GVCs in Central Europe - A Perspective of the Automotive Sector after COVID-19

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Visegrad Fund

Contents

List of abbreviations

3D – three-dimension
ACEA – European Automobile Manufacturers' Association
ACES – autonomous vehicles, connectivity, electromobility and shared mobility services
AGOA – The African Growth and Opportunity Act: a US Trade Act
BEB – battery electric bus
BEV – battery electric vehicle
BRICS – Brazil, Russia, India, China and South Africa
CAD – computer-aided design
CAM – computer-aided manufacturing
CEE – Central and Eastern Europe
CIF – cost, insurance, and freight
CNC – computer numerical control
CPS - cyber-physical systems concept
CSR – corporate social responsibility
DVX – domestic value added embodied in foreign exports
EORA – related to *UNCTAD-EORA* Global Value Chain database
ERP – enterprise resource planning
EU – European Union
EV – electric vehicle
EXP – exports
FDI – foreign direct investment
FOB – free on board
FVA – foreign value added
GDP – gross domestic product
GVC – global value chains
HR – human resources
IATF – International Automotive Task Force
IDE-JETRO – Institute of Developing Economies within the Japan External Trade Organization
IEA – International Energy Agency
ILO – International Labour Organization
IoT – Internet of Things
ISO – International Organization for Standardization
JIT – just in time
LCV – light commercial vehicle
M2M – machine-to-machine communication
MESR – Ministry of Economy of the Slovak Republic
MNC – multinational corporations
MNE – multinational enterprises
MV – motor vehicles

NACE – Statistical Classification of Economic Activities in the European Community
NAFTA – North American Free Trade Agreement
NGO – non-governmental organisation
NICs – Newly Industrialized Countries
ODM – original design manufacturers
OECD – Organisation for Economic Cooperation and Development
OEM – original equipment manufacturers
ORN – Offshoring Research Network
P2P – person-to-person communication
PC – passenger cars
PEI – Polish Economic Institute
PHEV – plug-in hybrid electric vehicle
PRC – People’s Republic of China
PTA – Preferential Trade Agreement
SARIO – Slovak Investment and Trade Development Agency
SME – small and medium-sized enterprises
STEM – Science, Technology, Engineering, Mathematics
TiVA – Trade in Value Added
TNC – transnational corporations
UNCTAD – United Nations Conference on Trade and Development
USSR – the Union of Soviet Socialist Republics
V-4 – Visegrad countries
VA – value added
VOC - volatile organic compound
WIOD – World Input-Output Database
WTO – World Trade Organisation

Introduction

The COVID-19 pandemic and its consequences continue to affect each economy and various components of the world economy. Pandemic has health, economic, social, and political impacts, all of which are interrelated and interact. Economies experienced pandemic-induced labour shortages, disruptions in transportation, closed workplaces, restrictions in travel, and disruptions in global supply chains. The available data for 2021 indicate that global value chains have adjusted to the pandemic conditions relatively quickly, but some industries, such as automotive, have experienced critical supply disruptions. There have been calls for increased domestic production (reshoring), especially in the automotive sector, where the shortage in semiconductors was the main reason for the collapse in trade in automobiles. Some forecasts indicated that Central and Eastern European (CEE) countries could benefit from reshoring automotive production because it would increase the resilience of supply chains.

While we are dealing less and less with pandemic-driven difficulties, there are new threats on the horizon – again from outside the economic world. This time, it is the war in Ukraine. As of this writing, Russia's armed aggression against Ukraine is still ongoing. It will cast a shadow over the economies of these two countries, the entire CEE region, and perhaps even the world. However, the study is devoted to assessing the impact of the COVID-19 pandemic on the automotive industry in the Visegrad countries (V-4). The effects of the ongoing war cannot be captured in such detail as the pandemic because of the limited time passed since it began. The war has only been going on for over two months, while the pandemic lasted more than two years. The effects of the war might be assessed and evaluated when it is over.

The impact of the pandemic can be analysed today, although some experts caution against taking a too hasty approach that the pandemic is over. As of currently (May 2022), the media have been reporting a dramatically increasing number of coronavirus infections in China, blocking Shanghai, the world's largest transhipment port and a hub for transport links in international trade. Many companies, especially those linked to foreign markets, have already been trying to re-arrange their daily operations and reorganize supply chains since the pandemic hit at the beginning of 2020. Nowadays, they may face an even more significant challenge related to decisions to relocate sources of supply out of Asia to more secure and closer locations. The pressure to make these changes seems to be mounting, especially with the recent news from Shanghai. Nevertheless, what does it look like so far? How have the last two years changed the automotive industry, which has been shaping its networks not only in Asian locations but also in Central and Eastern European countries?

