Cogent Economics & Finance*, 6(1), 1–18. <https://doi.org/10.1080/23322039.2018.1451265>
- Hsing, Y., & Hsieh, W.-J. (2012). Impacts of Macroeconomic Variables on the Stock Market Index in Poland: New Evidence. *Journal of Business Economics and Management*, 13(2), 334–343. <https://doi.org/10.3846/16111699.2011.620133>
- Hungarian Central Statistical Office. (2018). Retrieved January 30, 2019, from <http://www.ksh.hu/>
- Johansen, S., & Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52(2), 169–210. <https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x>
- Johansen, S. (1995). *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*. Oxford: Oxford University Press.
- Juselius, K. (2006). *The Cointegrated VAR Model: Methodology and Applications*. Oxford: Oxford University Press.

- Marques, L. M., Fuinhas, J. A., & Marques, A. C. (2013). Does the Stock Market Cause Economic Growth? Portuguese Evidence of Economic Regime Change. *Economic Modelling*, 32, 316–324. <https://doi.org/10.1016/j.econmod.2013.02.015>
- Megaravalli, A. V., Sampagnaro, G., & Murray, L. (2018). Macroeconomic Indicators and their Impact on Stock Markets in ASIAN 3: A Pooled Mean Group Approach. *Cogent Economics & Finance*, 6(1), 1–14. <https://doi.org/10.1080/23322039.2018.1432450>
- Ministry of Industry and Trade of the Czech Republic. (2018). Retrieved March 30, 2019, from <http://www.mfcr.cz/>
- Ministry of Finance of the Czech Republic. (2018). Retrieved March 30, 2019, from <http://www.mpo.cz/>
- National Bank of Slovakia. (2018). Retrieved March 30, 2019, from <http://www.nbs.sk/sk/titulna-stranka>
- National Bank of Poland. (2018). Retrieved March 30, 2019, from <http://www.nbp.pl/>
- Ndako, U. B. (2010). Stock Markets, Banks and Economic Growth: Time Series Evidence from South Africa. *The African Finance Journal*, 12(2), 72–92.
- Nežinský, E., & Baláž, V. (2016). Are the Confidence Indicators Meaningful for Forecasting Real Economy? Testing Power of Confidence Indicators for Industry Output, Prices and Employment in the Visegrád Group Countries. *Ekonomický časopis*, 64(10), 923–936.
- OECD. (2017). *Economic Surveys: Hungary 2017*. Retrieved January 10, 2019, from <https://doi.org/10.1787/19990529>
- OECD. (2017). *Economic Surveys: Slovak Republic 2017*. Retrieved January 10, 2019, from https://doi.org/10.1787/eco_surveys-svk-2017
- OECD. (2017). *Economic Surveys: Poland 2017*. Retrieved January 10, 2019, from http://dx.doi.org/10.1787/eco_surveys-pol-2017-en
- Olweny, T. O., & Kimani, D. (2011). Stock Market Performance and Economic Growth: Empirical Evidence from Kenya Using Causality Test Approach. *Advances in Management and Applied Economics*, 1(3), 153–196.
- Pal, K., & Mittal, R. (2011). Impact of Macroeconomic Indicators on Indian Capital Markets. *The Journal of Risk Finance*, 12(2), 84–97. <https://doi.org/10.1108/15265941111112811>
- Pilinkus, D. (2010). Macroeconomic Indicators and their Impact on Stock Market Performance in the Short and Long Run: The Case of the Baltic States. *Technological and Economic Development of Economy*, 16(2), 291–304. <https://doi.org/10.3846/tede.2010.19>
- Prague Stock Exchange. (2018). Retrieved January 10, 2019, from <http://www.pse.cz/>
- Růčková, P. (2015). Dependency of Return on Equity and Use of Finance Sources in Building Companies in V4 Countries. *E&M Economics and Management*, 18(3), 73–83. <https://doi.org/10.15240/tul/001/2015-3-007>
- Stoklasová, R. (2018). Default Rate in the Czech Republic Depending on Selected Macroeconomic Indicators. *E&M Economics and Management*, 21(2), 69–82. <https://doi.org/10.15240/tul/001/2018-2-005>
- Tvrdoň, M. (2016). Decomposition of Unemployment: The Case of The Visegrad Group Countries. *E&M Economics and Management*, 19(1), 4–16. <https://doi.org/10.15240/tul/001/2016-1-001>
- Vazakidis, A., & Adamopoulos, A. (2009). Stock Market Development and Economic Growth. *American Journal of Applied Sciences*, 6(11), 1932–1940. <https://doi.org/10.3844/ajassp.2009.1932.1940>
- Visegrad Declaration. (1991). *The Visegrad Group: the Czech Republic, Hungary, Poland and Slovakia*. Retrieved March 30, 2019, from <http://www.visegradgroup.eu/main.php?folderID=940&articleID=3940&ctag=articlist&iid=1>
- Wanzala, R. W., Muturi, W., & Olweny, T. (2017). The Nexus between Market Tightness and Economic Growth – A Case of Kenya. *Journal of Finance and Economics*, 5(6), 259–268. <https://doi.org/10.12691/jfe-5-6-2>
- Warsaw Stock Exchange. (2018). Retrieved March 10, 2019, from https://www.gpw.pl/root_en
- Wikipedia. (2019). Retrieved January 10, 2019, from https://en.wikipedia.org/wiki/PX_Index
- Wise-Owl.com. (2018). Retrieved March 30, 2019, from <https://www.wise-owl.com/investment-education/is-there-a-correlation-between-gdp-growth-and-stock-market-return>

FACE-TO-FACE AND ELECTRONIC COMMUNICATION WITH CUSTOMERS IN RETAILING AND COMPANY PERFORMANCE: A CASE STUDY IN THE ELECTRONICS AND COMMUNICATION EQUIPMENT RETAIL INDUSTRY IN THE CZECH REPUBLIC

Ludvík Eger¹, Petr Suchánek²

¹ West Bohemia University in Pilsen, Faculty of Economics, Department of Marketing, Trade and Services, Czech Republic, ORCID: 0000-0002-5437-3297, leger@kmo.zcu.cz;

² Masaryk University, Faculty of Economics and Administration, Department of Corporate Economy, Czech Republic, ORCID: 0000-0002-2606-4040, Petr.Suchanek@econ.muni.cz.

Abstract: Customers today can find the same assortments in a number of retail stores and through the Internet, thus effective store management has become a critical basis for developing strategic advantages. The aim of this research is to identify whether customer satisfaction measured by means of mystery shopping and the results of communication with the public on a company's Facebook profile assessed by quantitative analysis influence the performance of the selected companies. The evaluation of customer satisfaction and loyalty follows the older pilot study and is newly supplemented by an analysis of communication with customers using social media such as Facebook. The company's performance is evaluated through the financial ratios (ROA, ROE and ATO) based on accounting data available in the Magnusweb database. The research is focused on selected companies from the electronics and communication equipment retail industry in the Czech Republic and is unique from that point of view because it analyses communication with customers not only in retail shops but concurrently on their profiles for Facebook. The findings show how it is possible to assess the level of customer-oriented communication in retail shops and also the level of communication with customers on the social network. Retailers are increasing their focus on customers' experience in their shops and on social media sites. The research contributes to a better understanding of marketing in retail and on social media in the selected industry.

Keywords: Customer satisfaction, retail mystery shopping, Facebook engagement, enterprise performance, electronics and communication equipment.

JEL Classification: M21, M31.

APA Style Citation: Eger, L., & Suchánek, P. (2020). Face-to-face and Electronic Communication with Customers in Retailing and Company Performance: A Case Study in the Electronics and Communication Equipment Retail Industry in the Czech Republic. *E&M Economics and Management*, 23(3), 155–172. <https://doi.org/10.15240/tul/001/2020-3-010>

Introduction

Enterprise performance as well as customer satisfaction and loyalty are phenomena that are

at the forefront of the assessment of not only the current, but also the future value and prospects of an enterprise in today's demanding, highly

competitive conditions (Suchánek & Eger, 2019). Customer satisfaction and loyalty are prerequisites for strengthening the position of an enterprise in the market, and thus are also connected with achieving success in customer orientation (Kotler & Keller, 2013), which in turn is connected with the quality of services provided. The focus on service quality when selling competitive products combined with communication with customers via Facebook on a company's brand page (De Vierman, Cauberghe, Hudders, & De Pelsmacker, 2017) is a key factor to increasing the performance of a company. Today, organizations should consider the way they communicate with their target audience and consider social networks (particularly Facebook) and e-shops as a new way of expanding the business. In this context, Levy, Weitz and Grewal (2019, p. 397) argue that "customers can find the same assortments in a number of conveniently located retail stores and through the Internet, thus effective store management has become a critical basis for developing strategic advantages".

In the presented research, enterprise performance is measured based on an analysis of publicly available data (Magnusweb) from closing financial statements (specifically, balance sheets and profit and loss statements). This (quantitative) way of measuring performance based on accounting data is fairly common (compare with, e.g., Gunasekaran, Williams, & McGaughey, 2005; Gupta & Galloway, 2003). Mystery shopping is used to gather information about customer-oriented communication, their satisfaction with retail and customer feedback via Net Promoter Score (Eger & Mičík, 2017). The purpose of the mystery shopping survey is to investigate the level of customer-oriented service, customer satisfaction and to search for the relationship between customer satisfaction and the level of Net Promoter Score (NPS) in the selected retail industry.

However, this research goes further than the pilot study (Suchánek & Eger, 2019) and newly analyzes the communication of selected companies with the public on the social network Facebook, which is still the dominant tool in the field of social media marketing in the Czech Republic (EUROSTAT, 2018). Social media enables open communication, which helps organizations to understand customer needs and motivates them to respond proactively and efficiently to those

needs (Tajudeen, Jaafar, & Ainin, 2018). Successful company-consumer interactions foster customer loyalty and willingness to try new offerings. It is important to mention that for all the selected companies selling not only in their traditional stores, but also on the Internet, is important. Moreover, offline and online communication with customers is often interconnected when goods ordered online are handed over in the company's traditional retail network (brick and mortar stores). From this point of view, this research is unique and examines the link between customer-oriented communication in brick and mortar stores and on the Facebook social network and various financial ratios that measure the performance of companies in the Czech Republic. This research may contribute in several ways to the literature regarding retail and personal selling, electronic word of mouth, and customer satisfaction and customer loyalty.

First, we assess the influence of some part of the shopping environment and of customer-oriented communication on customer satisfaction and customer loyalty. Second, we analyze how selected companies used Facebook to communicate with customers and measure the engagement rate. Third, we operationalize and assess the company's performance. Fourth, the research adds to the very limited research on company performance and customer satisfaction in retailing in the Czech Republic.

1. Theoretical Background

1.1 Enterprise Performance

Performance can be defined in a variety of ways, also thanks to the fact that over the past several decades this definition has changed and been further specified with respect to the purpose for which the performance was used. The subject of this research is an enterprise, so performance needs to be defined within the context of an enterprise. Lorino (1997, in Ravelomanantsoa, Ducq, & Vallespir, 2018) defines performance in general terms as "everything that, and only that, which contributes to achieving strategic objectives". Hult, Hurley and Knight (2004) define performance in a similar way, albeit more specifically in relation to financial indicators "as the achievement of organizational goals related to profitability and growth in sales and market share, as well as the accomplishment of general firm strategic objectives".

Performance is generally perceived very broadly as a multidimensional construct (Neely & Wilson, 1992), specifically as effectiveness and efficiency. Performance can be understood as the extent to which the customer's requirements are met (effectiveness) and the measure of the economic use of the enterprise's resources leading to customer satisfaction (efficiency) (Neely, Gregory, & Platts, 2005).

Quantitative measuring of performance (efficiency) of an enterprise based on accounting data is fairly common (cf. Gupta & Galloway, 2003; Gunasekaran et al., 2005), also thanks to their relative reliability (Tosi, Werner, Katz, & Gomez-Mejia, 2000). From the financial standpoint, it is possible to use various financial indicators, specifically the combination of several ratio or absolute indicators (further, e.g., Chia et al., 2009). In this research, performance will be understood within the context of an enterprise as a two-dimensional construct. One dimension is made up of effectiveness represented by customer satisfaction, while the other dimension is represented by efficiency.

The quantitative measurement of enterprise performance based on accounting data is connected with the fact that customer satisfaction translates into a successful business in the sense of sales volume and consequently profit and rate of return (compare Neely et al., 1995). In the context of customer satisfaction, it is obvious that the key indicator that can evaluate the specific performance of an enterprise and which can be measured is the rate of return of the company (more specifically, the ROA indicator). This also corresponds with a number of conducted research studies (e.g. Anderson et al., 1997; Terpstra & Verbeeten, 2014; Yeung, Ging, & Ennew, 2002).

Within a comprehensive approach to measuring company performance, there are various categories of financial indicators. Some authors use indicators related to the rate of return, activity, debt ratio, liquidity, growth indicators and asset structure indicators (Delen et al., 2013; Heikal, Khaddafi, & Ummah, 2014). In a number of research studies, financial performance in the context of customer satisfaction is evaluated by standard financial indicators, such as ROA, ROE (e.g. Al-Hawari & Ward, 2006). It suggests itself to use the financial indicators ROA, ROE and ATO which are well-proven in the conditions of Czech companies (Suchánek & Králová, 2018).

Several studies suggest that there is a positive relationship between customer satisfaction and enterprise performance (e.g. Levy et al., 2019; Yu et al., 2013). The findings from research conducted by Chi and Gursoy (2009) suggest that customer satisfaction has a significant positive impact on financial performance. The same result was achieved in the pilot study (Suchánek & Eger, 2019), which did not deal with internet communication and evaluated the selected indicators only over a short period of time. The report by FeedbackSystems (2016) summarizes findings from several studies and argues: "One of the main benefits of customer satisfaction research is the capability to observe trends in indicators that are directly tied to financial performance". This is also the focus of this new research, conducted in the context of the Czech Republic.

1.2 Retail, Personal Selling, Customer Satisfaction

Consumer satisfaction and retention are critical for retail also in the area of electronics and communication equipment (Suchánek & Eger, 2019). Providing quality customer service is a way to be distinguished from competitors. An organization's employee skills and competencies (Egerová, 2015; Zeglát, Aljaber, & Alrawabdeh, 2014) are essential to making a successful service encounter and interaction. Researchers have found that customer satisfaction is a major driver of customer loyalty and earlier empirical findings revealed that customer loyalty could lead to a 25–85% increase in profit (Reichheld et al., 1990). Some studies show that up to 70% of organizations are losing customers due to poor customer service, and just less than 15% due to poor quality of the product (e.g. Michelson, 2015). Customer satisfaction affects positive word-of-mouth (compare with electronic word-of-mouth below) and future repeat purchase (Abu-ELSamen et al., 2011; Bolton et al., 1998). Customer service is an important topic because it has a strong link to long-term financial outcomes such as profitability (Abu-ELSamen et al., 2011; Duncan & Eliot, 2004; Yeung et al., 2002).

Communication in personal selling is an important part of sales behavior and can help any company increase its customer satisfaction (Gilbert & Veloutsou, 2006; Pimpakorn & Patterson, 2010; Wangenheim, Evanschitzky, & Wunderlich, 2007). If customers are satisfied,

have trust in salespeople and see value in the provided customer service, they are more likely to come back and repeat purchase in the future (El-Bachir, 2014; Gruca & Rego, 2005; Kim, Park, & Jeong, 2004). Traditionally, it is supposed that customer satisfaction is an important factor in the performance and competitiveness of retail shops (including online retail).

Some authors argue that customer loyalty is of greater importance than customer satisfaction (Fraering & Minor, 2013; Belás & Gabčová, 2016), while others (e.g. Khan & Rizwan, 2014) argue that customer satisfaction explains 93% of customer loyalty. In general, there are two approaches to customer satisfaction in literature, the expectancy-disconfirmation approach and the performance-only approach (Gilbert & Veloutsou, 2006). In this research, we work with the performance-only approach. According to our adopted approach, customer satisfaction is defined as “an overall evaluation based on the customer’s total purchase and consumption experience with a good or service over time” (Anderson, Fornell, & Mazvancheryl, 2004). The deterministic approach to customer loyalty (Odin, Odin, & Valette-Florence, 2001) which we use in this research addresses customer loyalty as an attitude manifested through customers’ preferences, buying intentions, supplier patronization and recommendation willingness.

This research is focused on selected electronics and communication equipment retail companies. Customer service and communication with customers have become more important in retailing than ever before (Beneke et al., 2012; Eger & Mičík, 2017; Jankal & Jankalova, 2011; Parment, 2013).

The mystery shopping technique can be used to assess how employees interact with customers and to identify customer satisfaction and areas for future service quality improvement. Mystery shopping studies have been conducted especially in retail by Gosselt, van Hoof, de Jong and Prinsen (2007), Janka and Jankalová (2011), Kehagias, Rigopoulou and Vassilikopoulou (2011) and Eger and Mičík (2017).

1.3 Social Networking Sites and Customer Satisfaction

Currently, the popularity of social networking sites provides virtual brands with new platforms,

such as brand pages on Facebook or accounts on Instagram or Twitter (De Vierman et al., 2017; Semerádová & Weindlich, 2019). When examining the role of social media and its influence in the marketing context, four main streams may be identified: brand communities, electronic word of mouth, networking analysis, and product-harm crisis (Gensler, Völcker, Liu-Tompkins, & Wiertz, 2013). The virtual communities offer companies new opportunities to interact with their customers. For example, using Facebook, companies and brands acquire the capacity to support activities, such as providing customer service, product information, special offers, and various types of entertainment (Simon & Tossan, 2018).

A number of studies focus on the relationship between social media marketing and financial performance. Alongside customer satisfaction, social media marketing is part of the effectiveness factor which determines the performance of an enterprise and also affects the financial aspect of its performance, specifically ROA (Kumar & Mirchandani, 2012). In the short-term, higher or more intensive use of social media by a company does not increase its financial performance (Smith et al., 2015). However, with respect to Facebook, it was discovered that the total number of comments has a positive effect on the company’s revenue (Yoon et al., 2018). This is also confirmed by research by Paniagua and Sapena (2014), which suggests that reaching a critical mass of “followers” and “likes” has a positive effect on the value of the company. The research also shows that it is important (specifically in the case of Facebook) whether the company responds to customers’ messages. Responding to negative messages leads to an increase in financial performance, while there is no noticeable effect of responses to positive messages on the company’s financial performance (Chung et al., 2020).

Several studies have consistently found a significant positive relationship between perceived interactivity on social media and outcome variables, such as attitude and behavior (Alalwan et al., 2017; Vendemia, 2017). Successful company-consumer interactions using social media support brand awareness, increase customer satisfaction and loyalty, and boost sales (Vendemia, 2017; Wang & Kim, 2017; De Veirman et al., 2017). Therefore, this research also investigates the impact of

communication on Facebook on customer engagement, specifically in the selected industry.

2. Research Methodology

2.1 Research Design

The research provides an answer to the following central research question: Is there an association between customer satisfaction resulting from the sale of products and the engagement with customers and potential customers on company profile for Facebook in selected companies in the electronics and communication equipment retail industry, and the performance of these companies?

To answer the research question, the research used a convergent parallel mixed methods research design, which allows the researcher to explore a research problem (Gray, 2009) using an embedded case study design (Yin, 2014). In the conducted research, both qualitative and quantitative data were collected during the same phase of research and the data were analyzed separately and independently (Creswell & Plano Clark, 2011). The quantitative approach comprises an analysis of the communication on Facebook profiles of selected companies and an analysis of the performance of the selected companies. The qualitative approach applies the mystery shopping survey and additionally a qualitative analysis of selected posts with the aim to explain communication with customers on Facebook in detail.

Before conducting our research, we formulated the following hypotheses:

H1: There are positive relationships between service skills and overall customer satisfaction.

H2: There is a positive relationship between customer satisfaction and customer loyalty in selected companies offering retail industry electronic and communication equipment.

H3: There is a positive relationship between engagement with customers and potential customers on company Facebook profiles and the performance of the selected companies offering retail industry electronic and communication equipment.

H4: There is a positive association between customer loyalty and the performance of selected companies offering retail industry electronic and communication equipment in the Czech Republic.

2.2 Characteristics of the Examined Sample of Companies

The research sample consisted of five companies that operated retail chains of electronics stores in the Czech Republic in 2017/2018. Specifically, these companies were: HP TRONIC Zlín, Ltd. (operating the chain of EURONICS stores), DATART INTERNATIONAL, Plc. (operating the chain of DATART stores), FAST ČR, Plc. (operating the chain of PLANE0 stores), OKAY, Ltd. (operating the chain of OKAY stores) and Electro World, Ltd. (operating the chain of ELECTRO WORLD stores). These companies rank among the six largest retailers of electronics in the Czech Republic (Marketing & Media, 2011). The companies DATART, Electro World and HP Tronic were also listed among the seven (excluding e-shops without brick-and-mortar stores) largest electronics retailers in the Czech Republic in 2016 (Redakce W4T, 2016).

Tab. 1: Selected companies in the electronics and communication equipment industry and their sales

Shop name	Net sales in 2018 (in billion CZK)	Rank according sales
Electro World	3.96	5.
Euronics + DATART	15 (of this DATART 7.5)	2.
Planeo	10.1	3.
OKAY	–	–
Alza.cz	25.3	1.
CZC.cz	4.1	4.

Source: own

It can thus be said that the sample of companies consists of the largest electronics retailers in the Czech Republic but does not include the companies Alza.cz and CZC.cz, which are especially connected with online shopping. Alza.cz is the market leader in online shopping and CZC.cz is in second place, and the selected companies follow these leaders in the online shopping area. For the year 2019, EURONICS is no longer in the sample of companies because of the company merger of DATART and Euronics at the end of 2018. Thanks to the fact that the brands under which the companies operate in the market are generally better known than the companies' names, the following text will use these store brands of the respective companies. Another reason is the Facebook-based research of the profiles representing their trademarks on the Internet. A comparison of the sales of the surveyed store names is given in Tab. 1.

2.3 Analysis of Financial Performance

Financial performance uses simple financial indicators (Venkatraman & Ramanujam, 1986), whereby it corresponds with the concept of performance, specifically the part related to efficiency (see above). Thanks to that, it is also possible to measure efficiency using financial indicators constructed from accounting data. Based on positive experience from prior research, the ROA and ROE indicators (from the rate of return category), supplemented by the ATO indicator (from the activity category), were chosen to measure efficiency (Suchánek & Králová, 2018). The ROA indicator is constructed as the ratio of EBIT (earnings before interest and taxes) to total assets. The ROE indicator is constructed as the ratio of net profit to the book value of equity. The ATO indicator is constructed as the ratio of total revenues to total assets. For all three of the above-mentioned indicators, it can be said that the higher their value, the higher the efficiency (as a part of enterprise performance).

The results were evaluated using two methods based on multiple criteria decision-making (cf. Babić & Plazibat, 1998). Using the first method (ranking method), the companies' results in the selected financial indicators were sorted by ranking, with their average ranking determining the final rank according to their performance (Šubrt et al., 2015). Using the other method, the average values of the said

indicators in the given industry (specifically, retail without motor vehicles) were ascertained. The results (averages) of the respective indicators for the industry were obtained from publicly available data from the Ministry of Industry and Trade of the Czech Republic (see Department 31400, 2016; Department 31400, 2017). Enterprises were evaluated either as performing (if the indicator value was above the industry average) or non-performing (if the indicator value was below the industry average). Subsequently, the results reached using both methods were synthesized and performance determined, i.e., the measure of performance of the researched companies.

2.4 Mystery Shopping

The scenario and research tool was used in research conducted by Eger and Mičík (2017) and in a pilot study by Suchánek and Eger (2019). The scenario of MS was validated by experts from retail industries and the planned research was piloted to assess the clarity and relevance of the questionnaire items (cf. Kehagias, Rigopoulou, & Vassilikopoulou, 2011; Suchánek & Eger, 2019). The process of scale construction was similar to the Dew and Xiao (2011) approach.

To obtain more objective assessments from the customer's point of view, not the employee's, skilled customers (mystery shoppers) evaluate the sales process. The survey also answers an ultimate question regarding loyalty, represented by the NPS indicator. This indicator is used in our research as a customer's cumulative statement of their loyalty (cf. deterministic approach to customer loyalty above), because companies with satisfied customers tend to enjoy greater customer loyalty, which leads to positive word of mouth (Luo & Bhattacharya, 2006; Xu & Goedegebuure, 2005).

The use of the immediate customer satisfaction measurement (last item in this MS scenario) and the answer to a single NPS question represents simplification and a research limitation (Grisaffe, 2007) in comparison to cumulated satisfaction, which summarizes complex indexes like the ACSi (cf. Eklöv & Westlund, 2002).

Mystery shopping is a useful technique for measuring service quality and has the potential to directly measure service performance across the range of present standards, including behavioral aspects (Wilson, 2001). In our

survey, the scenario was based on theoretical issues (ESOMAR, 2005; Ford, Latham, & Lennox, 2011; Kehagias, Rigopoulou, & Vassilikopoulou, 2011; Porter & Heyman, 2018; Schmidt & Hollensen, 2006; Vadi & Suuroja, 2006; Wilson, 2001). Its structure and the content of partial items were evaluated in prior research (Eger & Mičik, 2017) and in a pilot study by Suchánek and Eger (2019).

The scenario contains items divided into seven parts: store entrance (A), staff appearance (B), needs and benefits (C), listening and answering (D), offer-knowledge of the product (E), negotiating and satisfaction with the overall impression (F), while the last small section contains the NPS question and a scale (0–10) for answers. A Likert-type scale was used in the scenario to measure individual items (1 = strongly disagree (parts A–E)/very dissatisfied (part F), 5 = strongly agree (parts A–E)/very satisfied (part F)).

The survey was conducted in three regions (in small and large cities), which were selected to represent the level of customer service in retail of the selected companies. To achieve an objective result by mystery shopping, the survey followed the pilot study from the year 2017/2018 and was conducted in March and in April 2019. This means that we have the opportunity to evaluate the selected companies in this area over a longer period. The total number of all mystery shopping visits in 2019 was 168 (38 in Electro World, 57 in DATART, 34 in Planeo Elektro and 39 in OKAY Elektro points of sale).

2.5 Facebook Social Network and Customer Engagement

Consumer sociability behavior on Facebook may include various kinds of actions such as linking, commenting, sharing and emoji reactions. The characteristics of company posts result in consumer behavior regarding likes, comments, shares and overall engagement on Facebook. It is possible to divide consumer responses to company and brand posts on Facebook into two main parts. The first group of consumers represents active users of this social network while the second group represents passive users or people that do not use social media. From this point of view, the conducted research focused only on communication between active consumers and the company. Recent findings have shown that useful information related to

a company generates customer engagement according to the types of published posts (Kim & Yang, 2017; Vaiciukynaite, Massara, & Gatautis, 2017).

The analysis of company communication on Facebook used data mining using the Netvizz tool to analyze how the selected companies communicated on Facebook in the year 2018. To answer the research question, the engagement rate was calculated for the selected companies. Additionally, the change in activity on company Facebook profiles between 2017 and 2018 was evaluated.

In the next step, using Netvizz, the best posts of each selected company were selected and then a qualitative analysis focused on the content of the published posts and types of call to action was conducted. A total of 973 (Netvizz) records of posts from 4 companies with Facebook profiles for the year 2018 were selected for investigation (Links, Photos, Status, Videos).

3. Results

The mystery shopping visits (168) executed in three regions in the first half of 2019 to the aforementioned four companies allow us to evaluate the effect of the different variables on overall customer satisfaction. Tab. 1 allowed us to identify correlations between important parts (variables) from the research construct.

Tab. 2 compares selected areas and items of the customer-oriented service using the mystery shopping survey in the manner of shop interior, staff appearance, communication with customers (C, D, E) and satisfaction with the overall impression. The correlation matrix is used to investigate the dependence between variables from our construct focused on customer-oriented communication and on customer-oriented service (cf. Eger & Mičik, 2017). Tab. 2 newly compares the results of the pilot study from the year 2017/2018 with the current mystery shopping survey in 2019.

The reliability of the instrument is established by internal consistency (Cronbach's alpha). Almost all partial scales showed acceptable values above or near 0.7 (Nunnally & Bernstein, 1994). The area Needs and benefits contains only 2 items focused on these two features of the mentioned area and Cronbach's alpha is only 0.6. The values of Cronbach's alpha are the same as in the pilot study.

Tab. 2: Descriptive statistics, the individual section – customer-oriented service (mean, standard deviation, and correlation matrix)

Areas and number of items	α	A*	A	B*	B	C*	C	D*	D	E*	E	F*	F
A Store entrance (3)	.69	–	–										
B Staff appearance (2)	.75	.407	.392	–	–								
C Needs and benefits (2)	.57	.286	.359	.227	.288	–	–						
D Listening and answering (2)	.75	.294	.151	.280	.215	.446	.328	–	–				
E Offer-knowledge of the product (2)	.72	.284	.238	.261	.264	.535	.478	.593	.605	–	–		
F Satisfaction (2)	.85	.380	.373	.272	.323	.338	.534	.633	.580	.644	.637	–	–
Mean		3.8	3.9	4.4	4.4	3.7	3.6	4.0	3.9	3.8	3.6	3.9	3.9
SD		.70	.63	.66	.60	.89	.92	.6	.75	.79	.82	.72	.85

Source: own

Note: * Results of pilot study in 2017/2018.

Partial conclusions are as follows:

- “WAO” effect – Shop looks attractive from the outside – no significant correlations were found with other items except the item Staff appearance (weak correlation).
- Positive correlations exist between variables E-C, and E-D. The results are stable for both research surveys and indicate the importance of these features in product selling.
- The highest (moderate) correlation coefficient was found between the items Satisfaction with the overall impression and Offer-knowledge of the product. This fact expresses the importance of personal selling in the selected industry.
- As we assumed, the findings show that product presentation and communication with customers (D, E) have positive effects on customers’ expression of their satisfaction with the overall impression of the buying process (F satisfaction).

- The relationship between service skills and overall customer satisfaction is supported (H1).
The Net Promoter Score, or NPS, measures customer experience and predicts business growth. The NPS calculation:

$$NPS = \% \text{ Promoters} - \% \text{ Detractors} \quad (1)$$

The Net Promoter Score is an index ranging from –100 to 100.

As shown in Tab. 3, the company with the high NPS score also received the best rating by mystery shoppers in terms of the item: I am satisfied with the overall purchase experience (5-point Likert scale from 1 = very dissatisfied to 5 = very satisfied).

Tab. 3 demonstrates the association between the item overall customer satisfaction and the item customer loyalty (NPS). This Tab. 3 shows that there existed a relationship between

Tab. 3: Selected companies in the electronics and communication equipment industry and NPS

Shop name	Number of MS 2017/18*	MS 2019	Value of NPS*	Value of NPS	Satisfaction average*	Satisfaction average
Electro World	44	38	18	13	4.11	3.95
Euronics	41	0	0	–	3.81	–
DATART	42	57	2	–9	3.93	3.95
Planeo	36	34	–25	–3	3.75	4
OKAY	41	39	–22	–46	3.71	3.51

Source: own

Note: * Results of pilot study in 2017/2018.

overall customer satisfaction (from mystery shopping) and customer loyalty (index NPS) in the survey in 2017/2018. Tab. 3 also shows changes in the Net Promoter Score. Electro World received a good rating, Planeo was improving and OKAY received a worse rating in both indicators. The original proposition in conducted case study (H2) is supported (see the research limitation below). The results of our partial research confirm that customer satisfaction is a strong antecedent to customer loyalty (cf. Anderson & Sullivan, 1993; Xu & Goedegebuure, 2006; Eger & Mičák, 2017). In order to depict the connections between the selected variables, a statistical analysis was conducted. Due to the character of the data, the Kendall Tau indicator was used, on the basis of which the occurrence of the statistical significance was tested for the 2017/2018 data set ($t_k = 0.55$, $p = 0.0000001$) and for the 2019 data set ($t_k = 0.61$, $p = 0.0000001$).

To answer the research question in the subtopic focused on communication with customers using Facebook, the engagement rate (2) and reduced engagement rate (3) were calculated for the four selected companies. Engagement rate is a (old) metric that measures

the level of engagement that a piece of created content (post) receives from an audience. It shows how much people interact with the content on a company's Facebook profile.

$$\begin{aligned} \text{Engagement rate (ER)} &= \\ &= \frac{\text{Comments} + \text{Reactions} + \text{Shares}}{\text{Followers}} \end{aligned} \quad (2)$$

Reduced engagement rate (3) was calculated according to a recommendation by Kim and Yang (2017). In this case, a share weighs as much as 2 comments, and a like weighs as much as 1/10 of a comment.

$$\begin{aligned} \text{Reduced engagement rate (RER)} &= \\ &= \frac{\text{Comments} + 1/10 \text{ Reactions} + \text{Shares} * 2}{\text{Followers}} \end{aligned} \quad (3)$$

Tab. 4 displays basic data outputs from the Facebook profiles of the analyzed companies for the year 2018 as obtained via Netvizz. The column with the number of posts shows activity on the Facebook profile by means of posted messages a year and the last column shows the percentage change in achieved engagement (Likes + Comments + Reactions).

Tab. 4: Selected companies and their Facebook profiles, 2018

Shop name	Likes	Comments	Reactions	Shares	Followers	ER	RER	No. of posts 2017/2018	Engagement in % 2017/2018
Electro World	64,382	29,672	69,727	7,423	61,000	1.75	0.84	219/232	142.9
DATART	17,628	15,118	19,601	4,933	54,000	0.73	0.5	554/414	68.5
Planeo	1,361	227	1,532	1,165	24,000	0.12	0.11	183/93	45.6
OKAY	58,883	8,642	63,323	3,612	51,000	1.48	0.44	192/234	104.3

Source: own

Note: Data obtained via Netvizz in June 2019.

Partial conclusions are as follows:

- As can be seen from Tab. 4, the best engagement rate and reduced engagement rate were achieved by Electro World and good results were also seen for OKAY.
- DATART had a good number of followers in comparison to both mentioned companies and published a higher number of posts a year, but did not reach the engagement

rate of Electro World. This indicates lower efficiency of communication using the Facebook profile.

- As Tab. 4 shows, Planeo communicated very badly with customers and potential customers on Facebook.

It is important to mention that Electro World and OKAY present on their websites a visible logo of Facebook and call visitors to action.

Neither of the other companies call visitors to action but only display the Facebook logo with information about other social media.

As mentioned above, there are three different actions that individuals can do on Facebook: like, comment and share (Kim & Yang, 2017). Detailed analysis of the engagement rate shows differences in these metrics and additionally allows the quantity of feedback from audiences on Facebook to be measured using the three mentioned metrics: popularity, commitment and virality (Escobar-Rodríguez & Bonsón-Fernández, 2017).

Popularity was measured by means of the number of likes (year 2018). Companies reached values from 14.6 to 277.5 likes per post in the year 2018. The highest level of popularity was achieved by Electro World, followed by OKAY. Commitment refers to the number of comments per post. The values ranged from 2.4 to 127.9 and only one company, Electro World, achieved a value above 100. Virality shows the effectiveness of viral messages, which was measured according to the number of shares per post. The values ranged from 11.9 to 32. Only Electro World achieved a great viral effect through sharing. From this perspective, it can also be said that the company Electro World is the leader in acquisition popularity, commitment and virality. The results do not support the positive relation between the variables of the company's level of activity on Facebook and the performance (financial indicators) of the selected companies.

As can be seen from Tabs. 4, 5 and 6, Electro World achieved the best results in communication with customers on Facebook,

but according to the selected financial indicators it came last. On the contrary, DATART did not have good results in communication on Facebook, but in 2015 and 2017 it was the best in the sample of monitored companies according to selected financial indicators. No positive relationship was found between engagement with customers and potential customers on company Facebook profiles and the performance of the selected companies offering retail industry electronic and communication equipment (H3). This means that the original proposition in the conducted case study cannot be supported. The financial performance results in the various years are shown in Tabs. 5 and 6. These clearly indicate that the performance of the analyzed enterprises in mutual comparison varied in the particular years. The largest fluctuation is noticeable with DATART International, whose performance was the best in 2015 and 2017, but the lowest in 2016. Other companies saw less of a fluctuation in performance. HP Tronics Zlín jumped from second/third place in 2015 to first place in 2016 and returned again to second place in 2017. Fast ČR advanced from fourth place in 2015 to third place in 2016, and remained in third/fourth place in 2017. The position of OKAY remained practically unchanged in 2015 and 2016, and there were no data available for the year 2017. Electro World saw the worst performance in 2015 and 2016, and the situation did not change in 2017.

The results displayed in Tabs. 5 and 6 indicate that the performance of Euronics grew in 2016 (significant increase in ROE); however, the company saw a decrease in performance in

Tab. 5: Results of the selected financial indicators of the surveyed enterprises in 2015 and 2016, including the resulting ranks

Year	2015				2016			
	ROA	ROE	ATO	Final order	ROA	ROE	ATO	Final order
Electro World	-19.66%	156.66%	3.1	5	-11.25%	-116.90%	4.19	5
Euronics	2.33%	9.61%	2.42	2-3	3.12%	27.00%	2.49	1
DATART	1.95%	17.02%	3.61	1	1.56%	5.78	3.71	4
Planeo	6.08%	14.85%	1.83	4	6.69%	15.46%	1.85	3
OKAY	4.90%	19.43%	2.25	2-3	4.80%	15.03%	2.4	2
Industry average	6.55%	8.64%	2.29		8.81%	15.02%	2.28	

Source: own

2017 (with ROA and ATO below 2015 levels). The performance of DATART International saw an overall decrease (ROA slightly reduced, ATO slightly up, and a significant decrease in ROE), though 2017 saw a major increase in performance (despite a decrease in ATO). The performance of Planeo increased slightly in 2016; however, it fell in 2017 (despite a slight increase in ATO). OKAY saw a decrease in performance in 2016 (despite a slight increase

in ATO), with data for 2017 unavailable. The performance of Electro World increased in 2016, although it needs to be noted that the company's rate of return was poor, i.e., negative in both 2015 and 2016 (the positive result in ROE for 2015 is due to the ratio of negative profit and negative equity). The company's performance continued to grow in 2017 (with the exception of a decrease in ATO), with the rate of return getting in the black.

Tab. 6: Selected financial indicators of the surveyed companies in 2017, including the resulting rank

Shop name	ROA	ROE	ATO	Average rank based on indicators	Overall rank based on indicators	Overall rank based on industry average	Final order
Electro World	1.02%	7.26%	4.75	3.67	4	2–3	3–4
Euronics	1.81%	22.85%	2.17	2.67	2–3	2–3	2
DATART	3.19%	37.65%	2.4	1.67	1	1	1
Planeo	4.80%	11.93%	1.91	2.67	2–3	4	3–4
OKAY	–	–	–	–	–	–	–
Industry average	9.14%	15.32%	2.3				

Source: own

Based on the comparison of the NPS results from Tab. 3 and the performance shown in Tab. 6, it is clear that there is no positive association between customer loyalty and the performance of the selected companies offering retail industry electronic and communication equipment in the Czech Republic. Due to the small number of enterprises included in the case study, this hypothesis cannot be statistically tested in a standard way. Particularly the results of Electro World are at variance with the claim of the hypothesis, but the other companies do not reach the expected (identical) evaluation in terms of performance and loyalty, either. The original proposition (*H4*) in the conducted case study cannot be supported.

The conducted research analyzes five enterprises from a selected retail industry which represent only a quarter of total market turnover in this industry. But these enterprises are the most important players in this industry, and a deeper understanding of this issue is being gained in similar studies (cf. Chi & Gursoy, 2009). It is not possible to assume the implementation of comprehensive research for

the retail industry, where many small entities operate.

Discussion and Conclusion

The research results suggest that communication with customers (in this case through a Facebook profile) and customer loyalty (NPS) are closely related (see Tabs. 3 and 4), with the exception of the OKAY, though in its case the problem may be a general lack of communication, as this company (unlike the others) has not posted its financial results for 2017. The correlation between communication by means of Facebook and customer loyalty in the retailing is, for example, proven by Gamboa and Gonçalves (2014) and by Escobar-Rodríguez and Bonsón-Fernández (2017). The relationship between communication and loyalty in general is confirmed by, e.g., Oly Ndubisý (2007).

The mystery shopping results confirmed the findings from the previous studies (Eger & Mičik, 2017; Suchánek & Eger, 2019) and proved that customer-oriented services and positive communication with customers lead

to overall customer satisfaction and customer loyalty. According to our results, overall customer satisfaction leads to greater customer loyalty (similar conclusion reached by Anderson & Sullivan, 1993; Abu-ELSamen et al., 2011; Blessing & Natter, 2019; Xu & Goedegebuure, 2005).

When comparing the performance results of the particular companies and the level of loyalty of their customers, it is obvious that the statement about greater customer satisfaction and greater company performance is in fact not valid, as proven in the area of services (e.g. Suchánek & Eger, 2019; Zeithaml, 2000). However, this applies in a static view (in the comparison of results in 2017). However, when the dynamic performance development is taken into account, Tabs. 5 and 6 suggest that the trend in performance development could affect customer loyalty. Tabs. 5 and 6 indicate that the performance of Euronics and Planeo decreased in 2017, while that of DATART and Electro World increased. However, the loyalty evaluation was worse in Euronics and Planeo than in DATART and Electro World. This seems to suggest that what is more important than the immediate data for the particular year is the developmental trend over time, as the performance of Electro World is worse in the particular years than that of DATART as well as Euronics.

The only non-performing company in the sample (Electro World) is the shop with the highest customer loyalty and with the best result of engagement on its Facebook profile (metrics: popularity, commitment and virality). On the other hand, the best-performing shop (Euronics) came third in terms of customer loyalty in 2018 and second as the brand DATART in 2019. The second highest-performing shop was OKAY (2017), which took fifth place in terms of customer loyalty, and the third highest-performing company was Planeo, which in terms of customer satisfaction took fourth place in 2018. It is a pity that the company OKAY no longer provides financial indicators for the year 2017 so we cannot compare this indicator with the pilot study results. In terms of evaluating marketing communication on Facebook, it is clear that OKAY has significantly improved, while DATART and Planeo achieved insufficient results for 2018.

Customers now go above and beyond their traditional role as passive recipients of information to actively engage with companies

online (Yoon et al., 2018). Facebook is the preferred social media platform (EUROSTAT, 2018); companies consider that consumers who join this platform and become more engaged with their brands or products, will also be loyal to the company, and ultimately increase spending with the company.

Based on the research results, it appears that a short-term increase in the use of social media (in this case Facebook) does not result in an increase in financial performance, which corresponds with the conclusions of Smith et al. (2015). In this context, the findings suggest that the total number of comments received does not lead to an increase in the financial performance of an enterprise, which is partly at variance with the findings of Yoon et al. (2018). This also applies to the findings related to "followers" and "likes". Given the development of these variables and financial performance, it appears that the companies (including Electro World and OKAY) have not yet reached critical mass when it comes to the number of followers who would have a positive effect on the companies' financial performance, as ascertained by Paniagua and Sapena (2014).

As mentioned above, it was assumed that companies with higher positive results in customer satisfaction and loyalty also achieve better results in the selected financial indicators. The results of this research show that this may not be the case. However, retailers know that they are in a fully competitive market and they are increasing their emphasis on customer experience in retailers' stores and websites and social media sites, including the service they get from store employees and the quality of the shopping environment (cf. Levy et al., 2019).

The comparison of the ATO indicator and NPS results shows that the evaluation of companies based on ATO corresponds with the evaluation of customer loyalty according to NPS. Thanks to the fact that the ATO indicator is an indicator of efficiency (Warrad & Al Omari, 2015), it can be said that there is a positive relationship between efficiency and loyalty, i.e., high efficiency is connected with high customer loyalty. In other words, the higher the efficiency, the higher the customer loyalty (and vice versa). Due to the fact that effectiveness in this sense of the word is about (goods) turnover rate, and because of the tight competition in the electronics market, the high turnover rate

is usually at the expense of a lower margin of profit (cf. Guo & Wang, 2019). Lower margins then put pressure on the company's lower rate of return. Just to compare, the average profit margin (our calculation from freely available sources) of the largest on-line retailer, Alza.cz, was 7.9% in 2017, while it was 8.5% for Electro World and 23.3% for DATART.

Apart from profit margins, costs are also important. There is no published research that would prove a negative effect of loyalty-related costs on the company's performance. On the other hand, loyalty is connected with costs. For example, it is more costly to gain a new customer than to keep an existing one (Hegner-Kakar, Richter, & Ringle, 2018); it is very costly to lose a customer (Harris & Goode, 2004); and not all (long-standing) customers increase the company's rate of return (Niraj, Gupta, & Narasimhan, 2001). Our research also proves a positive correlation between customer satisfaction and customer loyalty. When customer satisfaction is connected with costs and therefore greater customer satisfaction is associated with higher costs (Iltner & Larcker, 1998), the same can be expected to hold true for loyalty.

It has been shown that the relationship between loyalty and a company's financial performance is more complex and that there are several conflicting effects at play. There is a positive relationship between loyalty and performance development (as a whole) as well as between loyalty and the company's effectiveness (asset turnover rate). On the other hand, there is a negative relationship between loyalty and the company's costs (whether it be costs associated with the acquisition of new customers or keeping existing ones, or goods procurement costs) as well as between loyalty and profit margin, with profit margin affecting the company's rate of return.

From the theoretical point of view, it appears that in terms of understanding the financial performance of an enterprise as a two-dimensional variable efficiency and effectiveness (for more details, see Neely & Wilson, 1992; Neely, Gregory, & Platts, 2005), the effectiveness variable cannot be limited solely to customer satisfaction. The research shows that the concept of effectiveness needs to be expanded to include social media (specifically Facebook) that are closely connected with customer satisfaction, or in other words, social media

also influence customer satisfaction. What is also apparent is the importance of the inner workings of an enterprise which has led to the current levels of both performance dimensions, which was (at least partially) discovered by way of mystery shopping.

Limitations

First, the research, focused on customer satisfaction and the performance of selected companies from the retail industry, was conducted in the context of the Czech Republic in 2017/2018 and 2019. Second, the conducted research survey focuses only on the most well-known companies in the mentioned retail industry without on-line shoppers. The research design did not allow for the formulated hypotheses to be statistically tested in the standard way, but made it possible to comment on the original propositions of the case study. One of the main limitations of this research is that customer satisfaction was examined as a unidimensional construct. The performance of retail companies depends not only on customers and their marketing activities, but also on the efficiency of the operation and management of the company. Some authors also state that mystery shopping may not be effective in predicting customer satisfaction (Blessing & Natter, 2019). And, of course, we still have limited knowledge about how companies in the context of the Czech Republic use social media and develop brand communities, e.g., on Facebook. Due to Facebook's new policy, the app Netvizz lost access to the 'Page Public Content Access' at the end of August 2019. Thus, the data presented in Tab. 4 are unique. We suggest that further research in different cultures and countries is now necessary in this field to more deeply understand how both face-to-face communication and electronic communication with customers can influence the performance of companies also from the financial point of view. Another problem lies in the incomplete performance results for the research sample of companies in 2018 and 2019, so some of the statements will not be able to be verified until later.

References

Abu-ELSamen, A. A., Akroush, M. N., Al-Khawaldeh, F. M., & Al-Shibly, M. S. (2011). Towards an integrated model of customer service skills and customer loyalty. The mediating role

of customer satisfaction. *International Journal of Commerce and Management*, 21(4), 349–380. <https://doi.org/10.1108/10569211111189365>

Al-Hawari, M., & Ward, T. (2006). The effect of automated service quality on Australian banks' financial performance and the mediating role of customer satisfaction. *Marketing Intelligence & Planning*, 24(2), 127–147. <https://doi.org/10.1108/02634500610653991>

Alalwan, A. A., Rana, N., Dwivedi, K., Y., & Algharabat, R. (2017). Social media in marketing: A review and analysis of the existing literature. *Telematics and Informatics*, 34(7), 1177–1190. <https://doi.org/10.1016/j.tele.2017.05.008>

Anderson, E. W., Fornell, C., & Mazvanchery, S. K. (2004). Customer satisfaction and shareholder value. *Journal of Marketing*, 68(4), 172–185. <https://doi.org/10.1509/jmkg.68.4.172.42723>

Anderson, E. W., Fornell, C., & Rust, R. T. (1997). Customer satisfaction, productivity, and profitability: Differences between goods and services. *Marketing science*, 16(2), 129–145. <https://doi.org/10.1287/mksc.16.2.129>

Babic, Z., & Plazibat, N. (1998). Ranking of enterprises based on multicriterial analysis. *International journal of production economics*, 56–57, 29–35. [https://doi.org/10.1016/S0925-5273\(97\)00133-3](https://doi.org/10.1016/S0925-5273(97)00133-3)

Belás, J., & Gabčová, L. (2016). The relationship among customer satisfaction, loyalty and financial performance of commercial banks. *E&M Economics and Management*, 19(1), 132–147. <http://dx.doi.org/10.15240/tul/001/2016-1-010>

Beneke, J., Hayworth, C., Hobson, R., & Mia, Z. (2012). Examining the effect of retail service quality dimensions on customer satisfaction and loyalty: The case of the supermarket shopper. *Acta Commercii*, 12(1), 27–43. <https://doi.org/10.4102/ac.v12i1.129>

Blessing, G., & Natter, M. (2019). Do Mystery Shoppers Really Predict Customer Satisfaction and Sales Performance? *Journal of Retailing*, 95(3), 47–62. <https://doi.org/10.1016/j.jretai.2019.04.001>

Bolton, R. N., Lemon, K. N., & Verhoef, P. C. (1998). The theoretical underpinnings of customer asset management: a framework and positions for future research. *Journal of the Academy of Marketing Science*, 32(3), 271–292. <https://doi.org/10.1177/0092070304263341>

Chi, C. G., & Gursoy, D. (2009). Employee satisfaction, customer satisfaction, and financial performance: An empirical

examination. *International Journal of Hospitality Management*, 28(2), 245–253. <https://doi.org/10.1016/j.ijhm.2008.08.003>

Chia, A., Goh, M., & Hum, S. H. (2009). Performance measurement in supply chain entities: balanced scorecard perspective. *Benchmarking: An International Journal*, 16(5), 605–620. <https://doi.org/10.1108/14635770910987832>

Chung, S., Animesh, A., Han, K., & Pinsonneault, A. (2020). Financial returns to firms' communication actions on firm-initiated social media: Evidence from Facebook business pages. *Information Systems Research*, 31(1), 258–285. <https://doi.org/10.1287/isre.2019.0884>

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage Publishing.

DATART INTERNATIONAL, Plc. (2016). *Výroční zpráva za období 1. května 2015 do 30. dubna 2016 [Annual Report for the period from May 1, 2015 to April 30, 2016]*. Retrieved from <https://or.justice.cz/ias/ui/rejstrik>

De Vierman, M., Cauberghe, V., Hudders, L., & De Pelsmacker, P. (2017). Consumers' motivations for lurking and posting in brand communities on social networking sites. In S. Rodgers & E. Thorson (Eds.), *Digital advertising* (pp. 207–221). New York, NY: Routledge.

Dew, J., & Xiao, J. J. (2011). The financial management behavior scale: Development and validation. *Journal of Financial Counseling and Planning*, 22(1), 43–59.

Delen, D., Kuzey, C., & Uyar, A. (2013). Measuring firm performance using financial ratios: A decision tree approach. *Expert Systems with Applications*, 40(10), 3970–3983. <https://doi.org/10.1016/j.eswa.2013.01.012>

Duncan, E., & Elliott, G. (2004). Efficiency, customer service and financial performance among Australian financial institutions. *The International Journal of Bank Marketing*, 22(5), 319–342. <https://doi.org/10.1108/02652320410549647>

Eger, L., & Mičik, M. (2017). Customer-oriented communication in retail and Net Promoter Score. *Journal of Retailing and Consumer Services*, 35, 142–149. <https://doi.org/10.1016/j.jretconser.2016.12.009>

Egerová, D. (2015). Employee Training and Development as a Tool for Improving the Competitiveness of Czech Enterprises. In *Proceedings of the 9th International Scientific Conference INPROFORUM* (pp. 75–80). Česká

Budějovice: University of South Bohemia in České Budějovice.

Eklöv, J. A., & Westlund, A. H. (2002). The pan-European customer satisfaction index programme – current work and the way ahead. *Total Quality Management*, 13(8), 1099–1106. <https://doi.org/10.1080/09544120200000005>

El-Bachir, S. (2014). The influence of the store atmosphere on the Consumer behavior. *Mediterranean Journal of Social Sciences*, 5(8), 229–235. <https://doi.org/10.5901/mjss.2014.v5n8p229>

Electro World, Ltd. (2015). *Výroční zpráva, 30. dubna 2015 [Annual Report, April 30, 2015]*. Retrieved from <https://or.justice.cz/ias/ui/rejstrik>

Electro World, Ltd. (2017). *Výroční zpráva, 30. dubna 2017 [Annual Report, April 30, 2017]*. Retrieved from <https://or.justice.cz/ias/ui/rejstrik>

Escobar-Rodríguez, T., & Bonsón-Fernández, R. (2017). Facebook practices for business communication among fashion retailers. *Journal of Fashion Marketing and Management*, 21(1), 33–50. <https://doi.org/10.1108/JFMM-11-2015-0087>

ESOMAR. (2015). *Codes and guidelines. Mystery Shopping Studies*. Retrieved January 30, 2020, from <http://www.esomar.org/knowledge-and-standards/codes-and-guidelines.php>

EURONICS ČR, Plc. (2015). *Výroční zpráva za rok 2015 [Annual Report for 2015]*. Retrieved from <https://or.justice.cz/ias/ui/rejstrik>

EURONICS ČR, Plc. (2020). *Points of sale*. Retrieved from <https://www.euronics.cz/prodejny/>

EUROSTAT. (2018). *Digital Economy & Society in the EU*. Retrieved October 30, 2019, from <https://ec.europa.eu/eurostat/cache/infographs/ict/2018/index.html>

FeedbackSystems. (2016). *Linking Customer Satisfaction to Financial Performance*. Retrieved September 10, 2017, from <http://www.feedbacksystems.com/executive-briefings/linking-customer-satisfaction-to-financial-performance>

Ford, R. C., Latham, G. P., & Lennox, G. (2011). Mystery shoppers: a new tool for coaching employee performance improvement. *Organizational Dynamics*, 40(3), 157–164. <https://doi.org/10.1016/j.orgdyn.2011.04.002>

Fraering, M., & Minor, M. S. (2013). Beyond loyalty: customer satisfaction, loyalty, and fortitude. *Journal of Services Marketing*, 27(4), 334–344. <https://doi.org/10.1108/08876041311330807>

Gamboa, A. M., & Gonçalves, H. M. (2014). Customer loyalty through social networks: Lessons from Zara on Facebook. *Business Horizons*, 57(6), 709–717. <https://doi.org/10.1016/j.bushor.2014.07.003>

Gensler, S., Völcker, F., Liu-Tompkins, Y., & Wiertz, S. (2013). Managing Brands in the Social Media Environment. *Journal of Interactive Marketing*, 27(4), 242–256. <https://doi.org/10.1016/j.intmar.2013.09.004>

Gray, E. D. (2009). *Doing research in the real world*. London: SAGE.

Grisaffe, D. B. (2007). Questions about the ultimate question: conceptual consideration in evaluating Reichheld's net promoter score (NPS). *Journal of Consumer Satisfaction, Dissatisfaction and Complaining Behavior*, 20, 36–53.

Gosselt, J. F., van Hoof, J. J., de Jong, M. D. T., & Prinsen, S. (2007). Mystery Shopping and Alcohol Sales: Do Supermarkets and Liquor Stores Sell Alcohol to Underage Customers? *Journal of Adolescent Health*, 41(3), 302–308. <https://doi.org/10.1016/j.jadohealth.2007.04.007>

Gilbert, G., & Veloutsou, C. (2006). A cross-industry comparison of customer satisfaction. *Journal of Services Marketing*, 20(5), 298–308. <https://doi.org/10.1108/08876040610679918>

Gruca, T., & Rego, L. L. (2005). Customer Satisfaction, Cash Flow, and Shareholder Value. *Journal of Marketing*, 69(3), 115–130. <https://doi.org/10.1509/jmkg.69.3.115.66364>

Gunasekaran, A., Williams, H. J., & McGaughey, R. E. (2005). Performance measurement and costing system in new enterprise. *Technovation*, 25(5), 523–533. <https://doi.org/10.1016/j.technovation.2003.09.010>

Guo, L., & Wang, Z. (2019). Ratio Analysis of J Sainsbury plc Financial Performance between 2015 and 2018 in Comparison with Tesco and Morrisons. *American Journal of Industrial and Business Management*, 9(2), 325–341. <https://doi.org/10.4236/ajibm.2019.92022>

Gupta, M., & Galloway, K. (2003). Activity-based costing/management and its implications for operations management. *Technovation*, 23(2), 131–138. [https://doi.org/10.1016/S0166-4972\(01\)00093-1](https://doi.org/10.1016/S0166-4972(01)00093-1)

Harris, L. C., & Goode, M. M. (2004). The four levels of loyalty and the pivotal role of trust: a study of online service dynamics. *Journal of Retailing*, 80(2), 139–158. <https://doi.org/10.1016/j.jretai.2004.04.002>

- Heikal, M., Khaddafi, M., & Ummah, A. (2014). Influence Analysis of Return on Assets (ROA), Return on Equity (ROE), Net Profit Margin (NPM), Debt to Equity Ratio (DER), and current ratio (CR), Against Corporate Profit Growth In Automotive In Indonesia Stock Exchange. *International Journal of Academic Research in Business and Social Sciences*, 4(12), 101–114. <https://doi.org/10.6007/IJARBS/v4-i12/1331>
- Hegner-Kakar, A. K., Richter, N. F., & Ringle, C. M. (2018). The Customer Loyalty Cascade and Its Impact on Profitability in Financial Services. In N. Avkiran & C. Ringle (Eds.), *Partial least squares structural equation modelling. International Series in Operations Research & Management Science* (Vol. 267, pp. 53–75). Cham: Springer.
- Hult, G. T. M., Hurley, R. F., & Knight, G. A. (2004). Innovativeness: Its antecedents and impact on business performance. *Industrial marketing management*, 33(5), 429–438. <https://doi.org/10.1016/j.indmarman.2003.08.015>
- Ittner, C. D., & Larcker, D. F. (1998). Are Nonfinancial Measures Leading Indicators of Financial Performance? An Analysis of Customer Satisfaction. *Journal of Accounting Research*, 36, 1–35. <https://doi.org/10.2307/2491304>
- Jankal, R., & Jankalová, M. (2011). Mystery Shopping – The Tool of Employee Communication Skills Evaluation. *Business: Theory and Practice*, 12(1), 45–49. <https://doi.org/10.3846/btp.2011.05>
- Kehagias, J., Rigopoulou, I., & Vassilikopoulou, A. (2011). Linked mystery shopping inventory to customer-seller encounters. *Journal of Customer Behavior*, 10(1), 7–34. <https://doi.org/10.1362/147539211X570492>
- Khan, B., & Rizwan, M. (2004). Factors Contributing to Customer Loyalty in Commercial Banking. *International Journal of Accounting and Financial Reporting*, 4(2), 413–436. <https://doi.org/10.5296/ijaf.v4i2.6537>
- Kim, C., & Yang, S.-U. (2017). Like, comment, and share on Facebook: How each behaviour differs from other. *Public Relations Review*, 43(2), 441–449. <https://doi.org/10.1016/j.pubrev.2017.02.006>
- Kim, M.-K., Park, M.-C., & Jeong, D.-H. (2004). The effects of customer satisfaction and switching barrier on customer loyalty in Korean mobile telecommunications services. *Telecommunications Policy*, 28(2), 145–159. <https://doi.org/10.1016/j.telpol.2003.12.003>
- Kotler, P., & Keller, K. L. (2013). *Marketing Management*. Prague: Grada.
- Kumar, V., & Mirchandani, R. (2012). Increasing the ROI of social media marketing. *MIT Sloan Management Review*, 54(1), 55.
- Levy, M., Weitz, A. B., & Grewal, D. (2019). *Retailing Management*. New York, NY: McGraw-Hill Education.
- Lorino, P. (2003). *Méthodes et pratiques de la performance: le pilotage par les processus et les compétences*. Paris: Éditions d'Organisation.
- Luo, X., & Bhattacharya, B. C. (2006). Corporate social Responsibility, Customer Satisfaction, and Market Value. *Journal of Marketing*, 70(4), 1–18. <https://doi.org/10.1509/jmkg.70.4.1>
- Magnusweb. (2017). Retrieved from <https://magnusweb.bisnode.cz/>
- Marketing & Media. (2011). *Mezi prodeji elektra loni vedl Electro World [Electro World led last year among electricity sellers]*. Retrieved September 10, 2017, from <https://mam.ihned.cz/c1-52337740-mezi-prodejci-elektra-loni-vedl-electro-world>
- Michelson Associates, Inc. (2015). *Mystery Shopping*. Retrieved March 15, 2015, from <http://www.michelson.com/mystery/>
- Neely, A. (2005). The evolution of performance measurement research: Developments in the last decade and a research agenda for the next. *International Journal of Operations & Production Management*, 25(12), 1264–1277. <https://doi.org/10.1108/01443570510633648>
- Neely, A., Gregory, M., & Platts, K. (1995). Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management*, 15(4), 80–116. <https://doi.org/10.1108/01443579510083622>
- Neely, A., & Wilson, J. (1992). Measuring Product Goal Congruence: An Exploratory Case Study. *International Journal of Operations & Production Management*, 12(4), 45–52. <https://doi.org/10.1108/01443579210011589>
- Niraj, R., Gupta, M., & Narasimhan, C. (2001). Customer profitability in a supply chain. *Journal of marketing*, 65(3), 1–16. <https://doi.org/10.1509/jmkg.65.3.1.18332>
- Nunnally, J., & Bernstein, L. (1994). *Psychometric Theory*. New York, NY: McGraw-Hill Higher Inc.