This monograph presents the results of a joint project conducted by four research institutions in Visegrad countries. It presents the global value chains (GVC) phenomenon in the automotive industry in Czechia, Hungary, Poland, and

Slovakia. The Visegrad countries group was formed after the collapse of the USSR (the Union of Soviet Socialist Republics) to manage the uncontrolled space of activities of countries previously strongly controlled by the USSR. All Visegrad countries, to a different extent, were (and still are) respecting Western values in both internal and international relations. The business had effectively filled a separate sphere of cooperation - going beyond the political goals initiated in 1991 when the Visegrad Group was established - the countries of the Visegrad Group are becoming more and more economically integrated. They are increasingly incorporated globally, with the European economies and each other. One reason is their increasing participation in global value chains. However, increasing participation in GVCs does not always bring benefits because they depend on the value added created in each process performed in a given country. Processes with low value added in the long term can push a country into the trap of long-term stagnation in creating value.

It is especially true for the automotive industry, which is highly dependent on value creation abilities, and the value chain in this sector is significantly fragmented. To alter the current status quo and gain more benefits from participation in GVCs, it is necessary for the V-4, as key players in the CEE region specialization in automotive production, to foster innovation abilities and stabilize their position as value added creators. The outbreak of COVID-19 posed both threats (disruption in production processes, demand shocks) and opportunities (re-definition of multinational companies' policies on foreign direct investment localization) that need to be investigated precisely to design an effective strategy for states on the way to high value added processes specialization.

The monograph aims to present the results of the project under the Visegrad fund called "GVCs in Central Europe – a perspective of automotive sector after COVID-19". We intend to answer the following questions: i) To what extent do V-4 companies participate in the automotive GVCs? ii) What are the likely impacts of COVID-19 on GVC participation of V-4 businesses iii) How to improve the position of national small and medium-sized enterprises (SME) in automotive GVCs?

We have divided the monograph into four chapters and a concluding section to address these issues. In the first chapter, "Theoretical background – measurement of GVCs", we present a brief development of global value chains in developing theoretical knowledge of international trade. In addition, the authors clarify the key concepts of TiVA (Trade in Value Added) and GVC and their position in international trade and some of the changes that emerged during the COVID-19 pandemic. In chapter two, "Recent trends in GVCs", we present the development and current status of GVCs participation within V-4 and drivers of participation in GVC. We also investigate the impact of COVID-19 on GVCs and the innovation-driven transformation of GVCs. Chapter three is devoted to "Characteristics of the automotive sector in V-4 countries: 2010-2021". Each subchapter presents the development of the sector in each Visegrad country.

Chapter four, “Recent changes in GVCs in the automotive sector in V-4 countries – case studies”, features a particular value added, since (in most cases) it deals with empirical examples of automotive companies and their perspectives on participation in GVCs. The cases may be used for educational purposes or by companies that want to improve their position in GVCs by learning from others’ experiences.

The final part presents conclusions and policy recommendations based on the findings presented in all chapters.

Authors

1 Theoretical background – measurement of global value chains

1.1 Transnational corporations and fragmentation of the production

The roots of global value chains go back to the emergence of the first multinational corporations. Today, companies based in one country and operating in at least one foreign market have several designations (MNCs – multinational corporations, MNEs – multinational enterprises, etc.). However, the most common designation is transnational corporations (TNCs). The concept of transnational corporations began to emerge in the post-World War II period after the declining intensity of the influence of state-owned companies, which was related to the development of commercial companies and the optimization of the cost structure (Ferenčíková et al., 2021). Companies with several, primarily private shareholders have come to the fore historically, especially in markets with developed stock exchanges (USA, Japan, Western Europe).

Nevertheless, it should be emphasized that their concept was much older and dates back to the emergence of the first publicly traded companies (early 17th century in the Netherlands) in international business at the time of the development of East India and West India. However, in the true sense of the word, transnational corporations began to emerge during the first wave of globalization in the late 19th century (Oatley, 2008). The companies involved in international activities at the time were dominated by UK producers, as they were the largest exporter of capital globally. British producers have invested in the US, Latin America, and Asia across the British Empire. Before the First World War, the investment of British companies accounted for almost half of the capital invested abroad (Jones, 2001), and their destination was to buy or create companies primarily in the field of mining and industrial production.