- ODBOR 31400. (2017). *Finanční analýza podnikové sféry za 1.–4. čtvrtletí 2016 [Financial analysis of the corporate sector for 1.–4. quarter 2016]*. Retrieved September 4, 2019, from <https://www.mpo.cz/cz/rozcestnik/analyticke-materialy-a-statistiky/analyticke-materialy/financni-analyza-podnikove-sfery-zarok-2016--228985/>
- ODBOR 31400. (2018). *Finanční analýza podnikové sféry za 1.–4. čtvrtletí 2017 [Financial analysis of the corporate sector for 1.–4. quarter 2017]*. Retrieved September 4, 2019, from <https://www.mpo.cz/cz/rozcestnik/analyticke-materialy-a-statistiky/analyticke-materialy/financni-analyza-podnikove-sfery-zarok-2017--237570/>
- Odin, Y., Odin, N., & Valette-Florence, P. (2001). Conceptual and operational aspects of brand loyalty, an empirical investigation. *Journal of Business Research*, 53(2), 75–84. [https://doi.org/10.1016/S0148-2963\(99\)00076-4](https://doi.org/10.1016/S0148-2963(99)00076-4)
- OKAY Elektro. (2020). O nás. Retrieved from <https://www.okay.cz/clanky/o-nas/>
- Oly Ndubisi, N. (2007). Relationship marketing and customer loyalty. *Marketing Intelligence & Planning*, 25(1), 98–106. <https://doi.org/10.1108/02634500710722425>
- Paniagua, J., & Sapena, J. (2014). Business performance and social media: Love or hate? *Business Horizons*, 57(6), 719–728. <https://doi.org/10.1016/j.bushor.2014.07.005>
- Parment, A. (2013). Generation Y vs. Baby Boomers: Shopping behavior, buyer involvement and implication for retailing. *Journal of Retailing and Consumer Services*, 20(2), 189–199. <https://doi.org/10.1016/j.jretconser.2012.12.001>
- Pimpakorn, N., & Patterson, G. P. (2010). Customer oriented behaviour of frontline service employees: The need to be both willing and able. *Australasian Marketing Journal*, 18(2), 57–65. <https://doi.org/10.1016/j.ausmj.2010.02.004>
- Planeo Elektro. (2020). *Points of sale*. Retrieved from <https://www.planeo.cz/prodejny>
- Porter, M. C., & Heyman, J. E. (2018). We've shopped before: Exploring instructions as an influence on mystery shopper reporting. *Journal of Retailing and Consumer Services*, 45, 12–20. <https://doi.org/10.1016/j.jretconser.2018.08.004>
- Ravelomanantsoa, M. S., Ducq, Y., & Vallespir, B. (2018). A state of the art and comparison of approaches for performance measurement systems definition and design. *International Journal of Production Research*, 57(15–16), 5026–5046. <https://doi.org/10.1080/00207543.2018.1506178>
- Redakce W4T. (2016). *DATART v Česku ve finančním roce 2015/2016 ztrojnásobil zisk na 27,4 milionu Kč [DATART in the Czech Republic tripled its profit to CZK 27.4 million in the financial year 2015/2016]*. Retrieved September 10, 2017, from <https://www.w4t.cz/DATART-v-cesku-ve-financnim-roce-2015-2016-ztrojnasily-zisk-na-27-4-milionu-kc/>
- Reichheld, F. F. (2003). The One Number You Need to Grow. *Harvard Business Review*, 81(12), 46–54.
- Schmidt, J. M., & Hollensen, S. (2006). *Marketing Research an International Approaches*. Harlow: Pearson.
- Semerádová, T., & Weindlich, P. (2019). *Marketing na Facebooku a Instagramu*. Brno: Computer Press.
- Simon, F., & Tossan, V. (2018). Does brand-consumer social sharing matter? A relational framework of customer engagement to brand-hosted social media. *Journal of Business Research*, 85, 175–184. <https://doi.org/10.1016/j.jbusres.2017.12.050>
- Smith, K. T., Blazovich, J. L., & Smith, L. M. (2015). Social media adoption by corporations: An examination by platform, industry, size, and financial performance. *Academy of Marketing Studies Journal*, 19(2), 1–18.
- Suchánek, P., & Eger, L. (2019). Customer Satisfaction and Enterprise Performance: A Study from Electronics and Communication Equipment Retail Industry in the Czech Republic. *Quality Management*, 20(172), 33–40.
- Suchánek, P., & Králová, M. (2018). Customer satisfaction and different evaluation of it by companies. *Economic Research – Ekonomická Istraživanja*, 31(1), 1330–1350. <https://doi.org/10.1080/1331677X.2018.1484786>
- Šubrť, T., Bartoška, J., Brožová, H., Dömeová, L., Houška, M., & Kučera, P. (2015). *Ekonomicko-matematické metody*. Plzeň: Aleš Čeněk.
- Tajudeen, F. P., Jaafar, N. I., & Ainin, S. (2018). Understanding the impact of social media usage among organizations. *Information & Management*, 55(3), 308–321. <https://doi.org/10.1016/j.im.2017.08.004>
- Terpstra, M., & Verbeeten, F. H. M. (2014). Customer satisfaction: cost driver or value driver? Empirical evidence from the financial

services industry. *European Management Journal*, 32(3), 499–508. <https://doi.org/10.1016/j.emj.2013.07.001>

Tosi, H. L., Werner, S., Katz, J. P., & Gomez-Mejia, L. R. (2000). How much does performance matter? A meta-analysis of CEO pay studies. *Journal of Management*, 26(2), 301–339. <https://doi.org/10.1177/014920630002600207>

Vadi, M., & Suuroja, M. (2006). Training retail sales personnel in transition economies: Applying model of customer-oriented communication. *Journal of Retailing and Consumer Services*, 13(5), 339–349. <https://doi.org/10.1016/j.jretconser.2005.11.001>

Vaiciukynaitė, E., Massara, F., & Gatautis, R. (2017). An Investigation on Consumer Sociability Behaviour on Facebook. *Engineering Economics*, 28(4), 467–474. <https://doi.org/10.5755/j01.ee.28.4.15078>

Vendemia, M. A. (2017). When do consumers buy the company? Perceptions of interactivity in company-consumer interactions on social networking sites. *Computers in Human Behavior*, 71, 99–109. <https://doi.org/10.1016/j.chb.2017.01.046>

Venkatraman, N., & Ramanujam, V. (1986). Measurement of Business Performance in Strategy Research: A Comparison of Approaches. *The Academy of Management Review*, 11(4), 801–814. <https://doi.org/10.2307/258398>

Wang, Z., & Kim, H. G. (2017). Can Social Media Marketing Improve Customer Relationship Capabilities and Firm Performance? Dynamic Capability Perspective. *Journal of Interactive Marketing*, 39, 15–26. <https://doi.org/10.1016/j.intmar.2017.02.004>

Wangeheim, F. v., Evanschitzky, H., & Wunderlich, M. (2007). Does the employee-customer satisfaction link hold for all employee groups? *Journal of Business Research*, 60(7), 690–697. <https://doi.org/10.1016/j.jbusres.2007.02.019>

Warrad, L., & Al Omari, R. (2015). The Impact of Turnover Ratios on Jordanian Services Sectors' Performance. *Journal of Modern Accounting and Auditing*, 11(2), 77–85. <https://doi.org/10.17265/1548-6583/2015.02.001>

Wilson, A. M. (2001). Mystery shopping: Using deception to measure service performance. *Psychology & Marketing*, 18(7), 721–734. <https://doi.org/10.1002/mar.1027>

Xu, Y., & Goedegebuure, R. (2005). Employee satisfaction and Customer satisfaction: testing the service-profit chain in a Chinese Securities firm. *Innovative Marketing*, 1(2), 49–59.

Yeung, M. C. H., Ging, L. C., & Ennew, C. T. (2002). Customer satisfaction and profitability: A reappraisal of the nature of the relationship. *Journal of Targeting, Measurement and Analysis for Marketing*, 11(1), 24–33. <https://doi.org/10.1057/palgrave.jt.5740064>

Yin, R. K. (2014). *Case study research: Design and methods*. Thousand Oaks, CA: SAGE Publications.

Yoon, G., Li, C., Ji, Y., North, M., Hong, C., & Liu, J. (2018). Attracting Comments: Digital Engagement Metrics on Facebook and Financial Performance. *Journal of Advertising*, 47(1), 24–37. <https://doi.org/10.1080/00913367.2017.1405753>

Yu, W., Jacobs, M. A., Salisbury, W. D., & Enns, H. (2013). The effects of supply chain integration on customer satisfaction and financial performance: An organizational learning perspective. *International Journal of Production Economics*, 146(1), 346–358. <https://doi.org/10.1016/j.ijpe.2013.07.023>

Zeithaml, V. A. (2000). Service quality, profitability, and the economic worth of customers: What we know and what we need to learn. *Journal of the Academy of Marketing Science*, 28(1), 67–85. <https://doi.org/10.1177/0092070300281007>

Zeglat, D., Aljaber, M., & Alrawabdeh, W. (2014). Understating the Impact of Employee Empowerment on Customer-Oriented Behavior. *Journal of Business Studies Quarterly*, 6(1), 55–67.

A DEA APPROACH FOR PERFORMANCE ASSESSMENT OF CALL CENTRE AGENTS

Viera Mendelová¹, Petra Strnáďová²

¹ Matej Bel University in Banská Bystrica, Faculty of Economics, Department of Quantitative Methods and Information Systems, Slovakia, ORCID: 0000-0002-4622-7433, viera.mendelova@umb.sk;

² Matej Bel University in Banská Bystrica, Faculty of Economics, Department of Language Communication in Business, Slovakia, ORCID: 0000-0002-4038-6177, petra.strnadova@umb.sk.

Abstract: *The paper focuses on a relatively new and prospective application of the data envelopment analysis (DEA) in the employee performance assessment. In the paper, a novel DEA approach is proposed for evaluating the performance of call centre agents, based on their relative efficiency. Since call centres handle a majority of customer-company interactions, performance of call centre agents largely influences the future success or failure of a company. To ensure the quality of customer service, permanent evaluation of call centre agents' performance is essential. The proposed DEA model consisting of two input variables (wage and working time) and five output variables (quick-answer calls proportion, customer satisfaction, net first contact resolution, call quality and inbound contact handle time) has been tested on 55 call centre agents working at the call centre of one of the largest telecommunications operators in the Slovak Republic. After measuring the performance of each agent, based on the DEA models, the call centre agents' performance was evaluated in the DEA matrix format. As a result, the call centre agents were divided into four groups: Stars, Cash Cows, Question Marks and Poor Dogs. Finally, based on the proposed approach, recommendations for call centre managers on how to improve or maintain the performance of each of these groups were drawn. The proposed approach provides a practical framework for call centre managers to assess the performance of the agents, and to plan and take steps to improve the quality of call centre services.*

Keywords: Performance appraisal, data envelopment analysis, call centre agents.

JEL Classification: M54, C60.

APA Style Citation: Mendelová, V., & Strnáďová, P. (2020). A DEA Approach for Performance Assessment of Call Centre Agents. *E&M Economics and Management*, 23(3), 173–190. <https://doi.org/10.15240/tul/001/2020-3-011>

Introduction

A call centre is, in general, an organizational unit of a company, which handles a huge volume of telephone calls, especially for taking orders and providing customer service. The origins of call centres date back to the 1960s and are linked to the UK-based Birmingham Press and Mail, which installed Private Automated Business Exchanges (PABX) to have agents dealing with the customer contacts. The call centres we know today started along with the invention of the Automated Call Distributor (ACD) technology, which uses algorithms to filter through calls, and allocate the right calls

to the right call centre agents, based on some pre-set rules.

As more and more companies are aware of the importance of retaining their customers, more attention is being paid to the Customer Relationship Management (CRM) system. As CRM has become the centre of companies' attention, call centres, which are at the forefront of the CRM strategy, are regarded as important communication channels between the company and its customers. It is generally believed that the attitude of the customers to the company is largely influenced by the interactions between the customers and the people in the company they get in contact with when addressing

their needs. Therefore, the call centre agents who have a direct contact with the company's customers play the key role in determining the final impression of the company the customers get. As a result, the performance of the call centre agents has a considerable impact on the overall performance of the company. If the call centre agents fail to sufficiently understand the customers' complaints and needs, the company may bear the serious consequence of losing the customers. On the other hand, if the customers are satisfied with the call centre agents who respond to their needs promptly and properly, the company may profit from the returning customers and even the new ones, because of positive references from the existing customers. This relationship of employees' performance to the company's performance is well-documented in the literature (Katzenbach & Smith, 1993; Kilduff et al., 2000; Higgs, 2005).

Companies should periodically assess the performance of each call centre agent, and use the information to improve the operations of their call centre. Therefore, performance appraisal (PA) of the call centre agents is an important part of the call centre management. In order to provide high quality service and to achieve customer satisfaction, call centre agents are commonly managed and monitored through a number of key performance indicators (KPIs). The evaluation of fulfilment of the individual KPIs usually requires setting the performance objectives and standards. They help to evaluate the individual KPIs by allowing for clear percentage of their fulfilment. In practice, several approaches to setting and evaluating the optimal target values for the KPIs are used. Beside the empirical or expert techniques, there is an increasingly popular option of benchmarking, i.e. comparison and identification of potential differences in the achieved results in relation to the industry competitors. The crucial problem of all these methods traditionally used in the PA of call centre agents is that aligning the high number of KPIs into a single composite indicator that covers the overall performance of a call centre agent is often quite challenging. As the pressure on call centre management to be more efficient increases, the call centre managers are forced to look for the most effective tools to evaluate call centre agent performance. It is quite essential to have such PA methods that allow for a wide range of KPIs to be taken into account and

provide relevant and comprehensive results related to the performance of call centre agents.

For this reason, especially in the recent years, new modern methods based on multi-criteria performance assessment have begun to emerge. The data envelopment analysis (DEA) represents one of the relatively frequently used methods for measuring technical efficiency of the decision-making units (DMUs). From the application point of view, DEA has usually been used in competitive benchmarking in order to evaluate efficiency of individual economic entities (DMUs) in relation to their competitors. However, another important perspective of using DEA in corporate governance has begun to crystallize recently. In this area, DEA has start to be presented as a tool of internal benchmarking where efficiency is assessed for sub-units within the DMU in question. In this context, several authors have taken advantage of this new application of DEA and applied DEA to the PA in different industries of economy. For example, Osman et al. (2011) proposed the DEA approach for the PA of nurses. The model was validated with 32 nurses working at an Intensive Care Unit (ICU) at one of the most recognized hospitals in Lebanon. Shirouyehzad et al. (2012) used DEA to evaluate employees' efficiency in a pipe company in Iran by using 55 employees as the sample. Tao (2012) combined the workforce scorecard and DEA to evaluate multi-department employee performance in a Chinese motor company. Zbrank (2013) applied DEA for the performance evaluation of 60 employees in a bakery company. Dugelová and Strenitzerová (2015) used DEA for performance evaluation of 12 employees in the international IT company in the Slovak Republic. Mahmudah and Lola (2018) estimated the efficiency of 102 employees in a Malaysian shipping company under profit sharing system, using a robust DEA approach. And finally, Najar et al. (2018) proposed the DEA matrix (DEAM) approach for the performance assessment of 30 nurses from the cardiology department of a hospital in Iran. Although there are several DEA applications to evaluate aggregate call centres performance (e.g. So, 2007; Abuelwafa, 2014), as far as we know, there is only one study (Abuelwafa, 2014) that applies DEA for the PA of call centre agents. Abuelwafa (2014) applied DEA to real three-month's aggregated performance data for 30 agents who work in different queues in the

same account of the call centre in the Middle East North Africa region. The data the author used consisted of one input, viz. queue service capacity target per hour, and three outputs, viz. (i) productivity (service capacity), (ii) quality, and (iii) punctuality (average of adherence and attendance). This study can be considered the first one, which has shown that the use of DEA in PA agents has its irrefutable advantages. However, to date there is no comprehensive methodology on how to apply DEA properly to assess call centre agents' performance.

As the use of DEA in PA is a relatively new aspect of its application and could be an effective and useful management tool for evaluation of call agents' performance as well, the main aim of this paper is to propose a DEA approach for the performance evaluation of call centre agents based on their relative efficiency. In the paper, the proposed DEA approach is validated with 55 live agents working at a call centre in one of the largest telecommunications operators in the Slovak Republic. It is anticipated that the methodology suggested herein may be recommended to the PA in similar sectors.

The paper organization is as follows. Section 1 gives background on call centre agents' performance assessment. In Section 2, a new proposed DEA methodology in the PA of call centre agents is clarified. Section 3 presents the results of the empirical analysis in which the proposed DEA methodology is applied to assess the performance of the inbound call centre agents working for one of the largest telecommunications operators in the Slovak Republic. The final section summarizes and concludes the paper.

1. Background

A call centre plays the key role in determining the satisfaction levels of the company's customers. It can be said that customers' satisfaction with the call centre services determines the customers' satisfaction with the company as a whole. Call centres can act as an in-house call centre established and run by the company in its headquarters, or an outsourced call centre run by an external company. In addition to this classification, call centre types are usually classified according to the type of calls they engage in. Call centres can be classified as (i) the inbound call centres where the customers call directly and require certain services, or (ii) the outbound call centres where the call

centre agents make a direct contact with the customers for the purpose of various marketing and business activities. For more details on development, characteristics and importance of call centres to the companies, refer to Anton (2000), Houlihan (2002), or Fielding (2003).

So as to guarantee high quality services and customer satisfaction, the call centre agents are guided and monitored by several KPIs. Anton (1997) suggested a group of 23 KPIs applicable in the call centres and classified them as operation-related, income-related, cost-related and service-quality-related indicators. Apart from that, the Customer Operation Performance Centre (COPC), an international call centre-related certificate authority, uses a total of 32 KPIs for the four domains: leadership/planning, process, people, and performance. The companies manage their call centres in like manner, i.e. with various KPIs, to improve the quality of service and to maximize customer satisfaction. Although many traditional quantitative and judgmental methods in the PA have been proposed (for more details see, e.g., Jafari et al., 2009; Armentrout, 1986; Arvey & Murphy, 1998), and call centre performance is a multi-dimensional problem, it is necessary to use more capable tools to help define overall performance on a single scale. One of the most commonly used techniques for performance measurement in call centres is benchmarking. Benchmarking enables quantification of the call centre performance, comparison of the call centre performance with the other call centres in industry, identification of the negative performance gaps, and definition of action needed in order to eliminate these gaps. One of the companies that provide information on benchmarks, scorecards and KPIs to the information technology and contact centre professionals worldwide is, for instance, MetricNet, LLC Company. MetricNet's benchmarking database is global and collects more than 3,700 benchmarks. Through them, MetricNet has identified nearly 80 industry best practices and 30 KPIs that companies around the world are using to achieve world-class performance.

However, this way of KPIs industry best practices comparison carries a risk of several limitations: (i) Performance comparison is usually conducted in the whole call centre (regardless the performance of the individual agents); (ii) Own gathering of the benchmarking values for KPIs is extremely time-consuming

and often even impossible, as the companies neither have to, nor want to provide internal information to the external subjects; (iii) Gathering of the benchmarking values for KPIs by the external companies (such as MetricNet) is often expensive as there are usually very strict financial conditions; (iv) Disregard of the specific conditions and character of the call centre, as mutual comparability in the industry can be insufficient; (v) Missing composite indicator that would speak of the call centre's overall achieved performance (simple comparison of the multiplex KPIs groups with the benchmarks does not necessarily bring clear results); (vi) Regard only for the output performance criteria, with no direct link to the input characteristics that may considerably affect the call centre agents' performance.

Apparently, from the foregoing it follows that the new methods for improvement of the call centre agents' evaluation are necessary. One option for elimination of the above-mentioned shortcomings of the traditional PA methods is the application of DEA. The main aim of this paper is to propose such DEA approach that would, in addition to the output performance indicators, also take the input characteristics of the individual call center agents into account, and thus provide a composite indicator of their overall performance.

2. Methodology: the Proposed DEA Approach

DEA is based on Farrell's methodology (see Farrell, 1957), which rests on a nonparametric construction of the production possibility frontier (PPF) through linear programming. The main idea of DEA is to determine the efficiency of the DMUs, based on their distance from the constructed PPF. In terms of methodology, the process of DEA application for the purpose of measuring efficiency in any DMUs group consists of the following crucial footsteps: (i) definition and selection of the DMUs, (ii) definition and selection of appropriate inputs and outputs for the analysis, (iii) selection and formulation of the most appropriate DEA model, and (iv) DEA results presentation.

2.1 Definition and Selection of the DMUs

In DEA, homogeneous DMUs with an ultimate goal of improving their performance have to

be used. A homogeneous set of the DMUs can be obtained by considering the following two main criteria (Ozbek et al., 2009): (i) the DMUs should be performing the same tasks with similar objectives, and (ii) the input-output variables characterizing the process of the DMUs in the data set should be identical, except for the differences in their magnitude or values. It follows that to attain a set of homogeneous DMUs for DEA, it is essential that the agents to be compared perform similar activities.

2.2 Identification of the Inputs and Outputs of Call Centre Agents' Activity

The basis for the application of DEA in the PA of call centre agents is that each agent can be seen as a DMU, which transforms a set of inputs into a set of outputs. On the grounds of the relationship between inputs and outputs, DEA could identify inefficient agents and suggest options to eliminate their inefficiencies. The group of inputs may include: (i) the socio-demographic indicators, which define physical and mental abilities of an agent, such as age, education, qualification, professional experience, talents, etc, and/or (ii) the economic indicators like wage, training hours, working hours, overtime hours, agent schedule adherence, etc. The group of outputs characteristic for the agent's work activity can be described with either (i) handle time indicators, e.g. inbound/outbound contact handle time, talk time, after call work time, etc, (ii) quality indicators, e.g. customer satisfaction, net first contact resolution rate, call quality, quick-answer calls proportion, successful calls proportion, etc and/or (iii) the economic indicators like the number of newly-acquired customers, the number of newly-concluded contracts, value of newly-concluded contracts, etc.

In addition to these input and output variables, which are directly related to the agents' activity, in practice there could be other factors that are beyond the agents' own control but have a significant impact on their activity. In the DEA terminology, these factors are often referred to as environmental variables, which express the environmental impact on the DMU and characterize the environment in which the DMU operates. An example of the environmental variables in a call centre can be (i) work environment indicators, e.g.

physical environment conditions (workplace noise levels, lighting, etc), or social working conditions (number of people in the office, the office size, etc), or (ii) external factors such as the number of inbound contacts, etc. DEA provides several approaches that enable taking the impact of the environmental variables in efficiency measurement into account.

In this paper, the proposed DEA approach is implemented in one of the largest telecommunications operators in the Slovak Republic. As an integrated telecommunications operator, it provides multiple services through its mobile and fixed networks. Live agents help clients with their requirements and provide information about the company's products and services. To assess the performance of the call centre and the individual live agents, the company regularly sets organization-wide goals and uses metrics to follow up their

achievement through particular objectives. On a monthly basis, the company monitors a set of KPIs that are used to judge the live agents' performance. Out of a relatively large number of monitored KPIs, a total of 10 most important indicators, based on an expert assessment of the company managers, were selected. These were then classified into a set of inputs and outputs according to their character. Tab. 1 presents input and output variables with their notations and definitions. The data characterizing the activities of 55 live agents in 2017, were provided to the authors by the company and are available on request. Tab. 2 presents the summary statistics of the considered variables.

The *W*, *AATH*, *WT*, and *AO* variables represent the factors determining the results of the agent's activity. Since their minimization should be considered in terms of improving

Tab. 1: All considered variables

Variable	Measurement unit	Notation	Definition
INPUTS			
Wage	EUR	W	The average monthly wage of the agent
Annual agent training hours	Hours	AATH	The average number of training hours (including classroom, self-study, etc) that the agent receives on an annual basis
Working time	Hours	WT	The average monthly number of hours at work (excluding break and lunch time)
Agent occupancy	%	AO	The percentage of time that the agent spends on handling incoming contacts, divided by the total number of hours at work (excluding break and lunch time)
Inbound contacts	Number	IC	The average monthly incoming call volume
OUTPUTS			
Quick-answer calls proportion	%	QACP	The percentage of all incoming calls that are answered within 30 seconds
Customer satisfaction	%	CS	The percentage of customers who are either satisfied or very satisfied with the agent's work
Net first contact resolution	%	NFCR	The percentage of calls that are resolved on the first interaction with the customer divided by all calls that are potentially resolvable on first contact
Call quality	%	CQ	The average call quality rating by internal expert (on a scale of 0% [the worst] to 100% [the best])
Inbound contact handle time	Seconds	ICHT	The average time that the agent spends on the contact, including talk time, wrap time, and after call work time

Source: own

efficiency, they are included in the group of inputs. The input variable IC expressing the average monthly incoming call volume represents environmental variable, which is beyond the agents' control, but which has a significant impact on agents' activity. On the other hand, the QACP, CS, NFCP, CQ and ICHT variables cover the results of the agents' activity represented by the quality of the calls made. Since their maximization should be considered in terms of improving efficiency (except for the ICHT variable), they are included in the group of outputs. The ICHT variable has a special position in the output group. This variable has the character of undesirable output that needs to be reduced in order to improve efficiency.

When selecting an appropriate combination of inputs and outputs for DEA, it is necessary to consider the following main aspects: (i) suitability of variables with respect to the economic definition of efficiency; (ii) meeting the condition of the maximum number of inputs and outputs in relation to the number of DMUs, and (iii) uniqueness of information contained in inputs and outputs underlined by a strong relationship between inputs and outputs, i.e. the outputs should be generated directly by the respective inputs. In accordance with the condition stated by Cooper et al. (2007, p. 116), i.e. that the number of DMUs needs to be at

least three times greater than the number of inputs and outputs, in the following efficiency evaluation the agents allow for maximum of 18 input and output variables. Since, as Tab. 1 shows, we consider 10 variables, this condition is met sufficiently.

The WT and AO inputs characterize the time-consuming aspect of the agents' activity. From a theoretical point of view, it can be assumed that working time increase will cause the agent to handle more calls. As a result, the agent should gain more experience, which in turn will help them improve the quality of their work. This assumption is also confirmed by the examined correlations (see Tab. 3) where the WT variable manifests positive linear correlations with the QACP, CS and NFCP outputs, and negative linear correlations with the ICHT output. On the other hand, an increase in the AO variable does not necessarily lead to an increase in the outputs considered. This is also confirmed by the correlation assessment (Tab. 3), where the AO variable records negative linear correlations with the NFCP and CQ outputs. If two agents use the same quantity of inputs to produce the same quantity of outputs and only the AO of the first agent is lower than the AO of the second agent, the first one cannot be said to be more efficient as it is clear that a smaller part of total working time was devoted to the main work

Tab. 2: Summary statistics of considered variables

	Average	Median	Max ^a	Min ^a	Stdev
INPUTS					
W	691.2	706.0	888.0 (A37, A38)	451.0 (A41)	132.3
AATH	17.3	11.0	122.0 (A11)	0 (A19, A22, A23, A33, A34, A35, A38, A44, A55)	21.1
WT	123.9	121.0	165.0 (A31)	77.0 (A16, A51)	27.0
AO	48.2	48.3	67.0 (A15)	31.5 (A36)	8.1
IC	427.0	347.0	1533.0 (A51)	54.0 (A13)	319.7
OUTPUTS					
QACP	43.2	44.1	78.1 (A40)	16.2 (A41)	14.6
CS	36.5	39.3	64.6 (A40)	12.1 (A8)	12.9
NFCP	24.4	23.4	51.9 (A11)	10.4 (A12)	9.4
CQ	39.0	37.2	81.6 (A11)	11.7 (A34)	16.1
ICHT	145.2	167.1	277.8 (A51)	12.4 (A40)	63.6

Source: own

Note: ^a The symbol in parentheses represents the ID of the corresponding agent.

activity. The AO variable aggregates two factors: the working time factor and the external factor of the inbound calls volume. In order to take both factors into account and avoid duplication, from the WT, AO and IC variables we select the WT variable which characterizes the working time factor, and the IC variable which expresses the external factor of the incoming calls volume.

As Tab. 3 shows, in the case of the AATH variable, the assumption of dependency of outputs on this input is disrupted for three outputs (QACP, CS and CHT). The broad range of development and training activities that the

company provides to its employees in order to diversify and expand knowledge and skills of the agents does not produce a positive result for all outputs in terms of improving the quality of the agents' activity. This should be a signal to the company to review the ways and means of delivering training activities so that they are, as much as possible, involved in improving the quality of services provided. However, since the assumption of direct dependence of outputs on this input is not met, the AATH variable is not further considered in our analysis.

Tab. 3: Correlations between considered variables

		INPUTS					OUTPUTS				
		W	AATH	WT	AO	IC	QACP	CS	NFCP	CQ	ICHT
INPUTS	W	1									
	AATH	-0.2331	1								
	WT	-0.2034	-0.2921	1							
	AO	-0.2031	-0.1590	-0.0369	1						
	IC	-0.0168	0.2809	-0.0200	-0.3174	1					
OUTPUTS	QACP	0.1980	-0.2177	0.4944	0.6771	-0.2237	1				
	CS	0.3562	-0.1643	0.0096	0.8053	-0.2704	0.8669	1			
	NFCP	0.3634	0.6171	0.1604	-0.1112	0.1821	0.3962	0.3131	1		
	CQ	0.5573	0.5952	-0.0799	-0.1781	0.1861	0.2719	0.3063	0.9554	1	
	ICHT	-0.0447	0.1919	-0.8546	-0.3072	0.0988	-0.8581	-0.4962	-0.4429	-0.2360	1

Source: own

Based on all the aforementioned arguments, the reduced group of inputs (W, WT and IC) is considered further. This selection ensures that the group of the outputs is directly generated by the group of the selected inputs.

Moreover, from the managerial point of view, it is a well-known fact that the individual KPIs do not have an equal importance in terms of the agents' activity assessment. It is generally believed that KPIs characterizing customer service, customer satisfaction and level of service are considered to be most important (see, e.g., Robinson & Morley, 2006). In the analysed call centre, it holds that in the group of inputs the wage (W) is perceived as approximately two-times more significant than working time (WT). In the group of outputs, the evaluation of calls by the customers (CS) is considered most important, the proportion of

calls that were resolved on the first interaction with the customer (NFCR) and evaluation of the calls by the internal evaluator (CQ) are of approximately equal importance, the proportion of quickly answered calls (QACP) and the handle time (ICHT) are also almost equally important. The CS indicator has about twice as high importance as the NFCR and CQ indicators, and about three-times higher importance than QACP and ICHT indicators.

2.3 The DEA Model Formulation

After the selection of the inputs and outputs, it is necessary to choose and formulate the most convenient DEA model in relation to the actual problem. In identifying the most appropriate DEA model, the following DEA classification criteria may be used. The first one represents the perspective of the inefficiency form that can

be identified with DEA. The second criterion is return to scale assumption, and the third one is the choice of DEA model orientation, or the choice of efficiency aspect that is to be quantified with DEA. The selection of DEA model should especially result from the formulated analysis objective and the nature of the inputs and outputs considered.

In terms of the first criterion, it is possible to use either (i) radial models (e.g. the CCR model by Charnes et al., 1978, or the BCC model by Banker et al., 1984), (ii) non-radial models (e. g. the additive model by Charnes et al., 1985; or the SBM model by Tone, 2001), or (iii) hybrid models. Radial models consider the radial or proportional nature of the variables under consideration and quantify weak Farrell efficiency. Non-radial models consider the non-radial or non-proportional nature of the variables considered and quantify strong Pareto-Koopmans efficiency. Hybrid models are applicable in the cases when in the set of inputs (outputs) there are the indicators with both radial and non-radial character. In our analysis, due to the prevailing non-radial nature of the variables considered (inputs/outputs can be changed independently of the other inputs/ outputs), non-radial models represent a more appropriate and comprehensive alternative to radial or hybrid models.

In terms of the second criterion, it is necessary to make a choice of the assumed returns to scale. In general, the constant returns to scale (CRS) or the variable returns to scale (VRS) can be assumed. Overall inefficiency that an agent might show could be caused by an inefficient operation of an agent himself, i.e. pure inefficiency, or by the disadvantageous conditions under which an agent is operating, i.e. scale inefficiency. While the pure technical efficiency reveals an ability of an agent to achieve the PPF in the short term, the scale efficiency indicates an ability of an agent to adjust the scale of his operations in the long term. It follows from the foregoing that if only pure efficiency needs to be evaluated, the VRS assumption should be selected, and if overall efficiency needs to be evaluated, the CRS assumption should be preferred. Here it should be noted that the assumption of CRS is appropriate only when all agents work at their optimal level. In reality, however, some factors like workload, stress and pressure can prevent the agents from working at their

optimal level. As for elimination of the influence of scale inefficiency for the purposes of the agents' efficiency measurement, it is more appropriate to use the VRS assumption. The CRS assumption can be used if the goal is to measure long-term efficiency (when the short-term efficiency variances, are not permitted as a result of the factors mentioned above), while the VRS assumption is more appropriate for the short-term efficiency measurements (when the potential negative influence of the previously mentioned factors on the efficiency achieved is taken into account). In our analysis, we consider both the CRS and VRS assumptions, as our effort is to evaluate and compare the efficiency of call centre agents both in the long and short terms.

The third criterion requires the choice of model orientation. We can use either (i) the input-oriented model when, in terms of efficiency increase, it is more appropriate to consider the potential decrease of the used input level at the given output level, (ii) the output-oriented model when, in terms of efficiency increase, it is more appropriate to consider the potential increase of the produced output level at the given input level, or (iii) the non-oriented model which allows simultaneous decrease of the inputs used and increase of the outputs achieved. It is obvious that while the oriented models reveal only the input or output efficiency, the non-oriented models aggregate both efficiency aspects and quantify overall efficiency. Since the goal in our analysis is to assess the overall performance of the call centre agents and identify all aspects of their efficiency, the non-oriented model is used in the analysis. As will be shown later, also the non-oriented model allows us to quantify the input efficiency (the ability of the agents to use optimal quantities of inputs with respect to the outputs achieved), and the output efficiency (the ability of the agents to achieve the optimum output levels with respect to the inputs used) separately. While the input efficiency measurement will enable identification of those agents who waste some inputs (agents with excess inputs), the output efficiency measurement will enable identification of those agents for whom there is room for improvement in the outputs achieved (agents with shortfalls in outputs).

Last but not least, in selecting a DEA model, it is necessary to take the specific characteristics of the considered variables

into account. Although the input IC variable affects the level of outputs achieved, the agents themselves do not have a direct impact on its level. This variable represents an external environmental variable that can be included in the DEA efficiency assessment in the form of an uncontrollable input variable. Moreover, it is necessary to take under advisement that the values of some inputs/outputs cannot be changed at discretion. Given the nature of the inputs considered (W and WT), we assume that their level can be changed without any limitation. The wage reduction below the minimum wage level as stipulated in the national legislation is possible, for instance, by changing the full-time employment contract of an agent to an "agreement on work performance" (service agreement), where the lower limit for wage or working time is not defined in the Slovak legislation. On the side of the outputs, however, there are some limitations of their possible changes. The QACP, CS, NFCP and CQ variables are expressed as a percentage, so the upper bound for the projected values of these variables is 100%. As stated before, the ICHT variable has a special position in the output group due to its undesirable output character. Moreover, even this variable cannot be reduced without limitation. There is certain minimum duration for each call. For the incoming calls, the agents have to introduce themselves and the company they represent, listen to the caller's request, and then provide a relevant answer. To take these variable constraints into account, the DEA models with bounded variables are commonly applied. Finally, it is necessary to consider the different importance of the individual inputs and outputs. For this purpose, the weighted forms of the DEA models could be used.

All aforementioned requirements are satisfied by using the non-oriented weighted

Slack-Based Measure model by Tone (2001) with non-controllable input variables, and bounded and undesirable output variables, hereinafter referred to as the WSBM model with no explicit emphasis on the fact that it is adjusted to consider specific variables. The general mathematical formulation of the WSBM model under the CRS assumption (WSBM-C model) can be constructed in the following exposition.

Let us consider the case of n DMUs. Let us assume that each DMU i , $i \in (1, \dots, n)$, transforms m inputs represented by the vector $\mathbf{x}_i = (x_{1i}, \dots, x_{mi})' \in R^m$ into s outputs represented by the vector $\mathbf{y}_i = (y_{1i}, \dots, y_{si})' \in R^s$. The group of m inputs of DMU i consists of a subset of m_1 controllable inputs represented by the vector $\mathbf{x}_i^C = (x_{1i}^C, \dots, x_{m_1i}^C)' \in R^{m_1}$ and a subset of m_2 non-controllable inputs represented by the vector $\mathbf{x}_i^{NC} = (x_{1i}^{NC}, \dots, x_{m_2i}^{NC})' \in R^{m_2}$, with $m_1 + m_2 = m$. The group of s outputs of DMU i consists of two subsets: a subset of s_1 desirable outputs represented by the vector $\mathbf{y}_i^D = (y_{1i}^D, \dots, y_{s_1i}^D)' \in R^{s_1}$ and a subset of s_2 undesirable outputs represented by the vector $\mathbf{y}_i^{UD} = (y_{1i}^{UD}, \dots, y_{s_2i}^{UD})' \in R^{s_2}$. Obviously, $s_1 + s_2 = s$. In order to take the differences in importance of the individual indicators into account, we shall establish normalized weights of relative importance for controllable inputs $\mathbf{w}^C = (w_1^C, \dots, w_{m_1}^C)'$, $\sum_{j=1}^{m_1} w_j^C = m_1$ and normalized weights of relative importance for desirable outputs $\mathbf{w}^D = (w_1^D, \dots, w_{s_1}^D)'$ and undesirable outputs $\mathbf{w}^{UD} = (w_1^{UD}, \dots, w_{s_2}^{UD})'$, with $\sum_{r=1}^{s_1} w_r^D + \sum_{r=1}^{s_2} w_r^{UD} = s_1 + s_2$. For the given DMU i , $i \in (1, \dots, n)$, let the vectors $\mathbf{u}_i^D = (u_{1i}^D, \dots, u_{s_1i}^D)' \in R^{s_1}$ and $\mathbf{l}_i^{UD} = (l_{1i}^{UD}, \dots, l_{s_2i}^{UD})' \in R^{s_2}$ represent the upper and the lower bounds of desirable and undesirable outputs, respectively. Based on this distinction, the optimization task of the WSBM-C model as specified before for each DMU o , $o \in (1, \dots, n)$ is formulated in (1):

$$\min_{s_{jo}^C, s_{ro}^D, s_{ro}^{UD}, \lambda_i} \rho = \frac{1 - \frac{1}{m_1} \sum_{j=1}^{m_1} w_j^C \frac{s_{jo}^C}{x_{jo}^C}}{1 + \frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} w_r^D \frac{s_{ro}^D}{y_{ro}^D} + \sum_{r=1}^{s_2} w_r^{UD} \frac{s_{ro}^{UD}}{y_{ro}^{UD}} \right)}$$

subject to

$$\begin{aligned} s_{jo}^C &= x_{jo}^C - \sum_{i=1}^n x_{ji}^C \lambda_i, & j &= 1, \dots, m_1, \\ x_{jo}^{NC} &= \sum_{i=1}^n x_{ji}^{NC} \lambda_i, & j &= 1, \dots, m_2, \\ s_{ro}^D &= \sum_{i=1}^n y_{ri}^D \lambda_i - y_{ro}^D, & r &= 1, \dots, s_1, \\ s_{ro}^{UD} &= y_{ro}^{UD} - \sum_{i=1}^n y_{ri}^{UD} \lambda_i, & r &= 1, \dots, s_2, \\ u_{ro}^D &\geq \sum_{i=1}^n y_{ri}^D \lambda_i, & r &= 1, \dots, s_1, \\ l_{ro}^{UD} &\leq \sum_{i=1}^n y_{ri}^{UD} \lambda_i, & r &= 1, \dots, s_2, \\ s_{jo}^C &\geq 0, s_{ro}^D \geq 0, s_{ro}^{UD} \geq 0, \lambda_i \geq 0, \end{aligned} \tag{1}$$

where λ_i is an intensity variable connected with DMU i , $\mathbf{s}_o^C = (s_{1o}^C, \dots, s_{s_1o}^C)'$ is a vector of

potential slacks (excesses) of the controllable inputs, $\mathbf{s}_o^D = (s_{1o}^D, \dots, s_{s_2o}^D)'$ is a vector of potential

slacks (shortfalls) of the desirable outputs, $\mathbf{s}_o^{UD} = (s_{1o}^{UD}, \dots, s_{s_o}^{UD})'$ is a vector of potential slacks (excesses) of the undesirable outputs, and ρ is a WSBM efficiency score taking the values in the interval (0,1]. The optimization task of the WSBM model under VRS assumption (WSBM-V model) takes the form of (1) with an additional constraining condition $\sum_{i=1}^n \lambda_i = 1$.

Let an optimal solution for the program (1) be $(\rho^*, \mathbf{s}_o^{C*}, \mathbf{s}_o^{D*}, \mathbf{s}_o^{UD*}, \boldsymbol{\lambda}^*)$. It is obvious that the DMU o ($\mathbf{x}_o^C, \mathbf{x}_o^{NC}, \mathbf{y}_o^D, \mathbf{y}_o^{UD}$) may be called WSBM-efficient if and only if $\rho^* = 1$, i.e. $\mathbf{s}_o^{C*} = \mathbf{0}, \mathbf{s}_o^{D*} = \mathbf{0}$ and $\mathbf{s}_o^{UD*} = \mathbf{0}$. A DMU that does not meet this requirement may be termed as WSBM-inefficient.

For a WSBM-inefficient DMU, i.e. a DMU with $\rho^* < 1$, let a vector of the projected controllable

inputs be denoted by $\hat{\mathbf{x}}_o^C = (\hat{x}_{1o}^C, \dots, \hat{x}_{m_1o}^C)'$, a vector of the projected desirable outputs be denoted by $\hat{\mathbf{y}}_o^D = (\hat{y}_{1o}^D, \dots, \hat{y}_{s_1o}^D)'$, and a vector of projected undesirable outputs be $\hat{\mathbf{y}}_o^{UD} = (\hat{y}_{1o}^{UD}, \dots, \hat{y}_{s_2o}^{UD})'$. The WSBM projection is given by (2):

$$\begin{aligned} \hat{\mathbf{x}}_o^C &= \mathbf{x}_o^C - \mathbf{s}_o^{C*}, \\ \hat{\mathbf{y}}_o^D &= \mathbf{y}_o^D + \mathbf{s}_o^{D*}, \\ \hat{\mathbf{y}}_o^{UD} &= \mathbf{y}_o^{UD} - \mathbf{s}_o^{UD*}. \end{aligned} \tag{2}$$

Using the optimal solution $(\rho^*, \mathbf{s}_o^{C*}, \mathbf{s}_o^{D*}, \mathbf{s}_o^{UD*}, \boldsymbol{\lambda}^*)$, the WSBM efficiency score ρ^* can be factorized into two factors, the input efficiency score ρ_1^* and the output efficiency score ρ_0^* , using the following decomposition:

$$\rho^* = \rho_1^* \times \rho_0^*, \tag{3}$$

where

$$\rho_1^* = 1 - \frac{1}{m_1} \sum_{j=1}^{m_1} w_j^C \frac{s_{jo}^{C*}}{x_{jo}^C} \quad \text{and} \quad \rho_0^* = 1 / \left[1 + \frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} w_r^D \frac{s_{ro}^{D*}}{y_{ro}^D} + \sum_{r=1}^{s_2} w_r^{UD} \frac{s_{ro}^{UD*}}{y_{ro}^{UD}} \right) \right].$$

This expression indicates that WSBM inefficiency, i.e. $\rho^* < 1$, is a result of the existence of input inefficiency $\rho_1^* < 1$ and/or output inefficiency $\rho_0^* < 1$.

The general mathematical formulation of the WSBM model (1) can be naturally adjusted to specific cases. In terms of measuring the efficiency of the 55 call centre agents, the vector of inputs for the given agent $i, i \in (1, \dots, 55)$, consists of two controllable inputs included in $\mathbf{x}_i^C = (x_{1i}^C, x_{2i}^C)'$, where x_{1i}^C denotes the variable W and x_{2i}^C stands for the variable WT, and one uncontrollable input x_{1i}^{NC} representing the variable IC. The vector of outputs consists of four desirable outputs QACP, CS, NFPC and CQ denoted by $\mathbf{y}_i^D = (y_{1i}^D, y_{4i}^D)'$ and one undesirable output ICHT denoted by y_{1i}^{UD} . Moreover, since the variables QACP, CS, NFPC and CQ are expressed as a percentage, the upper bound for the projected values of these variables was naturally set at 100%, i.e. $u_{ro}^D = 100\%$. In the case of undesirable output ICHT, the model (1) considers its minimization. However, as mentioned earlier, it cannot be minimized without any restrictions. It is unimaginable for

the agent to be able to reduce incoming contact handle time to 0 seconds. Therefore, the lower bound for this output was set at 10 seconds, i.e. $l_{1o}^{UD} = 10$. This threshold is the lowest possible duration of the shortest call. In conclusion, the above mentioned assumptions regarding the relative importance of the individual KPIs correspond with the weights of the controllable inputs $\mathbf{w}^C = (4/3, 2/3)'$ and the weights of relative importance for the desirable outputs $\mathbf{w}^D = (5/8, 15/8, 15/16, 15/16)'$ and an undesirable output $w^{UD} = 5/8$.

2.4 The DEA Results Presentation

In order to analyse the results taken from the WSBM-C and WSBM-V models, a DEA Matrix (DEAM) based on the approach presented by Osman et al. (2011) or Najar et al. (2018) is used. Using the decomposition (3), the WSBM-C efficiency score is disentangled into the input efficiency score and the output efficiency score. While input inefficiency is observed in those agents who waste some inputs (agents with nonzero excesses in some inputs), output inefficiency is observed in those agents where

some scope for improving the quality of the outputs achieved is possible (agents with nonzero shortfalls in some desirable outputs, or nonzero excesses in undesirable output). By comparing the resulting input efficiency score and output efficiency score, it is possible to evaluate the strengths and weaknesses of the individual agents in more detail, as well as to identify the groups of agents to which the same form of personnel policy can be applied. To this end, a certain threshold value can be set for both efficiency scores to separate the low-efficient agents (with a score less than the threshold value) from the high-efficient agents (with a score higher than the threshold value). Then, according to their joint efficiency evaluation, the agents are grouped into four groups similar to the ones observed in the BCG matrix (Hedley, 1976): *Stars*; *Cash Cows*; *Question Marks* and *Poor Dogs*. *Stars group* is formed of those agents that achieve relatively high input efficiency and relatively high output efficiency. *Cash Cows group* is formed of those agents that have some unused inputs, but the results of their activity are relatively satisfying. *Question Marks group* includes those agents that achieve relatively high input efficiency but relatively low output efficiency. The agents that achieve relatively low input inefficiency, as well as relatively low output inefficiency, are included in the last *Poor Dogs group*.

Because the WSBM-C model is based on the CRS assumption, it is relatively strict in terms of identifying the efficient agents. Its results can be seen as the overall efficiency assessment in the long term. The CRS assumption presupposes that all agents work at their optimum level. However, this may not be always possible in the short term, due to the influence of the external factors such as workload, stress and pressure. To take the impact of the above-mentioned external factors into account, the WSBM-V model should be applied. By comparing the WSBM-C efficiency score to the WSBM-V efficiency score, managers could acquire further useful information. Also, in this case it is necessary to set a certain threshold value for both the efficiency scores to separate the low-efficient agents from the high-efficient ones. According to their efficiency evaluation based on the WSBM-C and WSBM-V models, the agents could be also divided into four groups: *Stars*; *Cash Cows*; *Question Marks* and *Poor Dogs*. *Stars group* consists of the agents who

achieve relatively high performance both in the short- and long-term. *Poor Dogs group* includes the agents with relatively low performance in both the short- and long-term. *Cash Cows group* is formed of those agents that achieve relatively high performance in the long-term, but their performance in the short-term is relatively low. For these agents, there is a short-term fluctuation in efficiency due to, for instance, the impact of the external factors. And finally, *Question Marks group* is made up of those agents who achieve relatively high performance in the short-term, but their performance in the long-term is relatively low. The reason that could cause them to be inefficient in the long term could be just the effect of the external factors such as work stress and exhaustion, or temporary (health or social) indisposition.

3. Results

Based on the inputs and outputs considered, the WSBM-C and WSBM-V models were solved. The summary comparison of the results of these models is presented in Tab. 4, and the final results of the WSBM-C model for inefficient call centre agents are displayed in Tab. 5.

The results of the WSBM-C model indicate 19 agents achieving full efficiency (the WSBM-C efficiency score equal to 1) and 36 agents achieving inefficiency (the WSBM-C efficiency score less than 1). The average efficiency score of 0.726 means that the average call centre agent shows almost 72.6% of the best agents' performance. The least efficient agent A30 achieves only 29.9% efficiency of the agents with the maximum efficiency. The agent A30 can achieve full efficiency by having his/her wage (W), working time (WT) and incoming call handle time (ICHT) reduced by 43.60%, 52.30%, and 31.39%, respectively, and by increasing customer satisfaction (CS), net first contact proportion (NFCP) and call quality (CQ) by 57.65%, 126.59% and 159.47%, respectively.

From the call centre point of view, the most significant changes need to be made on the output side (for three outputs an average change of over 44% is needed). For up to 36 agents, the need to reduce the ICHT output is identified. Each inefficient agent has to reduce incoming call handle time by almost 50% on average. It follows that the main weakness of the agents in the monitored call centre are relatively long-lasting calls. On the other

Tab. 4: Results of the models used, descriptive statistics

	Average	Min	Stdev	Number of efficient agents	Number of inefficient agents	Efficient agents
WSBM-C model	0.726	0.299	0.240	19	36	A1, A2, A5, A11, A13, A15, A16, A17, A19, A20, A24, A28, A31, A36, A40, A43, A46, A51, A53
WSBM-V model	0.794	0.312	0.227	26	29	A1, A2, A4, A5, A9, A11, A13, A15, A16, A17, A19, A20, A21, A24, A28, A31, A36, A40, A41, A43, A46, A48, A49, A51, A52, A53

Source: own

hand, the agents attain a relatively high level of customer satisfaction. Although the need for increase of the CQ variable is identified in up to 20 agents, the rate of changes needed is not too significant. Each inefficient agent has to increase customer satisfaction by only 15.16% on average. The WSBM-C model also provides a reference set, i.e. the set of agents who are the efficiency benchmarks ($\lambda_i^* > 0$) for the inefficient agents. As Tab. 5 shows, the agent A40 is most often referred to as a reference set and is considered a benchmark for up to 23 inefficient agents.

Furthermore, to compare the input and output efficiency of the individual agents, we grouped the agents based on the DEAM framework to determine their performance. Fig. 1 illustrates the input-output-efficiency results with the same threshold value of 0.75 for both efficiency scores. According to the agents' joint efficiency evaluation (Tab. 5), they are divided into four groups based on the relative efficiency scores: (1) *Stars* (both efficiency scores are higher than 0.75); (2) *Cash Cows* (the input efficiency score is less than or equal to 0.75, and the output efficiency score is higher than 0.75); (3) *Question Marks* (the input efficiency score is higher than 0.75 and the output efficiency score is less than or equal to 0.75); and (4) *Poor Dogs* (both efficiency scores are less than or equal to 0.75). *Stars group* is formed of those agents that achieve relatively high input efficiency, i.e. in terms of quality, they have a relatively low input (W and WT) and relatively high output efficiency; in view of the inputs used, their activity is of relatively high quality. *Cash Cows*

group is formed of those agents that have some unused inputs (relatively high wages and long working time), but the quality of their activity is relatively high. Most such agents included in this group have been in their jobs for a relatively long time, have a level of quality gained from years of experience, or various training sessions, but their wages and working time are relatively high compared to the other younger colleagues. It would be rather risky to focus on reducing costs (wages and working time) in this group of agents. The pressure to reduce the costs of these agents could be counterproductive and demotivating not only for the agents in question, but also for the other agents. *Question Marks group* includes those agents that are of relatively low cost and relatively poor quality as well. These agents achieve relatively high input efficiency, i.e. with regard to the achieved quality, they use relatively low inputs, but also relatively low output efficiency. So, with regard to the inputs used they achieve relatively low quality. As to this group, it would be advisable that the management focus on supporting the improvement of the agents' performance quality through various training courses, e.g. on job knowledge, communication, etc. Relatively high-cost and low-quality agents are included in the last *Poor Dogs group*. It is up to the management to decide whether and how these agents should be motivated to improve their performance. As can be seen in Fig. 1, 32 agents (58.2%) are in the *Star group*, 11 agents (20%) in the *Cash Cows group*, 7 agents (12.7%) in the *Question Mark group*, and 5 agents (9.1%) in the *Poor Dogs group*.

Tab. 5: Results of the WSBM-C model – Part 1

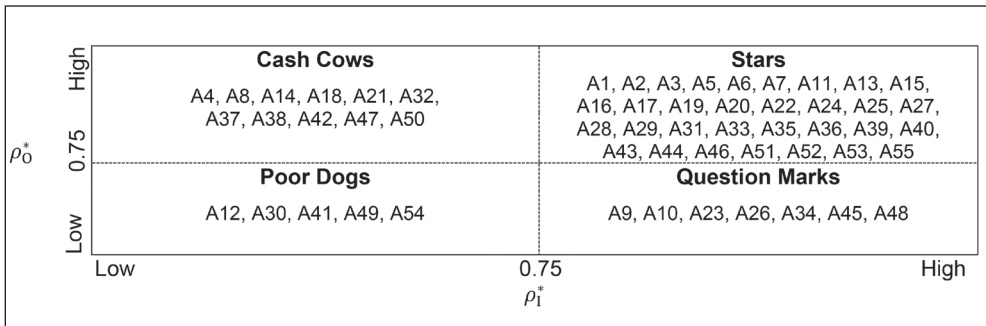
Agent ID	ρ^*	ρ_i^*	Excesses (in %)		ρ_0^*	Shortfalls (in %)				Excess (in %)	Reference set
			W	WT		QACP	CS	NFCP	CQ			ICHT
A3	0.746	0.837	24.45	0	0.892	6.58	0	30.66	17.20	18.91	A13, A17, A46
A4	0.648	0.729	40.68	0	0.889	21.57	0	19.53	0	49.24	A11, A17, A40, A46
A6	0.790	0.978	0	6.53	0.808	26.63	36.70	0.19	0	53.15	A11, A17, A40
A7	0.687	0.881	9.32	17.13	0.780	24.28	60.48	0	0	20.08	A2, A13, A40
A8	0.315	0.397	59.90	61.04	0.793	4.84	46.08	2.20	0	63.07	A11, A17
A9	0.718	0.973	0	8.24	0.739	1.68	0	57.23	89.79	60.77	A11, A15, A40
A10	0.581	0.848	4.73	36.06	0.685	0	27.39	65.34	95.46	44.05	A11, A40
A12	0.328	0.511	50.00	46.65	0.641	0	16.22	123.16	113.13	44.93	A11, A17
A14	0.449	0.597	42.81	35.16	0.751	2.77	0	71.18	58.95	66.97	A11, A40
A18	0.566	0.747	20.97	33.98	0.757	0	12.08	34.80	53.86	87.35	A15, A40
A21	0.412	0.521	54.01	35.62	0.791	13.01	0	60.48	33.56	56.81	A11, A17
A22	0.684	0.774	25.85	15.97	0.883	2.83	4.33	6.00	0	80.84	A13, A40
A23	0.561	0.768	32.68	4.30	0.730	22.85	0	75.10	46.00	91.05	A11, A40
A25	0.701	0.920	12.02	0	0.763	7.87	0	79.32	62.84	27.99	A11, A40, A46
A26	0.386	0.765	20.06	30.42	0.504	0	18.91	212.09	272.77	2.56	A11, A17
A27	0.920	0.994	0	1.88	0.926	5.97	7.42	0	0	35.76	A2, A13, A17, A40
A29	0.742	0.794	22.51	16.63	0.934	0	2.66	3.86	0	42.63	A13, A17, A40
A30	0.299	0.535	43.60	52.30	0.558	0	57.65	126.59	159.47	31.39	A11, A17
A32	0.389	0.439	59.38	49.59	0.886	4.26	0	13.54	0	77.89	A11, A17, A40
A33	0.843	0.890	16.51	0	0.947	3.06	0	10.79	3.25	20.37	A13, A15, A46
A34	0.461	0.865	0	40.55	0.533	0	34.71	119.61	259.64	28.62	A15, A17, A40
A35	0.723	0.826	17.68	16.95	0.876	0	6.64	12.71	14.52	52.31	A15, A40
A37	0.568	0.644	49.39	7.91	0.882	16.45	0	26.71	0	50.88	A11, A17, A40
A38	0.606	0.710	36.20	14.71	0.854	12.15	4.95	13.70	0	89.60	A11, A40
A39	0.638	0.816	15.24	24.59	0.781	19.59	49.59	0	0.63	54.81	A11, A40
A41	0.358	0.503	43.80	61.48	0.713	2.11	0	44.02	136.35	49.98	A11, A17
A42	0.604	0.713	28.77	28.55	0.848	6.70	28.64	2.94	0	46.85	A11, A40
A44	0.620	0.778	30.88	4.71	0.797	3.98	0	74.85	52.18	9.34	A13, A17
A45	0.640	0.879	12.34	11.51	0.727	36.12	59.35	3.71	0	80.29	A13, A40
A47	0.476	0.530	55.31	30.34	0.897	5.10	0	22.23	0	53.01	A11, A17, A40
A48	0.580	0.904	11.59	5.61	0.642	7.54	0	136.78	131.60	36.40	A13, A17
A49	0.355	0.477	49.09	58.68	0.744	0	53.09	0	19.93	85.84	A13, A15, A17

Tab. 5: Results of the WSBM-C model – Part 2

Agent ID	ρ^*	ρ_i^*	Excesses (in %)		ρ_o^*	Shortfalls (in %)				Excess (in %)	Reference set
			W	WT		QACP	CS	NFCP	CQ			ICHT
A50	0.553	0.619	37.29	39.85	0.894	0	12.78	0.57	0	55.93	A11, A17, A40
A52	0.817	0.873	19.01	0	0.936	9.42	0	10.35	0.57	28.97	A13, A17, A46
A54	0.461	0.682	47.32	0.74	0.675	41.16	0	124.10	67.69	55.56	A11, A40
A55	0.707	0.766	26.63	16.85	0.922	0	6.15	4.52	0	42.14	A2, A13, A15
Number of agents with nonzero slack			32	31		26	20	32	21	36	
Average slack (in %)			28.33	22.63		8.57	15.16	44.14	46.93	49.90	

Source: own

Fig. 1: Allocation of the agents: input vs. output efficiency



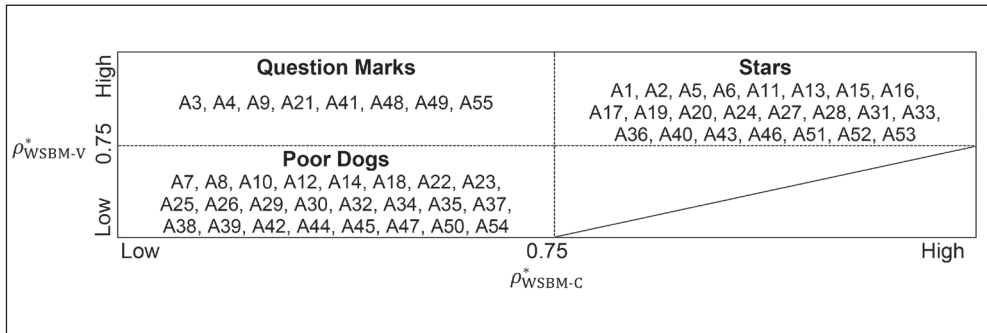
Source: own

As stated previously, the WSBM-C model is relatively strict in terms of identifying the efficient agents. Its results can be viewed as the overall efficiency assessment in the long term. However, in the short term the influence of the external factors such as workload, stress and pressure may be present. To assess performance of call centre agents in the short term, the WSBM-V model is applied in the next step of the evaluation. Compared to WSBM-C, which identified 19 efficient agents, the WSBM-V model, which takes the impact of the external short-term efficiency-measuring factors into account, identified 26 efficient agents (see Tab. 4). The average efficiency score of 0.794 means that the average call centre agent shows almost 79.4% of the best agent's performance.

Also, in this model the least efficient agent is the agent A30 who achieves only 31.2% efficiency of the agents with the maximum efficiency.

To compare the efficiency of the agents in the short and long term, we followed the proposed DEAM framework. As Fig. 2 illustrates, with reference to the agents' joint performance evaluation (based on the WSBM-C and WSBM-V models with the same threshold value set for both of them at 0.75), the agents are divided into three groups: (1) *Stars* (both scores are higher than 0.75); (2) *Question Marks* (the WSBM-C score is less than or equal to 0.75 and the WSBM-V score is higher than 0.75) and *Poor Dogs* (both scores are less than or equal to 0.75). It should be noted that since $\rho_{WSBM-C}^* \leq \rho_{WSBM-V}^*$ for each DMU $i, i \in (1, \dots, n)$

Fig. 2: Allocation of the agents: CRS vs. VRS approach



Source: own

and we consider the same threshold value for both models (0.75), no agent can be assigned to the lower right quadrant, i.e. *Cash Cow group*. Agents could be assigned to a given quadrant only if the threshold value for the WSBM-C model was less than the threshold value for the WSBM-V model. As can be seen in Fig. 2, 23 agents (41.8%) are in the *Star group*, 8 agents (14.5%) in the *Question Mark group*, and 24 agents (43.6%) in the *Poor Dogs group*. *Star Group* is the driving force of the call centre and should be motivated to maintain their excellent operational efficiency either by financial motivation (bonuses, recreational vouchers, etc), or by giving them more responsibilities and control over their work. The agents in the *Poor Dogs group* attain relatively low performance both in the short and long term. Their performance is unsatisfactory and it is up to the management to decide whether to motivate these agents to perform better, or to consider their dismissal. Finally, *Question Marks group* consists of those agents who achieve relatively high performance in the short-term, but their performance in the long-term is relatively low. The reason that could cause them to be ineffective in the long-term could be just the effect of the external factors such as work stress and exhaustion, or their temporary (health or social) indisposition. Whether it really is only a short-term deviation in their performance should be evaluated in a timeline, where their performance would be monitored over several time periods. Then it would be clear whether these agents tend to join *Stars group*, or rather *Poor Dogs group*.

Conclusions

Corporate performance measurement and assessment has long been in the centre of interest in corporate management. Companies are constantly compelled to find new ways of improving their performance in an effort to succeed in an increasingly competitive environment. Performance of a company is naturally determined by the performance of its employees. In general, the employees with knowledge and competence are the key assets that help the companies to retain their competitive advantage. Companies depend on singularity of their staff, as well as on the systems providing effective staff management in order to gain competitive advantage. Although staff performance assessment is one of the most sensitive areas of human resources management, it is an essential issue in this respect. The management have to specify which PA system is to be used, and then decide about the system implementation process.

The paper is devoted to the application of DEA in the PA, which is a relatively new perspective on the application of DEA in business practice. This area of DEA application can provide relevant and useful support for daily decision-making without often unavailable information about competitors in industry. The paper proposes a novel DEA approach for the relative performance evaluation of call centre agents, and specifies the steps of DEA application in the PA of call centre agents, including the design of possible inputs and outputs characterizing the activities of the

evaluated agents, the design of the most appropriate DEA model for the analysed problem, and the method of presentation of the results obtained within the DEAM format. The proposed DEA approach was validated with fifty-five live agents working at the call centre of one of the largest telecommunications operators in the Slovak Republic. This empiric example showed how to select the appropriate DEA model with respect to the considered group of agents, and to the considered group of inputs and outputs characteristic for the agents' activity. For the purpose of the call centre agents' performance assessment, two non-oriented DEA models (WSBM-C model and WSBM-V model) were applied. Based on the results, the groups of agents were created in accordance with their achieved performance. Such presentation of the DEA model results provided satisfactory discrimination among the assessed agents' performance levels.

The proposed DEA approach to performance assessment of the call centre agents may help the call centre managers by: (i) providing information on the agents' performance based upon one composite efficiency indicator, (ii) identifying the agents with low or high performance, (iii) providing proposals for performance improvement of the inefficient agents, (iv) helping the managers identify strengths and weaknesses of the call centre as a whole, and (v) allocating the agents into certain groups and thus making the managers' job easier, as they may choose the same policy for retaining or improving the performance of the agents in a given group. With the proposed approach and result analysis, the call centre managers are able to conduct proper analysis of the agents' performance on the grounds of their relative efficiency assessment.

It should be emphasized, however, that the results of the DEA models are, in general, very sensitive to the selection of the compared DMUs and considered inputs and outputs, as well as to the potential data errors (Ozbek et al., 2009). Seeing that DEA is a non-parametric method, it is impossible to assess the reliability of its results unlike, e.g. with the statistical methods. The choice of different inputs and outputs for call centre agents can provide different results. This point should not be seen as a defect of the proposed DEA approach because different combinations of inputs and outputs could reveal more weaknesses in achieving the agents'

performance. Similarly, although the analysis set a lower bound on the inbound contact handle time uniformly (lower bound for each agent was set at 10 seconds), this limit can be set individually by assessing the actual inbound contact handle time for individual agents. Another option could be setting the lower bound for given input at the level of minimal observed value for the given input. It should also be pointed out that the proposed DEAM approach based on two-dimensional analysis creates a sufficient discrimination between the agents' performance. However, in the cases with insufficient discrimination capacity, the threshold values can be adjusted. In this paper, the same threshold value was set for all the efficiency scores. Another approach would be to set the threshold value either by considering the expert estimation of a manager, or at the level of the average efficiency score.