With the beginning of the retreat of British companies and the resentment of their expansion during the Victorian era, companies from the ocean came to the fore. The first significant manifestations of the expansion of American companies in the international environment began to appear in the late 19th century when the leading sewing machine manufacturer Singer Sewing Machines established a permanent manufacturing plant in Glasgow, Scotland (Wilkins, 1970). Since the 1920s, the United States has been at the forefront of expanding companies. In the period after II. During World War II, American corporations "concreted" in the first place of the most expanding companies in the international environment (through investments abroad). Therefore, Japanese and European governments have discouraged domestic companies from establishing themselves in foreign markets by exporting domestic capital. As a result, two-thirds of the companies established in foreign markets by creating a new company came from the United States between 1945 and 1960. This has had very positive effects on American companies' market-oriented and cost-oriented foreign direct investments (FDI) in the international business environment. This situation did not change until the 1960s, when Japanese and European companies began to invest, especially in Latin America and Asia, in the bipolar division of many countries in the world economy. Another change in the structure of the largest companies in international business was the fall of the Iron Curtain, the expansion of companies from NICs (Newly Industrialized Countries) and later BRICS economies (Brazil, Russia, India, China and South Africa), and the relatively slow start of multinational companies from CEE countries (excluding raw material-oriented Russian companies). However, a significant change in their structure was the rapid economic growth of the Chinese economy and their later dominance in the rankings according to turnover and the profit achieved after 2010.

One of the most important theoretical frameworks for production fragmentation was proposed by Jones and Kierzkowski (1990, 1998, 2001). They stated that international fragmentation was occurring both within multinational organizations and through arms-length arrangements in the market. They added that as the price of international service links declines and as knowledge of potential international suppliers and legal systems becomes more widespread, the necessity for containing various production blocks under the umbrella of a multinational organization has been systematically reduced. According to them, the leading causes of the fragmentation are technical progress in service sectors (falling transportation costs), economies of scale in service activities and liberalization of barriers in international trade in services. Simultaneously, Venables (1999a) developed his idea of multinational production. He argued that falling transportation costs for intermediate goods lead to spatial production fragmentation. As firms divide their production between countries, they become vertical multinationals (if upstream activities are labour intensive) or horizontal multinationals (if downstream activities are labour intensive).

Contrary to Jones and Kierzkowski, Venables focused only on the fragmentation within transnational corporations. Nowadays, the idea developed by Jones and Kierzkowski appears to be more adequate as production fragmentation is linked not only with foreign direct investments but also with outsourcing. Thus, economists still use the concept proposed by Jones and Kierzkowski and still highlight the causes of the production fragmentation mentioned by them. However, due to digitization, automatization, artificial intelligence and e-commerce, companies can carry out more activities in their home country. So, recent changes in the world economy may encourage economists to develop new concepts of production fragmentation.

1.2 Definition and characteristics of GVCs

Reporting the development of foreign trade in standard World Trade Organization (WTO) statistics works on the principle of CIF (Incoterms 2020) parity in imports (FOB price + foreign direct trade costs such as transport costs and insurance) and FOB (Incoterms 2020) parity in goods exports (purchase price of goods + taxes - subsidies). Traditional reporting of international trade at these parities, though, means that we do not examine what part of the goods was actually produced in the domestic economy. The total export price of the goods is calculated for export value, regardless of the raw materials purchased abroad. This relativizes foreign trade statistics in quality aspect of gross exports.

However, large corporations (achieving economies of scale) mainly use several countries for individual components and activities when optimising production costs, taking advantage of the specific comparative advantages at their disposal. The People's Republic of China (PRC) economy is also linked to other economies in the region and consumer centres on the other side of the world. According to Zábojník et al. (2020), the traditional view of international trade is based on a model when a country produces goods and offers services that are exported as final products to consumers abroad. With the rapid growth of the FDIs and transnational corporations, in today's global economy, this type of trade only represents around 30% of all trade in goods and services. About 70% of international trade has recently been realized via global value chains (GVCs), as services, raw materials, parts, and components cross borders – often numerous times (OECD, 2019). This way, the product's final assembly is realized within one country, but intermediates products are fragmented among many companies from different countries. The phenomenon of how many intermediate products a country imports to produce a product and how many products a country exports to another country to produce new products draws attention to value added trade (Folfas, 2019).

From the beginning, the development of GVCs has been driven by large multinational companies that achieve competitive advantages and profits. Through the performance of specific production process activities, costs are minimized in some countries based on economies of scale and specialization and the benefits of local expenses. According to UNCTAD (2020), 80% of gross exports are currently linked to the international production networks of multinational companies.