To conclude, relevance of the employees' performance assessment is naturally determined by meeting the assumption of bringing tangible conclusions, i.e. it should rather serve as means than as the purpose. The assessment results need to be documented and discussed with the employees so they can form the base for further personnel decisions, especially in the field of effective staff deployment, remuneration of the "efficient" employees by e.g. job promotion or pay rise, or motivation and dismissal of the "inefficient" employees. It is important to be aware that human factor activation is affected by a whole complex of factors, such as physical and mental abilities over which the HR manager has no direct control. However, another set of factors affecting the desire and will to work provides space for the application of various motivation tools, which can help the HR managers improve staff efficiency. As for the financial forms of motivation, various types of remuneration can be chosen, e.g. bonuses, commissions, or profit sharing. The non-financial forms of motivation mainly include optimal working conditions so as to improve quality of working life, or provision of various corporate social services (corporate training courses, meal allowances, vacations and other leisure time activities, health care, corporate loans, pre-school children's day care, etc).

Acknowledgement: *The paper was supported by the grant scheme VEGA 1/0843/18 "Methodological aspects of DEA application on efficiency assessment of production units" of*

the Ministry of Education, Science, Research and Sport of the Slovak Republic.

References

- Abuelwafa, H. (2014). *Performance Evaluation in Call Centers: An Investigation into the Use of Analytics Tools* (Master Thesis). St. Louis, MO: Washington University in St. Louis. Retrieved October 1, 2019, from https://scholar.cu.edu.eg/sites/default/files/habuelwafa/files/thesis_final_version_performance_evaluation_in_call_centers_an_investigation_into_the_use_of_analytics_tools.pdf
- Anton, J. (1997). *Call Center Management by the Numbers*. Annapolis, MD: Purdue University Press/Call Center Press.
- Anton, J. (2000). The Past, Present and Future of Customer Access Centres. *International Journal of Service Industry Management*, 11(2), 120–130. <https://doi.org/10.1108/09564230010323534>
- Armentrout, D. R. (1986). Engineering Productivity Management and Performance Measurement. *Journal of Management in Engineering*, 2(3), 141–147. [https://doi.org/10.1061/\(ASCE\)9742-597X\(1986\)2:3\(141\)](https://doi.org/10.1061/(ASCE)9742-597X(1986)2:3(141))
- Arvey, R. D., & Murphy, K. R. (1998). Performance Evaluation in Work Settings. *Annual Review of Psychology*, 49(1), 141–168. <https://doi.org/10.1146/annurev.psych.49.1.141>
- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some Models for Estimating Technical Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, 30(9), 1078–1092. <https://doi.org/10.1287/mnsc.30.9.1078>
- Charnes, A., Cooper, W. W., Golany, B., Seiford, L. M., & Stutz, J. (1985). Foundations of Data Envelopment Analysis for Pareto-Koopmans Efficient Empirical Production Functions. *Journal of Econometrics*, 30(1–2), 91–127. [https://doi.org/10.1016/0304-4076\(85\)90133-2](https://doi.org/10.1016/0304-4076(85)90133-2)
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2(6), 429–444. [https://doi.org/10.1016/0377-2217\(78\)90138-8](https://doi.org/10.1016/0377-2217(78)90138-8)
- Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software* (2nd ed.). New York, NY: Springer Science and Business Media, Inc.
- Dugelová, M., & Strenitzerová, M. (2015). The Using of Data Envelopment Analysis in Human Resource Controlling. *Procedia Economics and Finance*, 26, 468–475. [https://doi.org/10.1016/S2212-5671\(15\)00875-8](https://doi.org/10.1016/S2212-5671(15)00875-8)
- Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society*, 120(3), 253–290. <https://doi.org/10.2307/2343100>
- Fielding, G. (2003). Taking Conversation Seriously: the Role of the Call Centre in the Organisation's Customer Contact Strategy. *Interactive Marketing*, 4(3), 257–266. <https://doi.org/10.1057/palgrave.im.4340187>
- Hedley, B. (1976). A Fundamental Approach to Strategy Development. *Long Range Planning*, 9(6), 2–11. [https://doi.org/10.1016/0024-6301\(76\)90005-4](https://doi.org/10.1016/0024-6301(76)90005-4)
- Higgs, M., Plewnia, U., & Ploch, J. (2005). Influence of Team Composition and Task Complexity on Team Performance. *Team Performance Management*, 11(7/8), 227–250. <https://doi.org/10.1108/13527590510635134>
- Houlihan, M. (2002). Tensions and Variations in Call Centre Management Strategies. *Human Resource Management Journal*, 12(4), 67–85. <https://doi.org/10.1111/j.1748-8583.2002.tb00078.x>
- Jafari, M., Bourouni, A., & Amiri, R. H. (2009). A New Framework for Selection of the Best Performance Appraisal Method. *European Journal of Social Sciences*, 7(3), 92–100.
- Katzenbach, J. R., & Smith, D. K. (1993). *The Wisdom of Teams: Creating the High Performance Organization*. Boston, MA: Harvard Business School Press.
- Kilduff, M., Angelmar, R., & Mehra, A. (2000). Top Management Team Diversity and Firm Performance: Examining the Role of Cognitions. *Organization Science*, 11(1), 21–34. <https://doi.org/10.1287/orsc.11.1.21.12569>
- Mahmudah, U., & Lola, M. S. (2018). Robust Approach for Efficiency Measurement of Employee Performance under Profit Sharing System. *Economic Journal of Emerging Markets*, 10(1), 1–7. <https://doi.org/10.20885/ejem.vol10.iss1.art1>
- Najar, A. V., Pooya, A., Zoeram, A. A., & Emrouznejad, A. (2018). Assessing the Relative Performance of Nurses Using Data Envelopment Analysis Matrix (DEAM). *Journal of Medical Systems*, 42(7), 125. <https://doi.org/10.1007/s10916-018-0974-x>
- Osman, I. H., Berbary, L. N., Sidani, Y., Al-Ayoubi, B., & Emrouznejad, A. (2011). Data Envelopment Analysis Model for the Appraisal and Relative Performance Evaluation of Nurses

at an Intensive Care Unit. *Journal of Medical Systems*, 35(5), 1039–1062. <https://doi.org/10.1007/s10916-010-9570-4>

Ozbek, M. E., Garza, J. M., & Triantis, K. (2009). Data Envelopment Analysis as a Decision-Making Tool for Transportation Professionals. *Journal of Transportation engineering*, 135(11), 822–831. [https://doi.org/10.1061/\(ASCE\)TE.1943-5436.0000069](https://doi.org/10.1061/(ASCE)TE.1943-5436.0000069)

Robinson, G., & Morley, C. (2006). Call Centre Management: Responsibilities and Performance. *International Journal of Service Industry Management*, 17(3), 284–300. <https://doi.org/10.1108/09564230610667122>

Shirouyehzad, H., Lotfi, F. H., Aryanezhad, M. B., & Dabestani, R. (2012). A Data Envelopment Analysis Approach for Measuring the Efficiency of Employees: A case study. *South African Journal of Industrial Engineering*, 23(1), 191–201. <https://doi.org/10.7166/23-1-230>

So, S. H. (2007). An Empirical Analysis on the Operational Efficiency of CRM Call Centers in Korea. *International Journal of Computer Science and Network Security*, 7(12), 171–178.

Tao, G. (2012). Multi-Department Employee Performance Evaluation Based on DEA Cross Efficiency. *Journal of Emerging Trends in Economics and Management Sciences*, 3(5), 553–558.

Tone, K. (2001). A Slacks-Based Measure of Efficiency in Data Envelopment Analysis. *European Journal of Operational Research*, 130(3), 498–509. [https://doi.org/10.1016/S0377-2217\(99\)00407-5](https://doi.org/10.1016/S0377-2217(99)00407-5)

Zbranek, P. (2013). Data Envelopment Analysis as a Toll for Evaluation of Employees' Performance. *Acta Oeconomica et Informatica*, 16(1), 12–21. <https://doi.org/10.15414/raae.2013.16.01.12-21>

ASSESSMENT OF LOGISTICS PLATFORM EFFICIENCY USING AN INTEGRATED DELPHI ANALYTIC HIERARCHY PROCESS – DATA ENVELOPMENT ANALYSIS APPROACH: A NOVEL METHODOLOGICAL APPROACH INCLUDING A CASE STUDY IN SLOVENIA

Patricija Bajec¹, Monika Kontelj², Aleš Groznik³

¹ University of Ljubljana, Faculty of Maritime Studies and Transport, Department of Transport Logistics, Slovenia, ORCID: 0000-0003-1511-1064, patricija.bajec@fpp.uni-lj.si;

² Mercator d. d., Slovenia, monika.kontelj@t-2.net;

³ University of Ljubljana, Faculty of Economics, Department of Business Informatics and Logistics, Slovenia, ales.groznik@ef.uni-lj.si.

Abstract: The objective of this study is to propose a trustworthy, valid and consistent methodological approach for measuring the efficiency of a logistics platform, where an entire country constitutes a logistic platform. Traditional Data Envelopment Analysis (DEA) is found to be an appropriate tool – if its weaknesses are eliminated. DEA results are highly influenced by the choice of appropriate inputs and outputs variables, but the method itself does not provide guidance for their identification. The authors therefore propose to integrate traditional DEA by combining the Delphi technique with the Analytical Hierarchy Process (AHP) method, which will assist in identifying proper, consistent input/output variables, evaluated by their relevance. The proposed framework allows the performance evaluation of the selected platform's element or elements. It is thus a useful decision support tool for enterprises (private, public, both) that are managing logistics platforms and trying to improve their productivity in order to sustain or improve their position on the competitive market. This methodology allows comparative efficiency analyses to be estimated for similar countries. The presented methodology on one hand enables tailor-made solutions, but on the other hand is very general, and, with minor adjustments, can be applied by a variety of firms and industries. It can be applied in private sector firms in production and service industries, to analyse the relative performance of diverse logistics and non-logistics services, and in public profit or non-profit organisations.

Keywords: Supply chain, logistics platform, measuring efficiency, methodology, Delphi, AHP, DEA.

JEL Classification: C39, D57, M21, O49, R42.

APA Style Citation: Bajec, P., Kontelj, M., & Groznik, A. (2020). Assessment of Logistics Platform Efficiency Using an Integrated Delphi Analytic Hierarchy Process – Data Envelopment Analysis Approach: A Novel Methodological Approach Including a Case Study in Slovenia. *E&M Economics and Management*, 23(3), 191–207. <https://doi.org/10.15240/tul/001/2020-3-012>

Introduction

Expanding markets highlight the importance of supply chains as well as logistics management, the effectiveness and efficiency of which rely on an extensive and complex array of interdependent logistics and supply chain issues: services, logistics networks (Bolumole, Closs, & Rodammer, 2015) and participants in the private and public sectors.

Private sector organisations, mainly bearing responsibility for the cost-effectiveness and agility of the supply chain (Fawcett, Waller, & Bowersox, 2011), are under constant pressure to respond to new customer requirements. These greatly depend on the quality, accessibility and reliability of logistics networks and their infrastructure.

Public sector organisations, mainly bearing responsibility for logistics networks and their infrastructures, thus face the challenge of planning a more “flexible logistics set-up, based on strategic rather than operational flexibility” (Abrahamsson, Aldin, & Stahre, 2003). Strategic flexibility requires new logistics structures and organisations, able to follow market changes and, to enhance economic productivity constantly, requires regional growth (Lakshmanan, 2011; Notteboom & Rodrigue, 2005) and overall regional prosperity.

In response to the current level of dynamism and competitiveness (Silva, Senna, Júnior, Fontes, & Senna, 2015) and regarding the close relationship, even interdependence, between the supply and logistics chains, the latter has to develop towards logistics platforms. A logistics platform is a very complex venture of organizations (private and public) (Silva et al., 2015) that requires capable leadership able to respond to stakeholders’ goals (Sheffi, 2013) and needs. A logistics platform can be, if implemented and managed efficiently, a source of competitive advantage for the region/country (Antún & Alarcón, 2014; de Carvalho, de Carvalho, & Lima Jr, 2013). This implies the necessity for governance and efforts to increase the productivity and efficiency of logistics platforms.

A limited number of studies have directly analysed the productivity of the whole or part of logistics platforms. Articles mostly analyse and propose tools for evaluating just one element of a logistics platform: truck scheduling, infrastructure efficiency, logistics service provider efficiency (Awad-Núñez, González-

Cancelas, Soler-Flores, & Camarero-Orive, 2015; Gattuso, Cassone, & Pellicanò, 2014; Srisawat, Kronprasert, & Arunotayanun, 2017). The efficiency of the logistics platforms was as a whole analysed only by de Carvalho et al. (2013) and by Yang et al. (2017). In both studies, a traditional non-parametric mathematical method, Data Envelopment Analysis (DEA) was used to measure the efficiency of platforms’ units. However, both studies lack the critical analysis of DEA concerning logistics platforms characteristics and specifics. It has, therefore, not yet been explored whether DEA is the most reliable and valid modelling technique.

The above mentioned gaps encouraged the authors to perform a more thorough and detailed analysis of the DEA method.

Three research questions (RQ) were developed:

RQ1: Are traditional DEA results feasible and robust enough?

RQ2: Are the traditional DEA model and its process consistent, transparent and practical enough for logistics platforms’ evaluation problems?

RQ3: Which DEA approach, if any, would decrease traditional DEA weaknesses and increase its trustworthiness and validity?

The objectives of this study are twofold. One is the proposal of a trustworthy and valid approach for assessing the efficiency of logistics platforms and highlighting their weakest element or elements. The second is the application of the proposed methodology in a real case study of the Slovenian logistics platform.

1. Literature Review

Not many articles have been written on this topic. Most of the articles analyse the efficiency of single logistics platform element. For example, the study of Gattuso et al. (2014) is focused on only the receiving area of a warehouse, as one of the logistics platform’s types. The authors introduced a mathematical model for solving a truck scheduling problem in order to increase the performance of one logistics platform element. Srisawat et al. (2017) also focused their research on only one, spatial, aspect of the logistics platform. However, they did develop a 4-stage decision model, integrated by the Analytic Hierarchy Process (AHP) multicriterial method and geographic information system (GIS) technology, for evaluating the spatial

efficiency of a regional logistics platform. Based on surveys, the list of all logistics platform efficiency indicators, as one of the crucial element of productivity analysis, was presented in this study. Similarly, Awad-Núñez et al. (2015) measured the sustainability of the locations of a dry port, using Multi-Criteria Decision Analysis and Bayesian Networks. Sarmiento, Renneboog and Verga-Matos (2017) measured the efficiency of seven highway projects in Portugal. There are numerous studies focused on measuring logistics service providers with different multi-criteria decision making (MCDM) methods (Azadi, Hosseinzadeh Zoroufchi, & Farzipoor Saen, 2012; Bansal & Kumar, 2013; Çakir, 2009; Daim, Udbye, & Balasubramanian, 2012; Qureshi, Kumar, & Kumar, 2007; Singh, Shankar, Kumar, & Singh, 2012; Wu & Yue, 2008; Yasaroglu, Özdağoğlu, & Özdağoğlu, 2006).

The authors whose research most directly analyse the efficiency of the logistics platform as a whole are de Carvalho et al. (2013). They proposed using a traditional non-parametric mathematical method, Data Envelopment Analysis (DEA), to measure the efficiency of platforms' units. The same method was used by Yang et al. (2017) for analysing the efficiency of Freight Villages. They highlighted the sensitivity of the DEA and therefore propose two solutions: (1) to reduce the error via removal of variables and by jack-knifing and (2) to extend input and output variables. Taking these two proposals and also the advantages of DEA into account, the method is a feasible benchmarking tool. Haralambides and Gujar (2012) were also critical of the selection of inputs/outputs when using DEA for evaluation of dry port efficiency. They argued that the DEA model has so far dealt with only desirable inputs/outputs and failed to address the undesirable (CO₂ emissions, etc). They, therefore, proposed a new eco-DEA model which evaluates undesirable and desirable outputs of dry ports. Markovits-Somogyi et al. (2011) highlighted the fact that DEA was widely utilised in the transport sector, but not for analysing the efficiency of distribution centres. After investigating the method and using it in a real case study, they concluded that DEA characteristics are perfect for analysing the distribution centre.

Other studies, listed below, only indirectly relate to logistics platform performance. For example, Yong (2017) analysed the correlations

of service innovations capability, delivery system and technology application on the performance of the O2O platform. A significant positive impact on platform performance was found to exist. Fanti et al. (2017) propose an application of Information and Communications Technology (ICT) tools and the Internet of Things to enhance and simplify collaboration among participants, which further positively influence productivity. Similarly, Cheng and Wang (2016) examine "the potential contributions of a logistics and transport data exchange platform in measuring the performance of supply chain stakeholders of a hub port at different stages along the chain". The same was done by Grzybowska and Gajsek (2016), which demonstrated that the implementation of a common information solution is a step on the way to contemporary and comprehensive logistics platforms.

In summary, there is a lack of studies dealing directly with productivity evaluation in regard to logistics platforms. The traditional DEA was found to be widely used for measuring the efficiency of logistics platform elements, but only twice was applied in cases of logistics platforms. However, this does not make the method itself the only and most reliable modelling technique for evaluating logistics platforms. Only one critical analysis in terms of logistics platforms was made. A comparative analysis of the most commonly used methods was therefore made by the authors, based on the most crucial evaluation criterion, type of results, and several crucial evaluation criteria and principles, proposed by Saaty and Ergu (2015). Measures of central tendency were found to be appropriate to deal with random error and technical efficiency. They are easy to compute and are structured methods. However, they do not identify the most productive units directly. They usually deal with single outputs and require a large number of units. DEA directly identifies the most productive units, enables a ranking of units, deals with multiple inputs and outputs and is structured. The method is sensitive to decision making units, inputs and outputs. Strengths, Weaknesses, Opportunities and Threats (SWOT) enables ranking, invites decision makers to consider important aspects and is able to handle mixed types of data. The method is uncertain, not structured and does not automatically determine weights. The AHP method is able to handle mixed types of data as well as deterministic and non-deterministic

features of information. The method is structured but requires a pairwise comparison of inputs and outputs. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is able to handle mixed types of data; it directly identifies the most productive unit, enables ranking, and is structured. However, the method is not able to handle non-deterministic features of information, without extension. Moreover, the method requires the direct rating of inputs/outputs. The ELimination Et Choix Traduisant la Réalité (ELECTRE) enables a ranking of units, is able to handle mixed types of data and is structured. However, the method is not able to handle non-deterministic features of information; without extension, it requires a pairwise comparison of inputs/outputs and is complex. The Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) enables a ranking of units, is able to handle mixed types of data and is not complex – but it's time consuming.

All of these methods are subject to a series of limitations. None of the methods, 'despite the existence of a large number of refined methods' (Saaty & Ergu, 2015), is perfectly suited to any logistics platform efficiency evaluation problems.

These insights, including the fact that DEA was found to be the most commonly used method in multi-criteria analysis of the logistics field in general and the only method applied for productivity measurement of logistics platforms, motivated us to critically analyse whether DEA is the appropriate method to evaluate the efficiency of a logistics platform, to suggest how DEAs weaknesses can be reduced or even eliminated, and to test the proposed methodology.

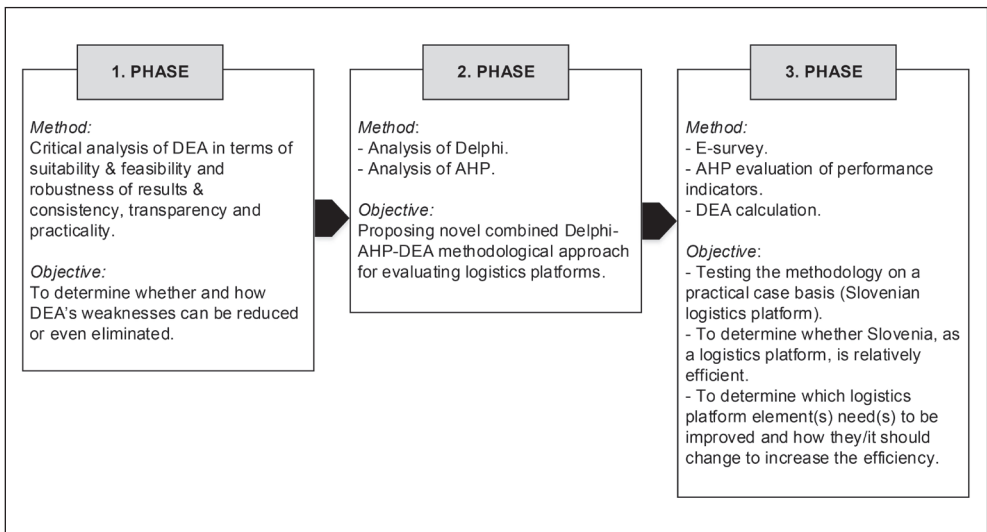
2. Methodology

A three-phase methodological approach is used. Firstly, a detailed DEA analysis was made in terms of utility for assessing logistics platforms. Based on these results, an integrated Delphi-AHP and DEA methodological approach was proposed and then illustrated using a case study of Slovenia in the final phase (Fig.1).

3. DEA Method

DEA is a non-parametric linear programming approach for evaluating the relative efficiency of decision-making units (DMUs) (Kocisova, Hass-Symotiuk, & Kludacz-Alessandri, 2018). The relative performance of an individual DMU is evaluated by comparing it to the most efficient

Fig. 1: Methodological approach



Source: own

DMU (Haralambides & Gujar, 2012). The performance measurement, which is shown as an efficiency score, shows the changes in inputs and outputs required in order to reach the most efficient DMU.

3.1 Basic DEA Models

Several forms of DEA models were developed. The most widely used are the CCR model and the BCC model. The CCR model, or constant return to scale (CRS), supposes constant return to scale; that is, all DMU are operating at an optimal scale (Yang et al., 2017). The BCC model supposes variable returns to scale (VRS) and does not assume proportionality between inputs and outputs (de Carvalho et al., 2013). Both of the models are input or output oriented. An input oriented model attempts to find the way to minimise the input characteristics of the DMU in order to become efficient. The output oriented model attempts to find the way to maximise the output characteristics to achieve efficiency. Neither the CCR nor BCC model provide enough information for ranking efficient units. A modified model proposed by Cook et al. (1992), Andersen and Petersen (1993) and Dyson et al. (2001) should be applied in this case. The selection of the appropriate DEA model depends on the characteristics of the problem analysed.

All DEA models assume that n DMUs (units) are to be evaluated. Each DMU_k ($k = 1, 2, \dots, n$) consumes m different inputs $x_k = (x_{1k}, x_{2k}, \dots, x_{mk})$ and produces s different outputs $y_k = (y_{1k}, y_{2k}, \dots, y_{sk})$. The DMU that needs to be measured with the aim of maximizing its efficiency rate is DMU_0 . DMU_0 is efficient if the efficiency rate results in a score of 1. However, all weights should be positive and all of the DMUs are to have a lower boundary of 1. Such a model could be defined as:

$$\max \frac{\sum_{i=1}^s u_i y_{i0}}{\sum_{j=1}^m v_j x_{j0}}$$

s.t.

$$\frac{\sum_{i=1}^s u_i y_{ik}}{\sum_{j=1}^m v_j x_{jk}} \leq 1; k = 1, 2, \dots, n; \tag{1}$$

$$u_i, v_j \geq \epsilon > 0; i = 1, 2, \dots, s; j = 1, 2, \dots, m;$$

where u_i and v_j are weights assigned to i - th output and j - th input and ϵ is a small non-Archimedean positive integer.

Model (1) converted to a linear programming format is called a **primary CCR model**:

$$z_1^* = \max_{\{\mu_1, \dots, \mu_s\}} \left\{ z = \sum_{i=1}^s \mu_i y_{i0} \right\},$$

s.t.

$$\sum_{i=1}^s \mu_i y_{ik} - \sum_{j=1}^m \omega_j x_{jk} \leq 0; k = 1, 2, \dots, n; \tag{2}$$

$$\sum_{j=1}^m \omega_j x_{j0} = 1;$$

$$\mu_i, \omega_j \geq 0 \quad i = 1, 2, \dots, s; j = 1, 2, \dots, m;$$

where u_i and v_j are exchanged to μ_i and ω_j using the Charnes-Cooper transformation.

The equivalent **dual model** to primary CCR model (2) can be expressed as:

$$\theta^* = \min \theta,$$

s.t.

$$\sum_{k=1}^n x_{jk} \lambda_k \leq \theta x_{j0}; j = 1, 2, \dots, m; \tag{3}$$

$$\sum_{k=1}^n y_{ik} \lambda_k \leq \theta y_{i0}; i = 1, 2, \dots, s;$$

$$\lambda_k \geq 0; k = 1, 2, \dots, n;$$

where $\lambda = (\lambda_1, \dots, \lambda_n)$ is a vector assigned to individual productive units. This model (3) is also called a 'weak efficiency' model, because it ignores the non-zero slacks (Markovits-Somogyi et al., 2011).

A non-ignoring non-zero slacks modified model, called an **envelopment model**, is defined as:

$$\theta^* = \min \left\{ \theta - \epsilon \left(\sum_{j=1}^m s_j^- + \sum_{i=1}^s s_i^+ \right) \right\},$$

s.t.

$$\sum_{k=1}^n x_{jk} \lambda_k + s_j^- = \theta x_{j0}; j = 1, 2, \dots, m; \tag{4}$$

$$\sum_{k=1}^n y_{ik} \lambda_k - s_i^+ = y_{i0}; i = 1, 2, \dots, s;$$

$$\lambda_k, s_j^-, s_i^+ \geq 0; i = 1, 2, \dots, s; j = 1, 2, \dots, m; k = 1, 2, \dots, n;$$

where ϵ is a non-Archimedean positive infinitesimal, normally pitched at 10^{-6} (Vincová, 2005), and s_j^- and s_i^+ are addition input and output variables.

The **dual model** equivalent to the envelopment CCR model (4), the multiplier model, can be expressed as:

$$z_2^* = \left\{ \max z = \sum_{i=1}^s \mu_i y_{i0} \right\}$$

s. t.

$$\sum_{i=1}^s \mu_i y_{ik} - \sum_{j=1}^m \omega_j x_{jk} \leq 0; \quad k = 1, 2, \dots, n; \quad (5)$$

$$\sum_{j=1}^m \omega_j x_{j0} = 1;$$

$$\mu_i, \omega_j \geq \varepsilon > 0; \quad i = 1, 2, \dots, s; \quad j = 1, 2, \dots, m.$$

Models (3) and (5) are input-oriented CCR models. A DMU_0 is CCR efficient if the optimum value of the model (4) function equals 1. In other cases it is inefficient. The lower the value, the less efficient the unit is compared to the rest of the population. This value indicates to what value inputs need to be reduced in order to reach the efficiency of a DMU_0 .

There are also output-oriented CCR models that could be written as follows:

$$\Phi^* = \max \left\{ \Phi + \varepsilon \left(\sum_{j=1}^s s_j^- + \sum_{i=1}^m s_i^+ \right) \right\}$$

s. t.

$$\sum_{k=1}^n x_{jk} \lambda_k + s_j^- = x_{j0}; \quad j = 1, 2, \dots, m; \quad (6)$$

$$\sum_{k=1}^n y_{ik} \lambda_k - s_i^+ = \Phi y_{i0}; \quad i = 1, 2, \dots, s;$$

$$\lambda_k, s_j^-, s_i^+ \geq 0; \quad i = 1, 2, \dots, s; \quad j = 1, 2, \dots, m; \quad k = 1, 2, \dots, n.$$

A DMU_0 is CCR efficient if the optimum value of the model (6) objective function equals 1. If the value of the objective function is greater than 1, the unit is inefficient. The variable Φ shows to what value outputs need to be proportionally increased in order to achieve efficiency.

The models suppose constant return to scale. In order to assume variable return to scale in the DEA BCC model, the additional convexity constraint $\sum_{k=1}^n \lambda_k = 1$ needs to be incorporated into model (4) and (6).

3.2 Reasons to Use DEA for Logistics Platform Efficiency Assessment

Firstly, DEA is able to determine the efficiency of a logistics platform's units comprehensively by taking multiple inputs and outputs into account (Hsu, Liao, Yang, & Chen, 2005). Secondly, DEA enables benchmarking with the best, consistent, logistics platforms. The comparison with best practices reveals potential opportunities for increasing the competitiveness of the logistics

platform. DEA not only evaluates the efficiency of the selected unit but also advises, using slack analysis, how to mend its behaviour to reach greater efficiency (Vincová, 2005).

The method, moreover, works in the case of a small sample (Sufian, 2007). This is an important fact in the case of logistics platforms lacking data, difficult and time consuming gathering of data, and even the risk regarding data accuracy. Most of the data is very scattered, difficult to access or even inaccessible.

DEA also automatically determines the weights (Yang et al., 2017) and eliminates the risk of subjective determination of the weights by the user. The weight of each input/output is optimized in order to present each unit in the best possible light (Huguenin, 2012).

The method has a rather low comprehensive structure, since it contains criteria which are not broken into sub-criteria. It involves medium mathematical procedures and meaningful axioms. It is thus medium complicated and can be used if the decision maker puts effort into learning it. However, there are also several software solutions that make the execution even easier.

3.3 Shortcomings of the DEA Method

DEA users most often face three problems. First is the selection of the appropriate DEA-model (Martí, Martín, & Puertas, 2017), CCR model and BCC model. The requirements of the user and the characteristics of the analysed problem actually dictate the selection of the DEA model. The suitability of the CCR model, which assumes that there is no strong correlation between the size of the DMU and the relative technical efficiency index can be further verified by using the Pearson correlation test (Johnes, 2006).

The second DEA pitfall regards the selection of the appropriate DMUs. The DEA itself does not provide guidance for the selection of the DMUs, but only proposes to "use homogeneous units, able to perform the same tasks with the same goals and to be under the same work conditions of the market" (de Carvalho et al., 2013). Normally, in the benchmark analysis, the selected unit is compared with the best performers, which further means that the DEA is based on extreme points (Vincová, 2005) and is thus sensitive to data and measurement errors.

There is no direct way to test the statistical significance of the DMU from the best-

performing unit (Kumar Singh & Kumar Bajpai, 2013). There are several techniques to test the reliability and robustness of the position of the best performing-units: (1) removal of variables and (2) Jack-knifing analysis. In the first analysis one input or output is removed at a time in order to see whether an efficient DMU is still ranked efficient (Ramanathan, 2003; Zhu, 2014). In the second analysis one efficient DMU is removed at a time in order to see the difference of efficiency scores (Charles, Kumar, & Kavitha, 2012).

As regards the number of DMUs, the rule of thumb proposes to have at least 2 times more DMUs than the sum of the number of inputs and outputs:

$$nr. \text{ of DMU} \geq 2(nr. \text{ of inputs} + nr. \text{ of outputs}) \quad (7)$$

Otherwise the DEA may lose the discriminating power (Tone & Tsutsui, 2009).

The third and the most problematic DEA difficulty regards the choice of the inputs and outputs. The rule of thumb only suggests the number of DMUs, which further influences the number of inputs/outputs, but does not indicate the ratio between the number of inputs or outputs nor the guidance regarding how to select the relevant inputs and outputs. Past studies thus show that the availability of data (Nataraja & Johnson, 2011) and suggestions by the authors are still factors that most often assist in identifying inputs and outputs (Bray, Caggiani, & Ottomanelli, 2015; Rajasekar & Deo, 2014). This fact, however, raises doubts about the appropriateness of the selected variables and consequently the robustness and reliability of the results. Moreover, valuable information may be lost.

In past studies the Pearson correlation test was used (Rajasekar & Deo, 2014) for evaluating the robustness of DEA results. In that case, an input/output coefficient below 0.6 in the Pearson correlation test showed that there was no need to eliminate the variable. Otherwise, the input/output needed to be omitted to retain maximum information (Jenkins & Anderson, 2003). Pastor et al. (2002) proposes using the test with values $\rho = 1.1$ and $p_0 = 0.15$ to assess the significance of individual variables and groups of variables. In case the removal of input/output results in a change in efficiency scores which is not substantial, the input/output can be removed. In case the resulting Pastor

p -values are close to zero, the contribution of input/output is relevant and should not be removed (Johnes, 2006). However, both sensitivity analyses are used when inputs/outputs are already selected and they therefore do not solve the problem of selecting the right input/output variables.

Aware of their great influence on the final results, the authors believe that this step is most critical and the weakest point of the DEA: but if to some degree ameliorated, the DEA may be the most valid method enabling both the overall efficiency of the logistics platform and the potential for each logistics platform to improve efficiency. The authors therefore suggest applying the traditional DEA method and performing the sensitivity analysis in a similar manner as was used in many past studies in the logistics field, despite the weakest stage of the method, related to inputs-outputs selection. An extension of DEA, adjusted for the logistics platforms' efficiency measurement is introduced in the next section.

4. Novel Delphi-AHP-DEA Approach

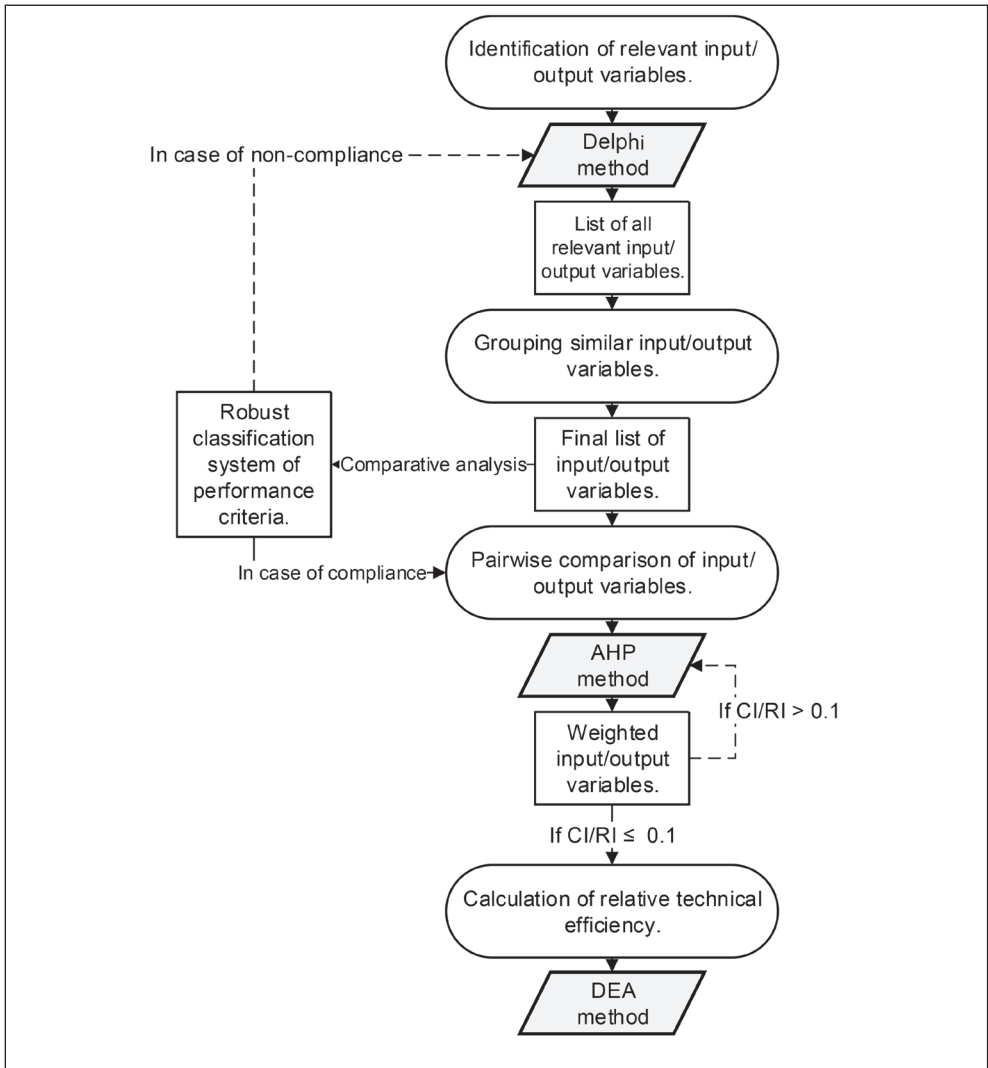
A two stage-methodological approach is proposed. The **first stage** (Fig. 2) reduces the risk of improper selection of relevant inputs/outputs from a large number of indicators significant for the logistics platforms. An integrated Delphi-AHP approach is proposed.

More precisely, the Delphi method is proposed for application for identifying and further evaluating, by applying AHP, the importance of inputs/outputs. A Delphi approach was selected because of the complexity of the elements/indicators of logistics platforms and their correlations, which require appropriate answers and deep understanding of the topic. A sample size of participants in the Delphi process should be large enough – minimum 10 and maximum 30 – participants from sectors which are directly or indirectly most involved in the implementation of the logistics platform and its processes (the public sector, as the owner of the infrastructure, the private sector as the owner and provider of logistics services, and the academic sector and/or consulting companies, mostly involved in the implementation and monitoring processes).

At least two steps need to be conducted. Participants during the *first step* are asked to identify relevant input and output elements (performance indicators), which in their opinion

Fig. 1:

Flowchart for Delphi-AHP methodology implementation



Source: own

contribute to the efficiency of the logistics platform. Following the first step, data are analysed and then integrated with respect to similarity. To reduce the risk of loss of valuable inputs/outputs, the authors propose comparing the obtained list of indicators with the list of general performance indicators, if they exist. If they do not exist, the authors advise making a systematic review of literature in this field.

In case the comparative analysis shows that some elements were not identified by the participants, they are further asked for reasons and their opinion on this topic. This process can be repeated until consensus regarding the listed elements is reached.

The same list of elements is submitted during the *second step* back to participants in order that they rank them according to their importance.

This step is extremely important since not all elements can be included in the DEA analysis because of the decrease of the discriminatory power of DEA when the number of elements increases. It is therefore very important to determine the appropriate elements, which must be identified in a consistent way. In order to satisfy this need for consistency, the authors decided to apply AHP's pairwise comparison of the inputs/outputs.

The AHP method involves four main steps: deconstruction of the decision problem into a hierarchy of interrelated elements, pairwise comparisons of the criteria with 9 degree scale application, calculation of criteria weights and final selection of the right decision (Jaskowski, Biruk, & Bucon, 2010). During the second step, the decision maker uses a 9 degree Saaty scale and compares each element in a square comparison matrix $A = [a_{ij}]$ of dimension n . The relative weights of criteria (w_1, \dots, w_n) are given by normalizing the Eigen vector W using the arithmetic mean:

$$w_i = \frac{1}{n} \sum_{j=1}^n \frac{a_{ij}}{A_j} \text{ for } i = 1, \dots, n; \quad (8)$$

where $A_j = \sum_{i=1}^n a_{ij}$ for $j = 1, \dots, n$. An approximation of the maximum eigenvalue λ_{max} is computed as:

$$\lambda_{max} = \sum_{i=1}^n A_i w_i. \quad (9)$$

On the basis of the characteristics of the comparison matrix, the method consistency can be checked using the consistency index (CI) (Forman, Saaty, Selly, & Waldron, 1983; Macharis, Springael, De Brucker, & Verbeke, 2004) defined as:

$$CI = \frac{\lambda_{max} - n}{n - 1}. \quad (10)$$

In order to conclude whether the evaluations are consistent, the consistency ratio (CR) is calculated as the ratio of the consistency index CI and the random consistency index CI^* given by Saaty (1990). In the view of Saaty (1990), the inconsistency should not be higher than 10 per cent.

After receiving the pairwise comparison matrix from all participants, the consistency index for each matrix has to be calculated. If CR is satisfactory the decision is taken based

on the normalized values; otherwise the matrix is considered again by the participant and this step is repeated till the value lies in a desired range.

After that a geometric mean, which is not significantly affected by fluctuation of sampling and is not affected by extreme values, is used to arrive at a final set of elements. They serve as inputs/outputs for further DEA steps, conducted in the **second stage** of the proposed methodology (Fig. 3). Three steps and several sensitivity analyses, presented in the flowchart and explained in Sections 3.1 and 3.2, are provided to get to the final answer in regard to relative efficiency.

5. Case Study

These sections discuss how the methodology explained above is applied to evaluate the technical productivity of Slovenia as a logistics platform. More precisely, the authors attempt to determine two things: (1) whether Slovenia, as a logistics platform, is relatively efficient and, if it is not efficient (2), which logistics platform's element(s) need(s) to be improved and how they/it should change to increase the efficiency.

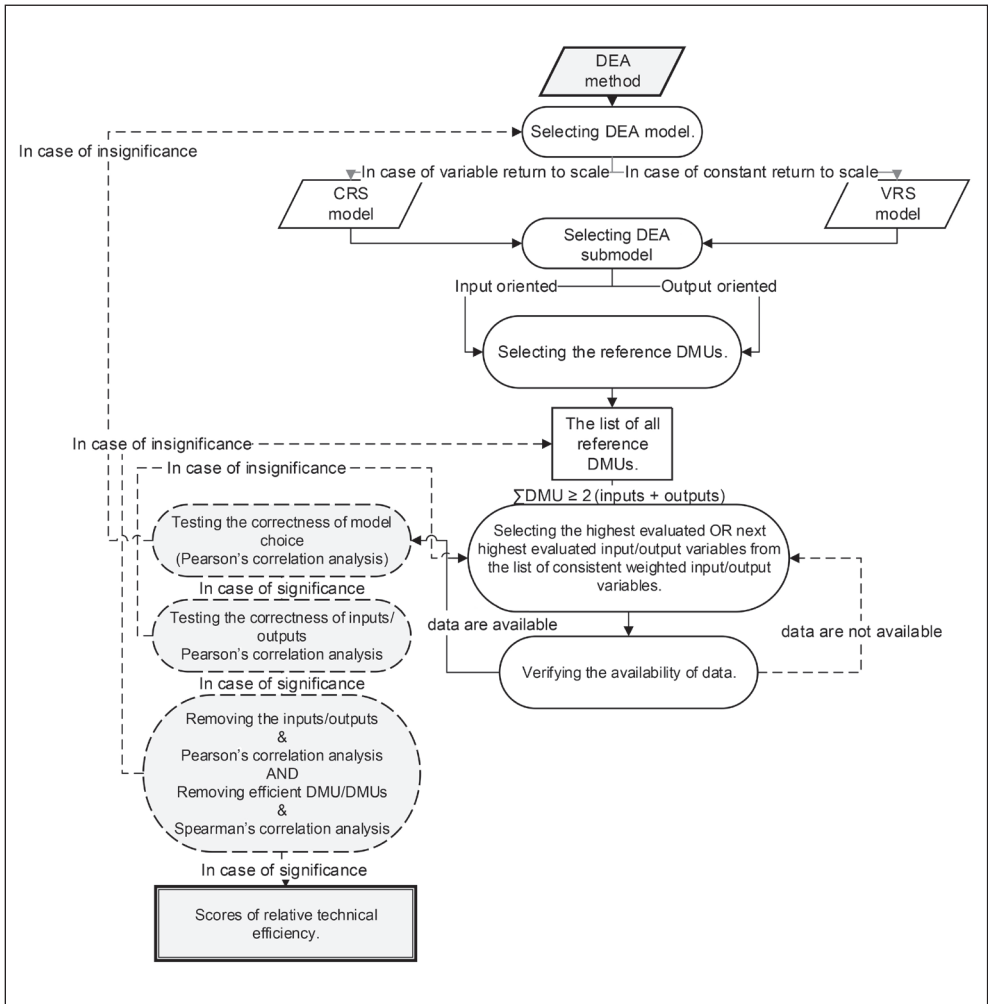
5.1 Identification of Input and Output Variables

Firstly, e-mail interviews were conducted between September and November 2017 with 13 experts from three different sectors (academic, public and private) which play a crucial role in the implementation and/or the organization of processes of the platform. The following open-ended question was submitted to the experts: Which input/output indicators are, in your opinion, important for the implementation of an efficient logistics platform in Slovenia?

This phase resulted in 39 qualitative and quantitative indicators, which were then, according to similarity integrated into 9 groups: (6 groups of inputs [Tab. 1, 1st column] and 3 groups of outputs [Tab. 1, 3rd column]).

Generally, the inputs are the resources consumed by the logistics platform for several logistics operations and the outputs are results from operations provided on the logistics platform. However, in the present case, the authors attempt to determine the way to improve crucial platform elements to increase the efficiency and therefore the output-oriented DEA approach is the only suitable model. This

Fig. 3: Flowchart for DEA method implementation



Source: own

model assumes maximisation of outputs by the fixed inputs. Consequently, generally used input elements (see above explanation) in the present case represent output elements and generally used output elements represent input elements.

Since not all inputs and outputs contribute equally to the efficiency of the logistics platform, and in order not to decrease the discriminatory power of the DEA method, a separate pairwise comparison of inputs and outputs is performed

in *the second phase* of interviews by the 7 and not 13 experts (only seven experts responded to the interview). This results in seven input comparison matrices and seven output comparison matrices. In order to confirm the consistency of the experts' evaluations a consistency ratio was calculated. 12 of 14 matrices were consistent. For the inconsistent two the second phase was repeated. When all matrices are consistent, a geometric mean is used to arrive at a final ranking of elements

Tab. 1: Priority ranking of inputs

Inputs (in the present case study outputs)	w	Outputs (in the present case study inputs)	w
Railway infrastructure	0.37384	Annual goods transhipment	0.62942
Logistics distribution centres	0.19509	Total gross domestic product (GDP)	0.19945
Modern IT	0.13503	Annual revenue from the logistics industry	0.17019
Logistics staff	0.12990		
Modern suprastructure	0.11122		
Administrative support	0.05492		

Source: own

according to their importance (Tab. 1, 2nd column), (Tab. 1, 4th column). Because of the limited number of pages, the AHP analysis results are not displayed.

5.2 Selecting DMUs

Taking into account recommendations of the DEA method (homogeneity, ability to perform the same tasks with the same goals, same work conditions) the following European countries, as a reference, were taken: Germany, Belgium, Denmark, Sweden, the Netherlands, Spain, France and potentially Italy. The selected countries are logistics 'superpowers' and have already successfully implemented logistics platforms.

With respect to the rule of thumb (7) only 4 inputs/outputs can be used in the DEA method (2 outputs + 2 inputs or 3 inputs + 1 output or 1 input + 3 outputs). The authors decided to include the two most important inputs from the set and the two most important outputs from

the set (marked bold in Tab. 1). After that, data collection starts. Combining different sources of data (Eurostat, statistical offices of individual countries, annual financial reports of ports, websites of logistics associations, of single logistics providers, of ministries) the authors managed to collect the necessary data for 2016, since for 2017 it was not yet possible to find all the requested data.

To further confirm whether the selection of input and output data is able to reflect the efficiency of the logistics platform and to verify whether an increase of output will not decrease the input of another item the Pearson's correlation analysis was used (Tab. 2). Although the correlation of the logistics distribution centre and total GDP is moderately significant (>0.6), the authors decided to take it into account because of the small sample size (only 8 countries) and because correlations of others inputs and outputs are less correlated.

Tab. 2: Correlations between variables

	Annual goods transhipment	Total GDP	Railway infrastructure	Logistics distribution centres
Annual goods transhipment	1			
Total GDP	0.254	1		
Railway infrastructure	0.228	0.156	1	
Logistics distribution centres	0.119	0.619	0.362	1

Source: own

5.3 Choice of Orientation and Returns to Scale

This study employs an output oriented model, since the authors attempt to maximize the outputs (elements of logistics platform) at the input level. Based on the fact that every investment in outputs results in an increase of inputs (investments in infrastructure has positive benefits on the growth of GDP), the CRS model, where constant return to scale is assumed and all DMUs are operating at an optimal scale, seems to be more appropriate. The correlation coefficient between the size of DMU (in our case total annual throughput) and CRS efficiency scores, 0.33, indicates that here is no correlation between the size of the DMU and efficiency, and so the CRS model proves to be appropriate.

5.4 Results and Analysis

The data were evaluated using DEA-Solver by Jablonsky (Jablonský, 2009). Tab. 3 shows the results obtained from the CRS model, which includes a different set of variables in order to evaluate the robustness of the results.

Initially, the DEA is applied to the full data set of 2 outputs and 2 inputs (Tab. 3, 2nd column). The countries that achieved technical coefficient scores equal to 1 are efficient. Coefficient scores higher than 1 display inefficiency. Then, the DEA without one input is applied. Firstly, only the input 'annual goods transshipment' is used (Tab. 3, 3rd column), then just the input 'total GDP' is used (Tab. 3, 4th column). At the end, the DEA without one output is applied (Tab. 3, 5th-6th column).

Tab. 3: Efficiency scores for the full CRS model and models without one input and one output

DMU	Full CRS model	Efficiency value without input		Efficiency value without output	
		Annual goods transshipment (in 1000 tons)	Total GDP (€ bill.)	Railway infrastructure (in km)	Logistics distribution centre (in km ²)
Germany	1	1	1	1	1
Belgium	2.230	2.230	9.797	3.338	2.791
Denmark	1.952	1.928	5.044	2.724	2.504
Sweden	1	1	1.840	2.538	1
Netherlands	3.247	3.245	25.697	3.569	5.218
Spain	1.259	1.258	2.983	4.440	1.258
France	1.150	1.523	1.407	2.449	1.150
Slovenia	2.412	7.958	2.499	130.479	2.449
Mean	1.780	2.517	6.277	18.817	2.171
Standard deviation	0.763	2.172	7.808	42.214	1.345
Nr. of efficient DMU	2	2	1	1	2

Source: own

Germany is efficient in all situations, which shows that its results are robustly efficient and its role as a reference in this model is not questionable. Sweden experiences variation in efficiency scores when variable annual GDP or length of railways is omitted. This indicates that the GDP and length of railways indicators are critical for the efficiency of Sweden. Sweden is therefore marginally efficient.

The Pearson correlation coefficient between the full CRS model and other models presented a range from 0.321 to 0.964. The results are therefore robust in general.

To test the robustness of the DEA two additional analyses were made. In the first Germany and in the second Sweden was removed from the set of DMUs. Tab. 4 shows that deleting Sweden has as great an impact

Tab. 4: Removal of efficient DMUs

DMU removed from analysis	Mean	Standard deviation	Nr. of efficient DMUs	Spearman's correlation coefficient
Germany	1.747	0.249	2	0.757
Sweden	1.278	0.752	2	0.724

Source: own

Tab. 5: Total output increases needed to make Slovenian logistics platform efficient

Outputs	Original value	Virtual value	Difference
Railway infrastructure	1,207	2,912	1,705
Logistics distribution centre	1.80	231.54	229.74

Source: own

as deleting Germany. In the case of removing Germany two countries are efficient; in the case of removing Sweden two countries are efficient as well. Spearman's rank correlation coefficient between the full DMU model and two models with one DMU removed indicated that the coefficients' ranges are significant and the efficiency analysis is stable.

It is worth highlighting that the scores for Slovenia are very low in all modes. Slovenia is therefore far from being efficient. Both outputs 'railway infrastructure' and 'distribution logistics centres' require adjustments. Railway infrastructure requires an increase of 1,705 km

and a logistics distribution centre increase of 229.74 km² (Tab. 5).

However, Slovenia is not able to build another 1,705 km of railways due to geographical limitations. The authors therefore calculated the efficiency value as if Slovenia had already built all the railway lines foreseen by Prometni inštitut Ljubljana (2011) (an additional 152 km of railway lines) (Tab. 6). Slovenia is still inefficient, but its index of relative technical efficiency is lower. These calculations confirm the DEA's possibility of generalizing feedback in order to reflect the real state of a decision and adjust that decision accordingly.

Tab. 6: Efficiency scores for full CRS model, but with additional 152 km railway lines

DMU	Full CRS model – present nr. of railway lines	Full CRS model – 152 km more
Germany	1	1
Belgium	2.230	2.229
Denmark	1.952	1.952
Sweden	1	1
Netherlands	3.247	3.247
Spain	1.259	1.259
France	1.150	1.150
Slovenia	2.412	2.143

Source: own

Conclusions

The development of logistics towards logistics platforms with high strategic flexibility and a design that is a resource base for new market positions is absolutely necessary. This demands a well designed and implemented efficiency monitoring model of logistics platforms.

A combined Delphi-AHP-DEA methodological approach was proposed. The integration of Delphi and AHP enables the identification of the set of inputs/outputs, tailored to the problem undergoing analysis; and, further, determination of their importance. The risk of the most critical step of DEA analysis, is compared to articles published so far, reduced and the results more robust. This partly answers the RQ3.

The integration of Delphi and AHP also enables transparency. The weights for each indicator are endogenously determined to reveal the maximum overall efficiency for each DMU and thus are not subject to specific normative preferences and are also clearly presented and can even be imposed or restricted if necessary. Reproducibility is therefore provided.

The proposed methodology uses the cardinal measurement model with a mathematically logical procedure and axioms and is therefore highly trustworthy (quality method and findings). The methodology generates results that are valid, since they reflect accurately the values of the user, which can also be interpreted via other empirical bases. The results are generally useful for different types of decisions. These facts answer the RQ3.

The DEA conducts several sensitivity analyses to validate the feasibility and robustness of its model and is therefore rated medium feasible and robust (Saaty, 2008). This fact answers the RQ1.

The Delphi-AHP-DEA approach is a structured approach involving several steps, the sequence of which is clearly defined. Each steps' results are either inputs for the next step or trigger the next step. The methodology upgrades theoretical knowledge, but at the same time corresponds to a real situation and thus represents the potential for great support for decision-makers.

The results of the Delphi-AHP-DEA approach can help decision makers understand where the major scope for improvement lies in their country and they may choose to examine why certain countries outperform them and explore whether their peers have adopted policies that are worthy

of adoption (Cylus, Papanicolas, & Smith, 2017). These facts answer the RQ2.

While progress has been made, the proposed framework still leaves some open paths for further improvements and investigation. The authors realised that there is a lack of a solid classification system of performance criteria, involving all sustainable pillars, which serves in the proposed methodology to compare the criteria obtained by the Delphi method. A development of a hierarchy-type performance-based model, based on a systematic literature review and international empirical survey, selected MCDM method for criteria evaluation and selection and including sensitivity analysis, such as the Cohen kappa statistics and many others, is required.

A proposed classification system would also be a good basis for the development of the new Delphi-AHP-Slack Based Measure (SBM)-DEA model, where not only desirable but also undesirable outputs of logistics platforms, such as CO₂ emissions, are taken into account.

The case study illustrated in the article was conducted in only one country, using rather small, but for this case study, the real number of DMUs and a relatively small number of inputs/output variables. Thus, there are improvements to be made in sample design to allow for further validation and enhancement of the model.

One limiting factor of this study is the rather small number of interviews that were performed. Future studies could expand the sample size.

In the conventional AHP, the pairwise comparison is made using a discrete scale of 1–9, which is simple and easy to use, but it does not take into account the uncertainty related to the mapping of participants' judgement to a number. The triangular fuzzy numbers, $\hat{1}$ to $\hat{9}$ could be utilized to improve the conventional nine-point scale.

References

- Abrahamsson, M., Aldin, N., & Stahre, F. (2003). Logistics platforms for improved strategic flexibility. *International Journal of Logistics: Research and Applications*, 6(3), 85–106. <https://doi.org/10.1080/1367556031000123061>
- Andersen, P., & Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management science*, 39(10), 1261–1264.
- Antún, J. P., & Alarcón, R. (2014). Ranking Projects of Logistics Platforms: A Methodology Based on the Electre Multicriteria Approach.

- Procedia – Social and Behavioral Sciences*, 160, 5–14. <https://doi.org/10.1016/j.sbspro.2014.12.111>
- Awad-Núñez, S., González-Cancelas, N., Soler-Flores, F., & Camarero-Orive, A. (2015). How should the sustainability of the location of dry ports be measured? A proposed methodology using Bayesian networks and multi-criteria decision analysis. *Transport*, 30(3), 312–319. <https://doi.org/10.3846/16484142.2015.1081618>
- Azadi, M., Hosseinzadeh Zoroufchi, K., & Farzipoor Saen, R. (2012). A combination of Russell model and neutral DEA for 3PL provider selection. *International Journal of Productivity and Quality Management*, 10(1), 25–39. <https://doi.org/10.1504/IJPM.2012.047940>
- Bansal, A., & Kumar, P. (2013). 3PL selection using hybrid model of AHP-PROMETHEE. *International Journal of Services and Operations Management*, 14(3), 373–397. <https://doi.org/10.1504/IJSOM.2013.052096>
- Bolunmole, Y. A., Closs, D. J., & Rodammer, F. A. (2015). The economic development role of regional logistics hubs: a cross-country study of interorganizational governance models. *Journal of Business Logistics*, 36(2), 182–198. <https://doi.org/10.1111/jbl.12088>
- Bourlakis, M., Melewar, T., Banomyong, R., & Supatn, N. (2011). Selecting logistics providers in Thailand: a shippers' perspective. *European Journal of Marketing*, 45(3), 419–437. <https://doi.org/10.1108/03090561111107258>
- Bray, S., Caggiani, L., & Ottomanelli, M. (2015). Measuring transport systems efficiency under uncertainty by fuzzy sets theory based Data Envelopment Analysis: theoretical and practical comparison with traditional DEA model. *Transportation Research Procedia*, 5, 186–200. <https://doi.org/10.1016/j.trpro.2015.01.005>
- Çakir, E. (2009). *Logistics outsourcing and selection of third party logistics service provider (3PL) via fuzzy AHP* (Master Thesis). Bahçeşehir University, Istanbul.
- Charles, V., Kumar, M., & Kavitha, S. I. (2012). Measuring the efficiency of assembled printed circuit boards with undesirable outputs using data envelopment analysis. *International Journal of Production Economics*, 136(1), 194–206. <https://doi.org/10.1016/j.ijpe.2011.11.010>
- Cheng, M. C. B., & Wang, J. J. (2016). An integrative approach in measuring hub-port supply chain performance: Potential contributions of a logistics and transport data exchange platform. *Case Studies on Transport Policy*, 4(2), 150–160. <https://doi.org/10.1016/j.cstp.2016.03.001>
- Cook, W. D., Kress, M., & Seiford, L. M. (1992). Prioritization models for frontier decision making units in DEA. *European Journal of Operational Research*, 59(2), 319–323. [https://doi.org/10.1016/0377-2217\(92\)90148-3](https://doi.org/10.1016/0377-2217(92)90148-3)
- Cylus, J., Papanicolas, I., & Smith, P. C. (2017). Using data envelopment analysis to address the challenges of comparing health system efficiency. *Global Policy*, 8(52), 60–68. <https://doi.org/10.1111/1758-5899.12212>
- Daim, T. U., Udbye, A., & Balasubramanian, A. (2012). Use of analytic hierarchy process (AHP) for selection of 3PL providers. *Journal of Manufacturing Technology Management*, 24(1), 28–51. <https://doi.org/10.1108/17410381311287472>
- de Carvalho, C. C., de Carvalho, M. F. H., & Lima Jr, O. F. (2013). *Efficient logistic platform design: the case of Campinas Platform*. Paper presented at XVI International Conference on Industrial Engineering and Operations Management, São Carlos, Brazil. Retrieved from http://www.abepro.org.br/biblioteca/enegep2010_ti_st_113_741_17234.pdf
- Dyson, R. G., Allen, R., Camanho, A. S., Podinovski, V. V., Sarrico, C. S., & Shale, E. A. (2001). Pitfalls and protocols in DEA. *European Journal of Operational Research*, 132(2), 245–259. [https://doi.org/10.1016/S0377-2217\(00\)00149-1](https://doi.org/10.1016/S0377-2217(00)00149-1)
- Fanti, M. P., Iacobellis, G., Mangini, A. M., Precchiazzi, I., & Ukovich, W. (2017). *A flexible platform for intermodal transportation and integrated logistics*. Paper presented at the Service Operations and Logistics, and Informatics (SOLI), 2017 IEEE International Conference (pp. 224–229). <https://doi.org/10.1109/SOLI.2017.8120998>
- Fawcett, S. E., Waller, M. A., & Bowersox, D. J. (2011). Cinderella in the C-suite: conducting influential research to advance the logistics and supply chain disciplines. *Journal of Business Logistics*, 32(2), 115–121. <https://doi.org/10.1111/j.2158-1592.2011.01010.x>
- Forman, E. H., Saaty, T. L., Selly, M. A., & Waldron, R. (1983). *Expert choice*. McLean, VA: Decision Support Software Inc.
- Gattuso, D., Cassone, G. C., & Pellicanò, D. S. (2014). A micro-simulation model for performance evaluation of a logistics platform. *Transportation Research Procedia*, 3, 574–583. <https://doi.org/10.1016/j.trpro.2014.10.036>

- Grzybowska, K., & Gajsek, B. (2016). Supply Chain Logistics Platform as a Supply Chain Coordination Support. In J. Bajo, M. J. Escalona, S. Giroux, P. Hoffa-Dąbrowska, V. Julián, P. Novais, N. Sánchez-Pi, R. Unland & R. Azambuja-Silveira (Eds.), *Highlights of Practical Applications of Scalable Multi-Agent Systems* (Vol. 616, pp. 61–72). Cham: Springer. https://doi.org/10.1007/978-3-319-39387-2_6
- Haralambides, H., & Gujar, G. (2012). On balancing supply chain efficiency and environmental impacts: An eco-DEA model applied to the dry port sector of India. *Maritime Economics & Logistics*, 14(1), 122–137. <https://doi.org/10.1057/mel.2011.19>
- Hsu, C.-I., Liao, P., Yang, L.-H., & Chen, Y.-H. (2005). High-tech firm's perception and demand for air cargo logistics services. *Journal of the Eastern Asia Society for Transportation Studies*, 6, 2868–2880. <https://doi.org/10.11175/easts.6.2868>
- Huguenin, J.-M. (2012). *Data Envelopment Analysis (DEA): a pedagogical guide for decision makers in the public sector*. Chavannes-près-Renens: Institut de hautes études en administration publique.
- Jablonský, J. (2009). Software support for multiple criteria decision making problems. *Management Information Systems*, 4(2), 29–34.
- Jaskowski, P., Biruk, S., & Bucon, R. (2010). Assessing contractor selection criteria weights with fuzzy AHP method application in group decision environment. *Automation in construction*, 19(2), 120–126. <https://doi.org/10.1016/j.autcon.2009.12.014>
- Jenkins, L., & Anderson, M. (2003). A multivariate statistical approach to reducing the number of variables in data envelopment analysis. *European Journal of Operational Research*, 147(1), 51–61. [https://doi.org/10.1016/S0377-2217\(02\)00243-6](https://doi.org/10.1016/S0377-2217(02)00243-6)
- Johnes, J. (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review*, 25(3), 273–288. <https://doi.org/10.1016/j.econedurev.2005.02.005>
- Kocisova, K., Hass-Symotiuk, M., & Kludacz-Alessandri, M. (2018). Use of the DEA method to verify the performance model for hospitals. *E&M Economics and Management*, 21(4), 125–140. <https://dx.doi.org/10.15240/tul/001/2018-4-009>
- Kumar, P., & Singh, R. K. (2012). A fuzzy AHP and TOPSIS methodology to evaluate 3PL in a supply chain. *Journal of Modelling in Management*, 7(3), 287–303. <https://doi.org/10.1108/17465661211283287>
- Kumar Singh, S., & Kumar Bajpai, V. (2013). Estimation of operational efficiency and its determinants using DEA: The case of Indian coal-fired power plants. *International Journal of Energy Sector Management*, 7(4), 409–429. <https://doi.org/10.1108/IJESM-03-2013-0009>
- Lakshmanan, T. R. (2011). The broader economic consequences of transport infrastructure investments. *Journal of transport geography*, 19(1), 1–12. <https://doi.org/10.1016/j.jtrangeo.2010.01.001>
- Macharis, C., Springael, J., De Brucker, K., & Verbeke, A. (2004). PROMETHEE and AHP: The design of operational synergies in multicriteria analysis: Strengthening PROMETHEE with ideas of AHP. *European Journal of Operational Research*, 153(2), 307–317. [https://doi.org/10.1016/S0377-2217\(03\)00153-X](https://doi.org/10.1016/S0377-2217(03)00153-X)
- Markovits-Somogyi, R., Gece, G., & Bokor, Z. (2011). Basic efficiency measurement of Hungarian logistics centres using data envelopment analysis. *Periodica Polytechnica Social and Management Sciences*, 19(2), 97–101. <https://doi.org/10.3311/pp.so.2011-2.06>
- Martí, L., Martín, J. C., & Puertas, R. (2017). A DEA-LOGISTICS PERFORMANCE INDEX. *Journal of Applied Economics*, 20(1), 169–192. [https://doi.org/10.1016/S1514-0326\(17\)30008-9](https://doi.org/10.1016/S1514-0326(17)30008-9)
- Matajič, M., Šrenac, M., Bolha, V., Dobrijević, A., Fridrih Praznik, M., Genjac, A., ... Kramar, U. (2011). *Analiza možnosti in potreb razvoja javne železniške infrastrukture v Republiki Sloveniji: Strokovno-razvojna naloga, končno poročilo*. Ljubljana: Prometni inštitut Ljubljana.
- Nataraja, N. R., & Johnson, A. L. (2011). Guidelines for using variable selection techniques in data envelopment analysis. *European Journal of Operational Research*, 215(3), 662–669. <https://doi.org/10.1016/j.ejor.2011.06.045>
- Notteboom, T. E., & Rodrigue, J.-P. (2005). Port regionalization: towards a new phase in port development. *Maritime Policy & Management*, 32(3), 297–313. <https://doi.org/10.1080/03088830500139885>
- Pastor, J. T., Ruiz, J. L., & Sirvent, I. (2002). A statistical test for nested radial DEA models. *Operations Research*, 50(4), 728–735. <https://doi.org/10.1287/opre.50.4.728.2866>
- Qureshi, M., Kumar, D., & Kumar, P. (2007). *Selection of potential 3PL services*

providers using TOPSIS with interval data. Paper presented at the Industrial Engineering and Engineering Management, 2007 IEEE International Conference (pp. 1512–1516). <https://doi.org/10.1109/IEEM.2007.4419445>

Rajasekar, T., & Deo, M. (2014). Is there any efficiency difference between input and output oriented DEA Models: An approach to major ports in India. *Journal of Business and Economic Policy*, 1(2), 18–28.

Ramanathan, R. (2003). *An introduction to data envelopment analysis: a tool for performance measurement*. New Delhi: Sage Publications.

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, 48(1), 9–26. [http://dx.doi.org/10.1016/0377-2217\(90\)90057-1](http://dx.doi.org/10.1016/0377-2217(90)90057-1)

Saaty, T. L. (2008). Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process. *RACSAM – Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas*, 102(2), 251–318. <https://doi.org/10.1007/BF03191825>

Saaty, T. L., & Ergu, D. (2015). When is a decision-making method trustworthy? Criteria for evaluating multi-criteria decision-making methods. *International Journal of Information Technology & Decision Making*, 14(06), 1171–1187. <https://doi.org/10.1142/S021962201550025X>

Sarmiento, J., Renneboog, L., & Verga-Matos, P. (2017). Measuring highway efficiency by a DEA approach and the Malmquist index. *European Journal of Transport and Infrastructure Research*, 17(4), 530–551. <https://doi.org/10.18757/ejtir.2017.17.4.3213>

Sheffi, Y. (2013). Logistics-intensive clusters: global competitiveness and regional growth. In *Handbook of global logistics* (pp. 463–500). New York, NY: Springer.

Silva, R. M. d., Senna, E. T. P., Lima, O. F. Jr, & Senna, L. A. d. S. (2015). A framework of performance indicators used in the governance of logistics platforms: the multiple-case study. *Journal of Transport Literature*, 9(1), 5–9. <https://doi.org/10.1590/2238-1031.jtl.v9n1a1>

Srisawat, P., Kronprasert, N., & Arunotayanun, K. (2017). Development of decision support system for evaluating spatial efficiency of regional transport logistics. *Transportation Research Procedia*, 25, 4832–4851. <https://doi.org/10.1016/j.trpro.2017.05.493>

Sufian, F. (2007). Trends in the efficiency of Singapore's commercial banking groups: A non-stochastic frontier DEA window analysis approach. *International Journal of Productivity and Performance Management*, 56(2), 99–136. <https://doi.org/10.1108/17410400710722626>

Tone, K., & Tsutsui, M. (2009). Network DEA: A slacks-based measure approach. *European Journal of Operational Research*, 197(1), 243–252. <https://doi.org/10.1016/j.ejor.2008.05.027>

Vincová, K. (2005). Using DEA models to measure efficiency. *Biatec*, 13(8), 24–28.

Wu, H.-b., & Yue, Y. (2008). 3PL Vendors Evaluation Project Based on Entropy Right TOPSIS. *Journal of Lanzhou Jiaotong University*, 27, 88–91.

Yang, C., Taudes, A., & Dong, G. (2017). Efficiency analysis of European Freight Villages: three peers for benchmarking. *Central European Journal of Operations Research*, 25(1), 91–122. <https://doi.org/10.1007/s10100-015-0424-5>

Yasaroglu, B. A., Özdağoğlu, G., & Özdağoğlu, A. (2006). Fuzzy logic-based decision making model on selection and evaluation of logistics service providers within a firm. Paper presented at the 4th International Logistics and Supply Chain Congress, Izmir, Turkey.

Yong, G. (2017). *The Impact of Service Innovation Capability on Logistics Platform Performance*. Paper presented at International Conference on Economics, Management Engineering and Marketing (EMEM 2017). <https://doi.org/10.12783/dtem/emem2017/17098>

Zhu, J. (2014). Quantitative models for performance evaluation and benchmarking: Data envelopment analysis with spreadsheets. In *International Series in Operations Research & Management Science* (Vol. 213). Cham: Springer. <https://doi.org/10.1007/978-3-319-06647-9>

PROSPECTIVE MADM AND SENSITIVITY ANALYSIS OF THE EXPERTS BASED ON CAUSAL LAYERED ANALYSIS (CLA)

**Sarfraz Hashemkhani Zolfani¹, Morteza Yazdani²,
Edmundas Kazimieras Zavadskas³, Hamidreza Hasheminasab⁴**

¹ Catholic University of the North, School of Engineering, Chile, ORCID: 0000-0002-2602-3986, sa.hashemkhani@gmail.com;

² Universidad Loyola Andalucía, Department of Management, Spain, ORCID: 0000-0001-5526-8950, morteza_yazdani21@yahoo.com;

³ Vilnius Gediminas Technical University, Institute of Sustainable Construction, Lithuania, ORCID: 0000-0002-3201-949X, edmundas.zavadskas@vgtu.lt;

⁴ University of Tehran, School of Civil Engineering, College of Engineering, Iran, Hasheminasab@ut.ac.ir.

Abstract: “Multiple Attribute Decision Making (MADM)” is an expert based field which is working based on real data and experts’ opinions. So many studies have been doing based on MADM methods which they usually use qualitative data based on experts’ ideas. Decisions based on the experts’ opinion shall be carefully designed to cope the real problems uncertainty. This uncertainty will be even more intricate if combining the problem with the ambiguity of the future study. Prospective MADM is a future based type of MADM field which is concentrating on decision making and policy making about the future. Prospective MADM (PMADM) can have both explorative and descriptive paradigms in the studies but it will more useful to be applied for strategic planning. In this regard, experts’ role would be even more challenging because one/some possible future/futures will be partially designed based on their opinions. Future and prediction always complicates the decision environment, especially methodologies founded on experts’ judgement. Considering experts’ preferences, attitude, and background, they may be a major source of inaccurate results. Causal Layered Analysis (CLA) is well-known “Futures Studies” method which is qualitative and usually is supporting other methods such as “Backcasting” and “Scenario Planning”. CLA has a deep point of view to the subjects to support a future with all those changes which are necessary for the main goal/goals. In this study, this idea will be proposed that CLA can be added to PMADM outline to decrease the risk of unsuitable decisions for the future and for this aim a case study about energy and CO₂ consumption in policy making level proposed and a hybrid MADM method based on BWM-CoCoSo applied in the PMADM outline for the procedure.

Keywords: Prospective Multiple Attribute Decision Making (PMADM), sensitivity analysis, experts, Causal Layered Analysis (CLA), Best Worst Method (BWM), COMbined COMpromise SOLUTION (CoCoSo).

JEL Classification: Q48, Q56, C91.

APA Style Citation: Hashemkhani Zolfani, S., Yazdani, M., Zavadskas, E. K., & Hasheminasab, H. (2020). Prospective MADM and Sensitivity Analysis of the Experts Based on Causal Layered Analysis (CLA). *E&M Economics and Management*, 23(3), 208–223. <https://doi.org/10.15240/tul/001/2020-3-013>

Problem Definition

Multiple Attribute Decision Making (MADM) methods have been working by real data and qualitative analysis of experts’ ideas. It is really

difficult and complicated to find more related experts to a topic which is solving but still there is a bigger challenge which is experts’ backgrounds. In so many cases there are so

many experienced experts but their attitudes are very dissimilar and diverse. It can be said that none of their ideas are incorrect but do they have a well-defined perspective to the main subject? Maybe based on so many limitations there is not enough chance to check their consistency rate about an issue but it is possible to make a higher consistency based on a pre-plan. Mostly, only investigators have enough knowledge about a new research because they are defining and illustrating it in different dimensions of the topic. Usually, for solving multi-attribute problems, investigators do not explain and express their exact ideas to the experts because of so many challenges and limitations such as time and other topics. Causal Layered Analysis (CLA) is a really helpful approach and method in defining a topic in depth. CLA is a method of Futures Studies field which is really useful in decision making, policy making and generally long-term planning. As everyone knows, our decisions today are making for the future whether short-term, medium-term or long-term.

Based on a well-prepared CLA outlook which shows a depth in its four levels, there is an opportunity to express exact point of view about the study to the experts from investigators side. The investigators can also examine the general paradigm of the researchers based on CLA analysis. This is really vital to have some experts who are really connected to the main idea, methodology and paradigm of the study. This is an advantage which CLA can guarantee it for the mentioned aim. This study is trying to show how much selecting experts is an important step which should be considered more in the MADM studies to increase the quality and output of a MADM challenge. Prospective MADM as a new approach has been developing lately. The classic outline of MADM is expanding based on PMADM approach and some new items have been adding to the old structure. One of another point which is really critical for the new approach is who are creating a future which has a core paradigm inside. So, CLA in general can be suitable for classic MADM but it has bigger influences and impacts on outputs of PMADM approach because PMADM proposed to solve bigger and more long-term challenges and problems. In this study, the process of experts' selection in PMADM outline will be discussed. To support this idea, Casual Layered Analysis (CLA) is applied to illustrate

a deep perspective in this procedure. This idea will be discussed with a real case study and based on a new hybrid MADM method, BWM-CoCoSo, will be analyzed.

1. Literature Review on Sensitivity Analysis and MADM Studies

All studies related to the sensitivity about MADM field can be categorized in two main categories.

First category: Those studies which are working on presenting a new way to add a sensitivity analysis to a common MADM method. Mostly, those studies proposed when researchers were using more than a method for solving the problems. It can be said that the main idea is to check robustness rate of results.

Triantaphyllou and Sanchez (1997) presented a sensitivity analysis for some deterministic methods such as: Weighted Sum Model (WSM), Weighted Product Model (WPM) and Analytic Hierarchy Process (AHP). Zavadskas et al. (2007) presented a new sensitivity analysis on SAW method but the idea was to check the role of criteria and normalization methods especially Linear Normalization. Toloie Eshlaghy et al. (2009) proposed a sensitivity analysis on criteria values in decision making matrix of SAW method based on calculations about deviation. Yazdani et al. (2016) applied different type of normalizations for the sensitivity analysis. MOORA and WASPAS were in the core of this research and their results with different normalization ways have compared. Pamučar et al. (2017) presented a new model for consistency evaluation of MADM methods for selecting an optimum option as an alternative. The model examined on some common MADM methods alike TOPSIS, COPRAS, VIKOR and ELECTRE. Mukhametzyanov and Pamučar (2018) proposed a new sensitivity model for MADM methods. The study developed based on the idea of working on top three alternatives based on final ranking and especially those cases which top three alternatives are not so much different. The model examined on several common MADM methods such as SAW, MOORA, VIKOR, COPRAS, CODAS, MABAC, PROMETHEE-I, II, and ORESTE-II.

Second category: Those studies which are concentrating on sensitivity analysis inside the original methods. It means some methods have been presented with the kind of sensitivity analysis which is mostly inconsistency rate.

It can be said that all methods such as Analytic Hierarchy Process (AHP) (Saaty, 1980), Analytic Network Process (ANP) (Saaty, 1996; 1999), Factor Relationship (FARE) (Ginevicius, 2011), Best Worst Method (BWM) (Rezaei, 2015) and Full Consistency Method (FOCUM) (Pamučar et al., 2018) which are working based on pairwise comparisons are working based on consideration of inconsistency rate of experts' ideas and main goal in mentioned method was decreasing inconsistency of ideas in practice. Hashemkhani Zolfani et al. (2018a) also presented a new extended version of SWARA method and this sensitivity analysis applied on experts' ideas to examine the results.

2. Methodology

In this part three sections will be presented as follow: 1. "Causal Layered Analysis (CLA)", 2. "Why CLA?", and 3. "Prospective MADM".

2.1 Causal Layered Analysis (CLA)

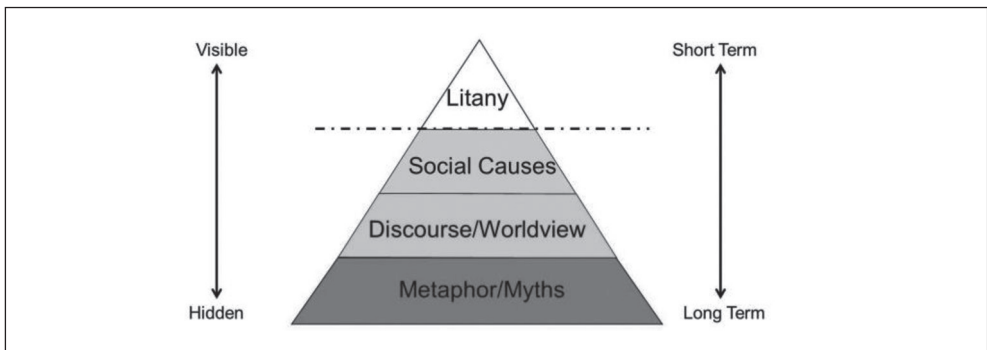
Firstly, CLA was introduced as one of Futures Studies method around two decades ago with this goal to create transformative spaces for making future alternatives instead of predicting the futures (Inayatullah, 1998). CLA is kind of communicative method that applies storytelling and narrative to consider and build all possible and probable futures (Heinonen et al., 2017). This method established and influenced by post-structural theory which illustrates and explores these causal layers in four levels and separate-deep layers (Milojević, 2015). These four levels are illustrated in Fig. 1.

1. "Litany" refers to those topics which usually consider as those "facts" that hardly ever proved, confirmed or asked. 2. "Social causes" focuses on system's paradigm and perspective on different topics such as political and cultural attributes, social issues, economic and eventually clarify behavioral rules back behind of the litany level. 3. "Discourse" illustrates important impressions that are historical, social and has great multi-dimensional impact on common logic, sense, values, worldviews and paradigms. 4. "Metaphors and Myths" which demonstrates storylines and wrong information and data which usually people and societies are justifying themselves (Milojević & Inayatullah, 2015).

2.2 Why CLA?

CLA is recognized by its criticizing paradigm as a futures research method which is working based on an understandable point of view about futures changes. This method is applying based on a core assumption about framing a challenge or a problem and considering its impact about how the probable changes will be followed (Ramos, 2003). CLA highlights the status of understanding the reality based on different layers of seeing and knowing things (Ketonen-Oksi, 2018). CLA has this potential to integrate other tools and methods and at the same time it is flexible to be integrated with other methods such as Scenario Planning and Backcasting. CLA is really helpful to be applied in emerging issues to present a better point of view about different topics (Ketonen-Oksi, 2018).

Fig. 1: CLA's levels



Source: Inayatullah (1998)

CLA has not applied with MADM methods since now and the application of that in the main procedure of solving a MADM problem will be unique and useful. According to the related literature of MADM methods, there is not a special trend related to the experts selecting process. Although solving a MADM problem based on different mathematical perspectives is important, selecting the experts seem more critical in reality. Those qualitative numbers which experts can select can even change the destiny of a nation. CLA is able to prove that a study is using an appropriate group of experts which they are able to see a problem from the eye of researchers related to the main set of goals.

2.3 Prospective MADM

During last decade, time importance and considering the future became a major topic in the field of Multiple Attribute Decision Making (MADM) and they also contained some new approaches such as Dynamic MADM and MADM based on Scenarios (Trutnevyte et al., 2012; Arms et al., 2012; Zhang, 2012; Durbach & Stewart, 2012; Hashemkhani Zolfani et al., 2013; Wang et al., 2014; Tadić et al., 2014;

Gonzalez-Prida et al., 2014; Ondrus et al., 2015; Jassbi et al., 2014; Hashemkhani Zolfani et al., 2016a; Siddiqi et al., 2016).

Prospective MADM is a new approach for decision making about future-related or future-based problems which they need to be solved in the multi-attribute framework (Hashemkhani Zolfani et al., 2016b). There was a need for consideration future orientations in the common decision making structure and especially in MADM methods and framework. Therefore, PMADM it can be seen as a new approach which can cover all future-based and multi-attribute problems because is working as a platform which is not limited to a special space (Hashemkhani Zolfani et al., 2016c).

PMADM presented in a multi-disciplinary research area which it meets Multiple Criteria Decision Making (MCDM) and its bigger picture which is Operations Research (OR) and Futures Studies, Foresight and its smaller picture Strategic Management. As it mentioned above, PMADM is a platform which has a new approach and it has a great potential to be considered an inter-disciplinary research field in the future (Hashemkhani Zolfani, 2018b).

Tab. 1: PMADM model based on future limitations

		C_1		C_{n+1}		C_n
Weights						
Limiters (L)/ Boosters (B)		$L_{1-1} \dots L_{1-n}$		$L_{n+1-1} \dots L_{n+1-n}$		$L_{n-1} \dots L_{n-n}$
	Based on C_1	Average	Based on C_{n+1}	Average	Based on C_n	Average
A_1 without L						
A_1 based on L_{1-1}						
A_1 based on ...						
A_1 based on L_{1-n}						
A_{n+1} without L						
A_{n+1} based on L_{n+1-1}						
A_{n+1} based on ...						
A_{n+1} based on L_{n+1-n}						
A_n without L						
A_n based on L_{n-1}						
A_n based on ...						
A_n based on L_{n-n}						

Source: Hashemkhani Zolfani (2016a)

The all new contributions of PMADM based on new items based on classic form of MADM are presented below:

1. Limiters/Boosters: Hashemkhani Zolfani et al. (2016b) presented the first new item in PMADM framework which can be called Limiters/Boosters. Limiters/Boosters can have the role of pay-offs of future scenarios for the evaluating alternatives in their positions. It can be illustrated where they are locating in the structure of a classic MADM framework as an example in the Tab. 1.

Tab. 1 is designed for the Limiters. Boosters can be put the same in the table. Pay attention that Limiters and Boosters can both apply at the same time in the process of decision making for decision making about the future because it can be happened in reality. Future probability also can be added to the process and all it can be measured as an introduction to the PMADM. Other items can be attached and added to the classic structure of PMADM to have a better outcome in evaluating criteria, relative weights and other probable calculations of the MADM framework.

2. Multi-aspect Criterion: is a new item in classic structure of MADM in PMADM area. It contains two main shapes of: “Hybrid criteria as a new criterion” and “a lately defined concept for the other criteria as a criterion”. The importance of time will be showed with this new item to control the definitions during the years. In future definitions and criteria can be mixed or developed in different aspects and approaches. It is really important to have

an explicit definition about a certain time in the future while the decision making process is happening (Hashemkhani Zolfani et al., 2018b).

3. Supportive-backup criteria: is another additive item to PMADM outline. While different future scenarios are considering, this new item can be really useful. It shapes all future decision making matrix in a one matrix and decision makers can shape to whatever they want and make their decision better and more effective (Hashemkhani Zolfani & Masaeli, 2019). An example is shown is Tab. 2.

3. Possible Structures

Generally, MADM is really dependent to the expert’s ideas and do many sensitivity analysis have been doing to check if the final answer based on experts’ opinions is reliable or is not possible to be counted as a consistent result. The process of selecting the experts is a really challenging procedure and usually it works in two main categories. In solving a problem usually knowledge of different fields will be needed. Therefore, the general concept and paradigm behind of each field would be really critical and vital for the investigators. Another key point is the expert, itself. When someone is selected, it does not mean necessarily he/she is coming from the paradigm which investigators are looking at it. Finally, these two main categories can be divided in two main sections as:

1. A position as chair of a field

This section will be discussed based on some simple examples.

Tab. 2: Position of “Supportive-backup” criteria

Supportive-backup criteria	C_1	C_2	C_{n-1}	C_n
	C_{s1-1}	C_{2^*-s1}	$C_{s1-n-1-sb1}$	...
	C_{s2-1}	C_{s1-2}	C_{n-1^*-s2}	...
	C_{u1-1}	...	...	...
A_1	...	...	...	...
Reserved A_1	...	...	...	...
Reserved A_1	...	...	...	...
Reserved A_1	...	...	...	...
...
...
A_n	...	...	...	...

Source: Hashemkhani Zolfani & Masaeli (2019)

First example: Future sustainability:

Consider an expert from Economic field who believes on short-term profits as it can be seen as a general policy of some countries as different strategies. In this case, investigators are inviting a person who should lead a research on sustainability path with his/her qualitative numbers in MADM field. Consider all topics about the future need a long-term point of view and will not be achievable with whom they do not believe in that.

Second example: Education and future generations: A comparison between education system of some countries show that probably related politicians have a bias on their systems. Considering Japan, Finland, the USA or Chile shows a huge different in the systems and designing new policies should be really independent from what countries are applying as their policies. Is not possible to invite from a person who does not believe in a different future which that study can guaranty a better life for the society.

Third example: Structure of policy making:

Experts like normal people can have their ideology or paradigm about everything. Now, consider political parties, ideological governments and groups and people who believe or not believe in the common political structures. All related topics to the goal of studies which investigators are following have interconnected to so many aspects and dimensions. This issue that investigators should know more about experts' background is a real challenge for the decision making processes especially topics related to the futures.

2. General characteristics of the expert

Some experts necessarily are not coming from obvious backgrounds. In so many cases experts do not have enough information and knowledge about what investigators are going to do because most the time researchers are working on new topics which can be not so common but what is necessary is different knowledge from different research fields and areas. CLA can be useful in these two categories. It can be seen what experts are thinking about a study when their general point of view and paradigm will be examinable. CLA gets this chance to the researchers to find the most suitable experts to their studies. Another point can be noticed that, in so many cases researchers need different point of view. In this case and by CLA researchers can be sure about

what they need about different point of views. It means if you there is a need for different ideas about something it can be definitely findable.

4. CLA in Practice

The idea is to evaluate experts in four levels of CLA but the first and second level can be what we can define and get easily from the ideas, easily. It feels Worldview level and myth and metaphor levels need more attention. For this mean, a case as an example will be considered. Baradaran Ghahfarokhi et al., (2018) applied CLA method for planning the future of the University of Tehran. Is this study, common levels have analyzed (How is it now?) and defined another four levels (what should be?). It shows that moving to a future it needs changes in different levels and shifting in paradigms mostly are needed. In this section some of the most important points as sample will be evaluated:

- In systematic causes, multi-source of financing and internationalization were mentioned. This is a part of the plan which researchers reached to that so all decisions should be lead to this goal of the second level.

What if an expert did not believe in free international relationships? What if an expert still believes in governmental financial supports?

- In worldview level, it mentioned if you as a university are not going to invest on new technologies, you will be left behind.

But what if political or ideological ideas come inside? Iran had a not suitable experience in producing airplanes. What will happen if the expert has preferences on special field? Any conflict of interest would be really dangerous for the future planning.

- In metaphor level: it stated that science and money together should be the goal and not only science for science for science only for money.

But most of people are thinking like that but in reality so many of them cannot think like that. This idiom which says that science is better than money is still common in the society. Meanwhile, because of bad financial situation some people are thinking completely different and they gave up. They prefer to follow the money way so they do not believe in science anymore. So, it is really challenging to find those experts who have a really clear background and probably they should be those specialists in their fields who could earn a considerable amount of money.

As it mentioned about outputs of what the University of Tehran should be changed for a brighter future, it can be said that in solving current problems of the university experts can have a great role. In this section some points will be discussed.

- Political issues are really related to the managing system of the university. So, researchers should be sure about experts' perspectives. Those experts who are thinking politically cannot be good options.
- For example in the mentioned study of Baradaran Ghahfarokhi et al. (2018), former ministers of science, research and technology were invited. The experiences would be really helpful but some positions had enough time to make some changes therefore, it seems better to invite more entrepreneurs and those who had some visits from the best universities of the world because future needs experience about what is going to happen and not only what is happened.
- Teamwork culture; experts should have good taste of doing teamwork. The process should be always with some feedbacks from researchers and other experts. This loop can guarantee a better decision and output about the future.
- Cultural habits and procedures; when there is a need for a radical change but some people which are experts for the researchers are deeply believed in some habits, procedures and routines.
- Knowledge about the future; The expert who is deciding about the future should know about what is happening in the world, all new trends, all new driving forces, newest strategies of universities, related multi-disciplinary fields, new international foresight programs, new international regulations, latest related publications and future of education in general.

5. Possible Evaluation Ways

There are so many ways for this evaluation about experts' paradigms and perspectives. Common ways of gathering data in qualitative studies would be helpful. The most important ones can be as follow:

- Background evaluation: Political background, past experiences, publications and all other documents and information which illustrate expert's point of view.

- Questionnaire: Based on questionnaires which main authors can prepare they can check experts' ideas about the topic. It can be useful for both sides because experts can understand the main idea and paradigm of the study really better.
- Interview: With an interview researchers can explain their goals and perspectives to the experts and at the same time can examine the experts' opinions according to the objectives. The key point is to have the same goals and in way of reaching to the goals they can be completely free to present different attitudes.
- Conference meetings: In a conference meeting investigators can present the main aim of the study and based on a dialogue among experts, researchers can select the most related experts among them for the study. It should not be a designed conference meeting from researchers' side and it can be a panel from other conference meetings or it can be a not organized meeting and can be done in random inside other related international or national conferences.
- A mix method: A mix of mentioned ways above researchers can analyze the experts in the more deeply way.

Experts have a really key role in solving MADM problems specially those which are completely to the long-term decisions. PMADM needs to be more robust in comparison to the classic MADM form of solving the problems. The role of experts can build and change the future for all so a new point of view, in this regard, will be inevitable.

6. Case Study

In this section, a case from energy sector has been selected. Energy is a critical issue in Iran which has huge gas and oil natural resources. Iran is one of the biggest CO₂ producers in all around the world because of the heavy industries which it has. Based on Paris agreement's agenda Iran has to decrease four percent of producing CO₂ until the end of 2020 and eight more percent till the end of 2030. Nowadays, Iran has so many polluted cities especially in winter periods. So, Iran like so many other countries has to do a strategic planning for the better air quality in the future. In this study, authors did not go deep inside the topic but some suggestions presented to some

selected experts of energy which had some practical experiences and positions in related governmental organizations. On the other hand, some international experts were also selected to make a suitable combination.

In total, 20 experts have been invited which half of them were inside the country and the others were from outside the country. Among the experts, five experts were Iranians from outside the country and five were from other countries. To be clearer, authors did some interviews with them with an indirect way of asking about their ideas about the future of energy in Iran. The idea was to measure the main paradigm and background of them. To measure them better, authors tried to check what they think about the society, history of the country, international paradigm, general information about the country, general information about future of the energy and all other related topics which the experts would like to talk about that. So, it was not an open ended type of interview with them. Meanwhile, some main and key factors were defined by authors. Some factors such as: Believe in an international role of the country (C_1), clean air as the human right (C_2), moving to renewable energies in Iran (C_3), investing more in renewable energies and all other new energies in the future (C_4), moving to the more private economy in Iran (C_5), decreasing dependency of economy to the oil (C_6), benchmarking from other successful economies like Norway (C_7), political trend of thinking (to be independent as much as possible) (C_8) and the paradigm to the Iranian exceptional national identity in the future (C_9).

6.1 Best Worst Method (BWM)

Rezaei (2015) configured a novel and applied decision analysis tool called BWM based on a linear programming perspective. BWM received considerable attentions in various fields (van de Kaa et al., 2017; Chitsaz & Azarnivand, 2017). This method conveys the decision-making problem in order to find the weight and rank of decision criteria. The idea behind the BWM runs an operable model in complex decision environments (Rezaei et al., 2016). Wide range of applications employed BWM in different decision environments (Rezaei et al., 2015; Ahmadi et al., 2017; Gupta, 2018). To look for the impotence weights of decision criteria using BWM, the steps below must be followed:

Step 1 – Determining set of decision criteria: $\{c_1, c_2, \dots, c_n\}$;

Step 2 – Choosing the best and the worst criteria by decision maker (DM). The best criterion represents the most desirable or the most significant one while the worst criterion is the least important one among others;

Step 3 – Conducting the pairwise comparisons between the best criterion and the other criteria by DM. In this step, the goal is to identify the preference of the most important criterion to the other criteria. DM uses a scale from 1 to 9 (1: *equally important*, and 9: *extremely more important*). The comparison outcome is described as Best-to-other vector: $A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$, where a_{Bj} represents the preference of the best criterion B over the criterion j and $a_{BB} = 1$;

Step 4 – The DM conducts pairwise comparison between the other criteria and the worst criterion. Same as last step, the comparison results are expressed by Other-to-worst vector: $A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T$, where a_{jW} represents the preference of the best criterion j over the criterion W and $a_{WW} = 1$;

Step 5 – Calculating the optimal weights: $(W_1^*, W_2^*, \dots, W_n^*)$. For each pair of $\frac{W_B}{W_j}$ and $\frac{W_j}{W_W}$, the optimal weight should meet the requirement that $\frac{W_B}{W_j} = a_{Bj}$ and $\frac{W_j}{W_W} = a_{jW}$. To satisfy the conditions, the maximum absolute differences $|\frac{W_B}{W_j} - a_{Bj}|$ and $|\frac{W_j}{W_W} - a_{jW}|$ for all j is minimized. Also, taking into consideration the non-negativity characteristic and sum condition of the weights, the following problem can be formulated:

$$\text{Min max } \left\{ \left| \frac{W_B}{W_j} - a_{Bj} \right|, \left| \frac{W_j}{W_W} - a_{jW} \right| \right\}$$

s.t:

$$\sum_j W_j = 1, \quad W_j \geq 0 \text{ for all } j$$

If we transform the above model, we have the second equation:

$$\begin{aligned} &\text{min } \xi \\ &\text{s.t:} \\ &\left| \frac{W_B}{W_j} - a_{Bj} \right| \leq \xi, \quad \text{for all } j \\ &\left| \frac{W_j}{W_W} - a_{jW} \right| \leq \xi, \quad \text{for all } j \\ &\sum_j W_j = 1, \quad W_j \geq 0 \text{ for all } j \end{aligned}$$

After finding the results, the consistency level of the comparisons must be achieved. The consistency ratio of BWM can be expressed by

Tab. 3: BWM consistency index

	1	2	3	4	5	6	7	8	9
Consistency index	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Source: Rezaei et al. (2015)

using ξ^* and the corresponding consistency index (Tab. 3), as follows:

$$\text{Consistency Ratio} = \frac{\xi^*}{\text{Consistency index}} \quad (3)$$

It can be seen that the smaller the ξ^* , the smaller the 'consistency ratio', and the more consistent the vectors are.

Experts were invited to participate in this study and evaluate factors. According to the BWM algorithm, they first must choose the best and worst factors. For this, they all agreed that C_3 can be the best item and C_8 is the worst attribute. Then respondents (experts) have to compare in pair the best and worst criteria to others as these two tables show. For example, C_3 has 4 times more importance than C_6 . Then

Tab. 4: Exports best, worst factor selection and pairwise comparison for BWM

Best to others	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_3	3	4	1	5	6	4	3	7	5
Others to the worst	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_8	3	4	5	6	5	3	5	1	4

Source: own

based on the vectors of the Tab. 4, we formulate a LP model which is seen below:

$$\begin{aligned} &\min \xi \\ &\text{s.t.} \\ &\left| \frac{W_3}{W_1} - 3 \right| \leq \xi, \quad \left| \frac{W_3}{W_2} - 4 \right| \leq \xi, \quad \left| \frac{W_3}{W_4} - 5 \right| \leq \xi, \\ &\left| \frac{W_3}{W_5} - 6 \right| \leq \xi, \quad \left| \frac{W_3}{W_6} - 4 \right| \leq \xi, \quad \left| \frac{W_3}{W_7} - 3 \right| \leq \xi, \\ &\left| \frac{W_3}{W_8} - 7 \right| \leq \xi, \quad \left| \frac{W_3}{W_9} - 5 \right| \leq \xi, \quad \left| \frac{W_1}{W_8} - 3 \right| \leq \xi, \\ &\left| \frac{W_2}{W_8} - 4 \right| \leq \xi, \quad \left| \frac{W_3}{W_6} - 5 \right| \leq \xi, \quad \left| \frac{W_4}{W_6} - 6 \right| \leq \xi, \\ &\left| \frac{W_5}{W_8} - 5 \right| \leq \xi, \quad \left| \frac{W_7}{W_8} - 5 \right| \leq \xi, \quad \left| \frac{W_9}{W_8} - 4 \right| \leq \xi; \\ &\sum_{j=1}^9 W_j = 1 \quad W_j \geq 0 \text{ for all } j \end{aligned}$$

The LP model is solved by LINDO or other programs and the weights are reported as seen

in Tab. 3. It is seen that C_3 weight is 0.28 while C_8 which is the least important factor contains the importance of 0.033.

6.2 COmbined COmpromise SOLUTION (CoCoSo) Method

CoCoSo (Yazdani et al., 2019) is a recent developed decision-making tool using an integrated form of Simple Additive Weighting (SAW) and Exponentially Weighted Product model (MEW). This method solves a decision problem using the following steps:

1 – Determining the initial decision-making matrix including criteria and alternatives as shown below:

$$x_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}; \quad (4)$$

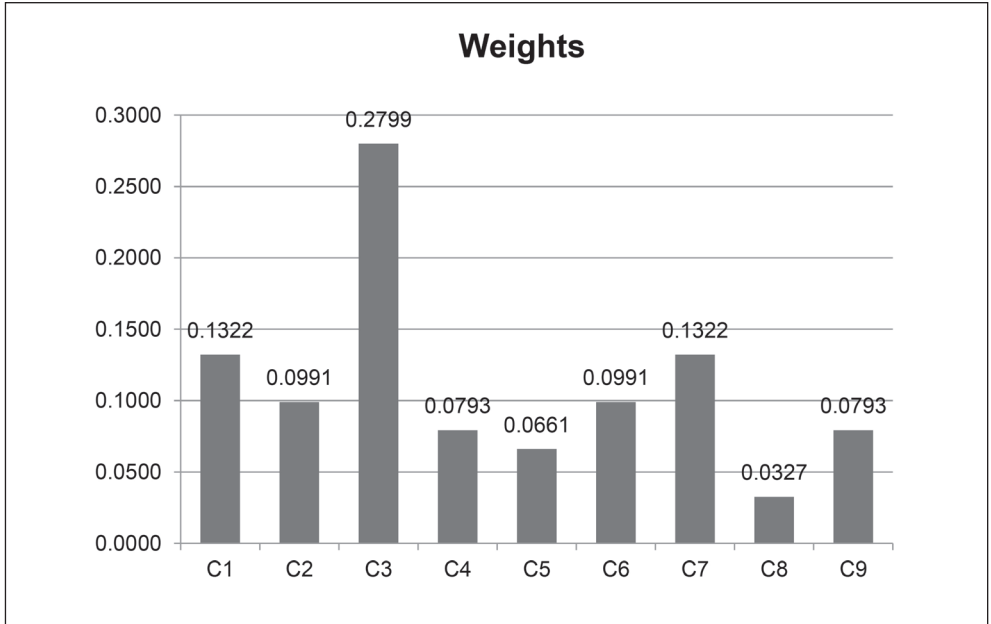
$$i = 1, 2, \dots, m; j = 1, 2, \dots, n.$$

Tab. 5: BWM weights computation and consistency ratio

Weights	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉
	0.132	0.099	0.280	0.079	0.066	0.099	0.132	0.033	0.079
Consistency ratio	0.117								

Source: own

Fig. 2: Computed weights of BWM



Source: own

2 – The normalisation of decision matrix is performed using:

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ for benefit criterion} \quad (5)$$

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ for cost criterion} \quad (6)$$

3 – To catch the weighted normalized matrix for each alternative and also the power weight of comparability sequences for each alternative as S_i and P_p , respectively:

$$S_i = \sum_{j=1}^n (w_j r_{ij}) \quad (7)$$

$$P_i = \sum_{j=1}^n (r_{ij})^{w_j} \quad (8)$$

4 – To rate decision alternatives we have designed three formulas (6), (7), and (8), as seen here:

$$a) K_{ia} = \frac{P_i + S_i}{\sum_{i=1}^m (P_i + S_i)} \quad (9)$$

$$b) K_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i} \quad (10)$$

$$c) K_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{(\lambda \max_i S_i + (1-\lambda) \max_i P_i)}; 0 \leq \lambda \leq 1 \quad (11)$$

In formula (8) λ (usually $\lambda = 0.5$) is chosen by decision-makers. However, the flexibility and

stability of the proposed CoCoSo can rely on other values.

5 – The final ranking of the alternatives is determined based on k_p values (as more significant as better):

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}) \quad (12)$$

The process of evaluating the experts has two main sections. First, those experts who in evaluation do not have a minimum 7 in each criterion will be deleted from the final evaluation because they can be considered as a suitable expert for the study. Tab. 6 shows the first step and those experts who could not meet the main perspective of the study were highlighted in red.

The second step will be the final ranking and evaluation based on CoCoso method.

Tab. 7 indicates the required material for forming a multi criteria evaluation by CoCoSo and the BWM weights. The first step in finding best alternative in CoCoSo is to normalize the matrix, this action is performed using formulas (5) and (6). For this decision problem, all the criteria are beneficial, therefore we just need to apply formula (5). Tab. 8 draws the normalized matrix for CoCoSo. Next step is to aggregate the weights of decision factors into the decision making formulation. This task can be accomplished through the formulas (7) and (8). We obtain S_i values which are shown in Tab. 9. The structure of CoCoSo allows us to define a Power weighted decision matrix which is shown by Tab. 10 and P_i values are appeared in the last column. The rest of the process is to compute three aggregate functions and deliver the final priority of alternatives. We handle this

Tab. 6: Evaluation matrix of the experts

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉
Weights	0.132	0.099	0.280	0.079	0.066	0.099	0.132	0.033	0.079
A ₁	8	7	8	9	7	8	7	7	7
A ₂	7	8	7	8	6	6	7	8	7
A ₃	6	5	7	6	5	6	5	6	7
A ₄	7	7	8	7	8	8	9	7	8
A ₅	7	8	8	8	8	7	7	7	7
A ₆	8	7	6	7	7	6	7	7	7
A ₇	7	8	8	7	8	9	8	8	7
A ₈	7	8	6	6	5	8	7	7	7
A ₉	9	8	7	8	7	7	7	8	8
A ₁₀	8	7	8	8	8	7	7	8	8
A ₁₁	5	6	5	6	7	6	7	4	5
A ₁₂	6	6	5	7	6	7	7	6	6
A ₁₃	4	5	4	6	7	6	7	5	5
A ₁₄	8	8	7	8	9	8	7	8	8
A ₁₅	5	6	7	7	6	7	8	5	6
A ₁₆	7	7	6	7	8	7	6	5	6
A ₁₇	7	8	9	8	8	7	7	8	7
A ₁₈	6	6	7	7	6	5	7	8	7
A ₁₉	8	7	8	7	8	9	8	8	7
A ₂₀	7	6	7	6	5	7	8	6	5

Source: own

step using formulas (9), (10), (11) and (12) and the responses are encountered in Tab. 11. CoCoSo is an effective decision tool that for this specific decision problem order the alternative ranking as:

$$A_{14} > A_7 > A_{19} > A_{10} > A_{17} > A_4 > A_9 > A_1 > A_5$$

Fig. 3 illustrates the preference order to decision alternatives while shows how *K* values are close. This confirms the stability of the applied model.

Tab. 7: Decision making matrix

Initial matrix	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉
A ₁	8	7	8	9	7	8	7	7	7
A ₄	7	7	8	7	8	8	9	7	8
A ₅	7	8	8	8	8	7	7	7	7
A ₇	7	8	8	7	8	9	8	8	7
A ₉	9	8	7	8	7	7	7	8	8
A ₁₀	8	7	8	8	8	7	7	8	8
A ₁₄	8	8	7	8	9	8	7	8	8
A ₁₇	7	8	9	8	8	7	7	8	7
A ₁₉	8	7	8	7	8	9	8	8	7

Source: own

Tab. 8: Normalized decision table

Initial matrix	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉
A ₁	0.5	0.0	0.5	1.0	0.0	0.5	0.0	0.0	0.0
A ₄	0.0	0.0	0.5	0.0	0.5	0.5	1.0	0.0	1.0
A ₅	0.0	1.0	0.5	0.5	0.5	0.0	0.0	0.0	0.0
A ₇	0.0	1.0	0.5	0.0	0.5	1.0	0.5	1.0	0.0
A ₉	1.0	1.0	0.0	0.5	0.0	0.0	0.0	1.0	1.0
A ₁₀	0.5	0.0	0.5	0.5	0.5	0.0	0.0	1.0	1.0
A ₁₄	0.5	1.0	0.0	0.5	1.0	0.5	0.0	1.0	1.0
A ₁₇	0.0	1.0	1.0	0.5	0.5	0.0	0.0	1.0	0.0
A ₁₉	0.5	0.0	0.5	0.0	0.5	1.0	0.5	1.0	0.0

Source: own

Tab. 9: Weighted normalized decision matrix

Initial matrix	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	S _j
A ₁	0.066	0	0.14	0.079	0	0.0495	0	0	0	0.335
A ₄	0	0	0.14	0	0.033	0.0495	0.132	0	0.079	0.434
A ₅	0	0.099	0.14	0.0395	0.033	0	0	0	0	0.312
A ₇	0	0.099	0.14	0	0.033	0.099	0.066	0.033	0	0.47
A ₉	0.132	0.099	0	0.0395	0	0	0	0.033	0.079	0.383
A ₁₀	0.066	0	0.14	0.0395	0.033	0	0	0.033	0.079	0.391
A ₁₄	0.066	0.099	0	0.0395	0.066	0.0495	0	0.033	0.079	0.432
A ₁₇	0	0.099	0.28	0.0395	0.033	0	0	0.033	0	0.485
A ₁₉	0.0660	0	0.14	0	0.033	0.099	0.066	0.033	0	0.437

Source: own

Tab. 10: Power weighted matrix

Initial matrix	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	P _j
A ₁	0.9126	0	0.8236	1	0	0.9337	0	0	0	3.67
A ₄	0	0	0.8236	0	0.9553	0.9337	1	0	1	4.71
A ₅	0	1	0.8236	0.9467	0.9553	0	0	0	0	3.73
A ₇	0	1	0.8236	0	0.9553	1	0.9126	1	0	5.69
A ₉	1	1	0	0.9467	0	0	0	1	1	4.95
A ₁₀	0.9126	0	0.8236	0.9467	0.9553	0	0	1	1	5.64
A ₁₄	0.9126	1	0	0.9467	1	0.9337	0	1	1	6.79
A ₁₇	0	1	1	0.9467	0.9553	0	0	1	0	4.90
A ₁₉	0.9126	0	0.8236	0	0.9553	1	0.9126	1	0	5.60

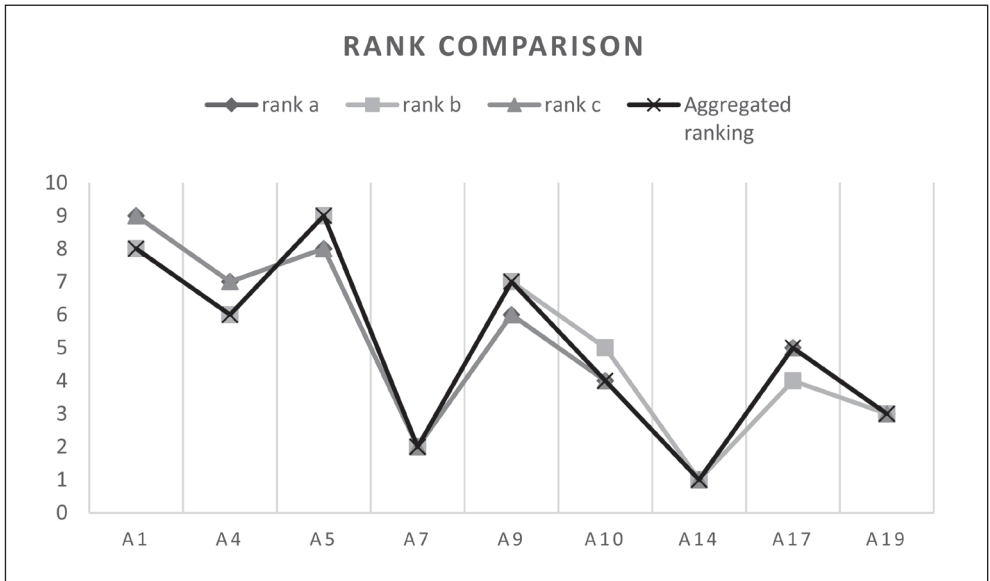
Source: own

Tab. 11: Alternative score computation and aggregate ranking of CoCoSo

Alternatives	Ka	rank (a)	Kb	rank (b)	Kc	rank (c)	K	Aggregated ranking
A ₁	0.0811	9	2.0738	8	0.5502	9	1.3541	8
A ₄	0.1043	7	2.6758	6	0.7071	7	1.7445	6
A ₅	0.0818	8	2.0152	9	0.5547	8	1.3344	9
A ₇	0.1248	2	3.0597	2	0.8466	2	2.0301	2
A ₉	0.1080	6	2.5759	7	0.7323	6	1.7271	7
A ₁₀	0.1221	4	2.7900	5	0.8284	4	1.9028	4
A ₁₄	0.1464	1	3.2379	1	0.9928	1	2.2368	1
A ₁₇	0.1091	5	2.8911	4	0.7402	5	1.8626	5
A ₁₉	0.1224	3	2.9299	3	0.8301	3	1.9618	3

Source: own

Fig. 3: Comparison of different rank strategy by CoCoSo



Source: own

7. Conclusion

The field of MADM has been fast growing field in the new century in the outline of decision making. The rate of introducing new methods has increased and more additive complicated mathematical models such as fuzzy and grey numbers added to the field but it feels still there are some deficiencies in the concept. PMADM has introduced to add a platform to the classic structure of MADM to compensate the deficiencies of classic MADM as much it can.

In this study discussed about how a qualitative method, CLA, which used to apply in classic "Futures Studies" investigates can lead a mathematical field which definitely needs qualitative data as well. As it was mentioned, usually CLA has been applying as a support system for studies about the future and the main idea came from this characteristic of CLA which can tie with other methods, approaches and structures really well.

There are not so many studies about evaluating experts who are cooperating in a Multi-Attribute solving method. Usually it

is up to the investigators and researchers to select the best qualified experts in the field of study which can be multi-disciplinary as well without any limitation. Also as it investigated above about a published research based on CLA method, experts should believe in those positive changes which researchers are really trying to design and plan. So, here the role of CLA can be seen which it shows how those four deep levels can prove us are researchers of a study going to select an appropriate person for their studies or no.

In so many common decision making problems, real data can make the role of experts lighter but it should not be forget data future and all studies about that need more qualitative data which mean experts probably will have more role in that and our probable future is creating with their minds. Eventually, this study can be a help for the all researchers to select better experts regarding to their studies which are not probably short-term and unrelated to the society.

References

- Arms, H., Wiecher, M., & Kleiderman, V. (2012). Dynamic models for managing big decisions. *Strategy & Leadership*, 40(5), 39–46. <https://doi.org/10.1108/10878571211257177>
- Baradaran Ghahfarokhi, M., Mohaghar, A., & Saghafi, F. (2018). The futures of the University of Tehran using causal layered analysis. *Foresight*, 20(4), 393–415. <https://doi.org/10.1108/FS-01-2018-0001>
- Durbach, I. N., & Stewart, T. J. (2012). Modeling uncertainty in multi-criteria decision analysis. *European Journal of Operational Research*, 223(1), 1–14. <https://doi.org/10.1016/j.ejor.2012.04.038>
- Ginevičius, R. (2011). A New Determining Method for the Criteria Weights in Multi-Criteria Evaluation. *International Journal of Information Technology & Decision Making*, 10(6), 1067–1095. <https://doi.org/10.1142/S0219622011004713>
- González-Prida, V., Viveros, P., Barberá, L., & Crespo Márquez, A. (2014). Dynamic analytic hierarchy process: AHP method adapted to a changing environment. *Journal of Manufacturing Technology Management*, 25(4), 457–475. <https://doi.org/10.1108/JMTM-03-2013-0030>
- Hashemkhani Zolfani, S. (2018). *Futures Studies Based on Decision Making Methods* (Doctoral dissertation – in Persian). Tehran: Amirkabir University of Technology.
- Hashemkhani Zolfani, S., Aghdaie, M. H., Derakhti, A., Zavadskas, E. K., & Morshed Varzandeh, M. H. (2013). Decision making on business issues with foresight perspective; an application of new hybrid MCDM model in shopping mall locating. *Expert Systems with Applications*, 40(17), 7111–7121. <https://doi.org/10.1016/j.eswa.2013.06.040>
- Hashemkhani Zolfani, S., Maknoon, R., & Zavadskas, E. K. (2016a). Multiple attribute decision making (MADM) based scenarios. *International Journal of Strategic Property Management*, 20(1), 101–111. <https://doi.org/10.3846/1648715X.2015.1132487>
- Hashemkhani Zolfani, S., Maknoon, R., & Zavadskas, E. K. (2016b). An introduction to Prospective Multiple Attribute Decision Making (PMADM). *Technological and Economic Development of Economy*, 22(2), 309–326. <https://doi.org/10.3846/20294913.2016.1150363>
- Hashemkhani Zolfani, S., Maknoon, R., & Zavadskas, E. K. (2016c). MADM and Futures Studies; A necessity. In *Proceedings of the 9th International Scientific Conference “Business and Management 2016”* (pp. 1–7). <http://dx.doi.org/10.3846/bm.2016.62>
- Hashemkhani Zolfani, S., & Masaeli, R. (2019). From Past to Present and into the Sustainable Future: PMADM Approach in Shaping Regulatory Policies of Medical Device Industry in the New Sanction Period. In P. Chatterjee, M. Yazdani, & S. Chakraborty (Eds.), *Sustainability Modeling in Engineering: A multi-Criteria Perspective* (pp. 73–95). Singapore: World Scientific. https://doi.org/10.1142/9789813276338_0003
- Hashemkhani Zolfani, S., Yazdani, M., & Zavadskas, E. K. (2018a). An extended stepwise weight assessment ratio analysis (SWARA) method for improving criteria prioritization process. *Soft Computing*, 22(22), 7399–7405. <https://doi.org/10.1007/s00500-018-3092-2>
- Hashemkhani Zolfani, S., Zavadskas, E. K., Khazaelpour, P., & Cavallaro, F. (2018b). The Multi-Aspect Criterion in the PMADM Outline and Its Possible Application to Sustainability Assessment. *Sustainability*, 10(12), 4451. <https://doi.org/10.3390/su10124451>
- Heinonen, S., Minkkinen, M., Karjalainen, J., & Inayatullah, S. (2017). Testing transformative energy scenarios through causal layered analysis gaming. *Technological Forecasting & Social Change*, 124, 101–113. <https://doi.org/10.1016/j.techfore.2016.10.011>
- Inayatullah, S. (1998). Causal Layered Analysis. *Futures*, 30(8), 815–829. [https://doi.org/10.1016/S0016-3287\(98\)00086-X](https://doi.org/10.1016/S0016-3287(98)00086-X)
- Jassbi, J. J., Ribeiro, R. A., & Varela, L. R. (2014). Dynamic MCDM with future knowledge for supplier selection. *Journal of Decision Systems*, 23(3), 232–248. <https://doi.org/10.1080/12460125.2014.886850>
- Ketonen-Oksi, S. (2018). Creating a shared narrative: the use of causal layered analysis to explore value co-creation in a novel service ecosystem. *European Journal of Futures Research*, 6, 5, <https://doi.org/10.1186/s40309-018-0135-y>
- Milojević, I. (2015). Conclusion. In S. Inayatullah & I. Milojević (Eds.), *CLA 2.0 transformative research in theory and practice* (pp. 535–557). New Taipei City: Tamkang University.
- Milojević, I. & Inayatullah, S. (2015). Narrative foresight. *Futures*, 73, 151–162. <https://doi.org/10.1016/j.futures.2015.08.007>

- Mukhametzyanov, I., & Pamučar, D. (2018). A sensitivity analysis in MCDM problems: A statistical approach. *Decision Making: Applications in Management and Engineering*, 1(2), 51–80. <https://doi.org/10.31181/dmame1802050m>
- Ondrus, J., Bui, T., & Pigneur, Y. (2015). A foresight support system using MCDM methods. *Group Decision and Negotiation*, 24(2), 333–358. <https://doi.org/10.1007/s10726-014-9392-8>
- Pamučar, D., Stević, Z., & Sremac, S. (2018). A New Model for Determining Weight Coefficients of Criteria in MCDM Models: Full Consistency Method (FUCOM). *Symmetry*, 10(9), 393. <https://doi.org/10.3390/sym10090393>
- Pamučar, D., Božanić, D., & Ranđelović, A. (2017). Multi-Criteria Decision Making: An example of sensitivity analysis. *Serbian Journal of Management*, 12(1), 1–27. <https://doi.org/10.5937/sjm12-9464>
- Ramos, J. M. (2003). *From critique to cultural recovery: critical futures studies and causal layered analysis*. (Monograph Series 2003 No. 2). Melbourne: Australian Foresight Institute Swinbourne University.
- Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, 53, 49–57. <https://doi.org/10.1016/j.omega.2014.11.009>
- Saaty, T. L. (1980). *The Analytical Hierarchy Process*. New York, NY: McGraw-Hill.
- Saaty, T. L. (1996). *Decision Making in Complex Environments, The Analytical Hierarchy Process for Decision Making with Dependence and Dependence and Feedback*. Pittsburgh, PA: RWS Publications.
- Saaty, T. L. (1999). Fundamentals of analytic network process. In *Proceedings of the International Symposium on the Analytic Hierarchy Process, 12–14 August 1999* (pp. 348–379). Kobe, Japan.
- Siddiqi, A., Ereiqtat, F., & Anadon, L. D. (2016). Formulating Expectations for Future Water Availability through Infrastructure Development Decisions in Arid Regions. *Systems Engineering*, 19(2), 101–110. <https://doi.org/10.1002/sys.21337>
- Tadić, S. R., Zečević, S. M., & Krstić, M. D. (2014). Ranking of logistics system scenarios for central business district. *Promet – Traffic & Transportation*, 26(2), 159–167. <https://doi.org/10.7307/ptt.v26i2.1349>
- Toloie Eshlaghy, A., Rastkhiz Paydar, N., Joda, K., & Rastkhiz Paydar, N. (2009). Sensitivity analysis for criteria values in decision making matrix of SAW method. *International Journal of Industrial Mathematics*, 1(1), 69–75.
- Triantaphyllou, E., & Sánchez, A. (1997). A Sensitivity Analysis Approach for Some Deterministic Multi-Criteria Decision-Making Methods. *Decision Sciences*, 28(1), 151–194. <https://doi.org/10.1111/j.1540-5915.1997.tb01306.x>
- Trutnevte, E., Stauffacher, M., & Scholz, R. W. (2012). Linking stakeholder visions with resource allocation scenarios and multi-criteria assessment. *European Journal of Operational Research*, 219(3), 762–772. <https://doi.org/10.1016/j.ejor.2012.01.009>
- Wang, Y., Shi, X., Sun, J., & Qian, W. (2014). A grey interval relational degree-based dynamic multi-attribute decision making method and its application in investment decision making. *Mathematical Problems in Engineering*, 1, 1–6. <http://dx.doi.org/10.1155/2014/607016>
- Yazdani, M., Zavadskas, E. K., Ignatius, J., & Doval Abad, M. (2016). Sensitivity Analysis in MADM Methods: Application of Material Selection. *Inzinerine Ekonomika-Engineering Economics*, 27(4), 382–391. <https://doi.org/10.5755/j01.ee.27.4.14005>
- Yazdani, M., Zarate, P., Zavadskas, E. K., & Turskis, Z. (2019). A Combined Compromise Solution (CoCoSo) method for multi-criteria decision-making problems. *Management Decision*, 57(9), 2501–2519. <https://doi.org/10.1108/MD-05-2017-0458>
- Zavadskas, E. K., Turskis, Z., Dejus, T., & Viteikienė, M. (2007). Sensitivity analysis of a simple additive weight method. *International Journal of Management and Decision Making*, 8(5/6), 555–574. <https://doi.org/10.1504/IJMDM.2007.013418>
- Zhang, Z. (2012). An approach to dynamic multi-attribute decision making for choosing green supplier. *Journal of Convergence Information Technology*, 7(21), 261–269. <https://doi.org/10.4156/jcit.vol7.issue21.33>

Notices to Readers

All articles in the journal have been double-blind peer reviewed by a minimum of two independent experts in the relevant field. Authors are responsible for the linguistic accuracy of their manuscripts.

Journal Title:

E+M EKONOMIE A MANAGEMENT
E&M ECONOMICS AND MANAGEMENT

Editor in chief

prof. Dr. Ing. Miroslav Plevný

Faculty of Economics, University of West Bohemia
tel.: +420 377 633 501, e-mail: plevny@kem.zcu.cz

Executive editor

prof. Ing. Miroslav Žižka, Ph.D.

Faculty of Economics, Technical University of Liberec
tel.: +420 485 352 345, e-mail: casopis@tul.cz

Editorial Board

prof. Ing. Jaroslav Belás, Ph.D.

Faculty of Management and Economics, Tomas Bata University in Zlín
tel.: +420 576 032 410, e-mail: belas@fame.utb.cz

prof. Ing. Ivan Jác, CSc.

Faculty of Economics, Technical University of Liberec
tel.: +420 485 352 361, e-mail: ivan.jac@tul.cz

doc. RNDr. Jaroslav Koutský, Ph.D.

Faculty of Social and Economic Studies, Jan Evangelista Purkyně University
tel.: +420 475 284 711, e-mail: jaroslav.koutsky@ujep.cz

prof. Ing. Hana Mohelská, Ph.D.

Faculty of Informatics and Management, University of Hradec Králové
tel.: +420 493 332 370, e-mail: hana.mohelska@uhk.cz

doc. Ing. et Ing. Renáta Myšková, Ph.D.

Faculty of Economics and Administration, University of Pardubice
tel.: +420 466 036 510, e-mail: renata.myskova@upce.cz

doc. Ing. Marianna Siničáková, Ph.D.

Faculty of Economics, Technical University of Košice
tel.: +421 556 022 141, e-mail: marianna.sinicakova@tuke.sk

doc. Ing. Michal Tvrdoň, Ph.D.

School of Business Administration in Karviná, Silesian University
tel.: +420 596 398 460, e-mail: tvrdon@opf.slu.cz

doc. Ing. Peter Krištofik, Ph.D.

Faculty of Economics, Matej Bel University in Banská Bystrica
tel.: +421 484 462 121, e-mail: peter.kristofik@umb.sk

Assistant of the editorial office

Mgr. Linda Ringlova

tel.: +420 485 352 273, e-mail: linda.ringlova@tul.cz

Scientific Board

prof. John R Anchor

University of Huddersfield, United Kingdom

dr hab Adam P. Balcerzak

Nicolaus Copernicus University of Torun, Poland

dr hab Yuriy Bilan

Rzeszow University of Technology, Poland

prof. Ing. Jan Čapek, CSc.

University of Pardubice, Czech Republic

Assoc. Prof. Dan-Cristian Dabija, PhD

Babeş-Bolyai University, Romania

prof. Ing. Jiří Fárek, CSc.

Technical University of Liberec, Czech Republic

prof. Ing. Ladislav Hájek, CSc.

University of Hradec Králové, Czech Republic

prof. RNDr. Josef Hynek, Ph.D., MBA

University of Hradec Králové, Czech Republic

Dr Frank Lefley

Royal Holloway, University of London, United Kingdom

prof. Ing. Marta Orviská, PhD.

Matej Bel University in Banská Bystrica, Slovakia

prof. Dr. Ing. Drahomíra Pavelková

Tomas Bata University in Zlín, Czech Republic

prof. RNDr. Jaroslav Ramík, CSc.

Silesian University, Czech Republic

prof. Edson Luiz Riccio, Ph.D.

University of São Paulo, Brazil

Assoc. Prof. Manuel J. Sánchez-Franco

University of Sevilla, Spain

Assoc. Prof. Jelena Stankevičienė

Vilnius Gediminas Technical University, Lithuania

Assoc. Prof. Jonas Šaparauskas

Vilnius Gediminas Technical University, Lithuania

prof. RNDr. Vincent Šoltés, CSc.

Technical University of Košice, Slovakia

prof. Ing. Milan Zelený, Ph.D., M.S.

Fordham University at Lincoln Center, New York, USA,
Tomas Bata University in Zlín, Czech Republic

Address of the editorial office

Technical University of Liberec
Faculty of Economics
Editorial Office of the Journal E&M Economics and Management
Voroněžská 13
461 17 Liberec 1
The Czech Republic
Tel.: +420 485 352 345
E-mail: casopis@tul.cz

The journal is published quarterly.

The issue 3/2020 has been released on 28th August 2020.

Subscription:

Subscription orders must be sent to the editorial office. The price is 60 EUR a year.
It is possible to order older issues only until present supplies are exhausted (15.86 EUR an issue).

Published by: Technical University of Liberec
Studentská 2, 461 17 Liberec 1, The Czech Republic, ID no. 46747885

Production: Wolters Kluwer ČR, a. s.
U nákladového nádraží 10, 130 00 Praha 3, The Czech Republic, ID no. 63077639

Number of prints: 100 pcs, **MK ČR E 18765, ISSN 1212-3609, ISSN (online) 2336-5064, price:** 15.86 EUR
www.ekonomie-management.cz