Global value chains are a phenomenon in the period of economic research after the New Trade Theory. This principle has indicated how product completion is fragmented in countries, regions, and continents. Companies outsourcing and offshoring product assembly activities subsequently benefit from comparative advantages in countries where they relocated such activity (Zábojník et al., 2020). GVCs depend on the fragmentation of production and trade in intermediates to take advantage of the cost advantages of each site or stage in the chain up to the stage of assembly. This partially solves the problem related to the overrated parameter of gross export mentioned above. GVCs are typically used by multinational companies and are becoming more critical (OECD, 2015), despite the disturbances in international markets brought about by the global pandemic

COVID-19 and the energy crisis in Europe since the end of 2021.[1] The global value chain includes all activities that companies engage in, whether in the domestic market or in foreign markets, from its concept to its end-use. GVCs are increasingly organizing world trade, manufacturing and foreign direct investment worldwide. Generally, GVC is a sequence of all functional activities required in value creation involving more than one country. The value chain shows a range of specific activities that engage businesses in marketing products. These activities include design, production, marketing, logistics, and product distribution to the final customer. These activities do not have to be performed by only one company but can be shared by different companies (OECD, 2015).

The concept of international and global value chains, according to Bair (2005), first appeared in the 1970s in connection with commodity chains research, with Terence Hopkins and Immanuel Wallerstein (1977) featuring among the researchers. The mentioned researchers designed it as a heuristic to study the operation of global capitalism and the reproduction of the stratified and hierarchical world system beyond the territorial confines of the nation-state. On the other hand, the global commodity chain perspective in the early 1990s focused on the organization of contemporary global industries and how power asymmetries of MNCs lead firms affected the prospects for national development (Gereffi, 2018). This caused a split in traditional world-systems theory.

The essence of the idea of commodity chains was a detailed mapping of all inputs and production operations that lead to the production of the final product. The first publication that explicitly utilized the global commodity chain framework was a study of the footwear industry by Gereffi and Korzeniewicz (1990). This concept consisted of a detailed description of the supply chain and operations from the raw material to the production of the final product. Creating export niches in the footwear commodity chain was partly a story of how and why the previous industry leaders allowed new capabilities for the emergent exporters, and how intermediaries (e.g., trading agents) linked small producers to global markets (Gereffi, 2018). The paper related to the commodity chain concept generated spirited controversy and a lot of interest among scholars (Gereffi, 2018).

In the 1980s, under the influence of the literature on world trade and value chains (Porter, 1998), the term "global commodity chain" began to be used. Terms such as “commodity” and "value" chain are very similar, but "value chain" is more complex, more ambitious in that it also tries to describe the organization of production (Slušná & Balog, 2015). Jennifer Bair explains this idea in her work

[1] Certain need to identify qualitative involvement in international trade by companies and national economies was brought about in particular by a study by the European Commission, which confirmed the PRC as the largest exporter of high-tech products, in a deeper analysis of some economists (Xing and Detert, 2010 and Xing 2011) added value on exported smartphones as very low (up to 5%). In the assembly of such products, Chinese companies, especially until 2014, contributed to a relatively low value, which stemmed mainly from activities within the value chain, which did not incorporate the results of science, research or strategic know-how in the field of technology and design (Zábojník et al., 2020).

"Global Capitalism and Commodity Chains" (Bair, 2005). New horizons in production fragmentation and its impact on economically developed and peripheral economies cause a serious debate on how to characterize a variety of overlapping terms used to describe the network relationships that make up the global economy. According to Gereffi (2018), the term “global value chain” was subsequently adopted due various reasons including the association of “commodity” with undifferentiated primary products (agriculture commodities, crude oil, minerals), leaving out manufactured goods and services, potential confusion with the world-systems theory usage of commodity chain and the term “value” aligned closely with the concept of “value added”, which focused attention on the process of creating, capturing and sustaining value in global supply chains (Sturgeon, 2009). Important findings on the topic were brought by Gereffi et al. (2005), who provided a theoretical framework for the value chain analysis and described different types of global value chain governance. After 2010, economic research activities started to be oriented more on the level of countries’ participation or position in GVCs (Kersan-Škabić, 2019), primarily the countries from the CEE region since the economic growth led by the FDIs started to culminate. Currently, the term "global value chain" refers to the complete set of activities that companies and their employees perform from the very first, the initial concept of the product to its final use by customers. The emergence of global value chains is the result of an increasing division of labour (Chilimoniuk-Przeździecka, 2018). This is reflected in the advancing fragmentation of production operations, which are divided between the countries of the world (Zábojník, 2019). Each country specializes in those parts of the production process with a specific comparative advantage (Baláž et al., 2019). State-of-the-art theories in international business come with the transformation of GVCs into a "global value network" (OECD, 2013). Network represents the complexity of the interactions among global producers: “economic processes must be conceptualised in terms of a complex circuitry with a multiplicity of linkages and feedback loops rather than just “simple” circuits or, even worse, linear flows” (Hudson, 2004).

As for the definition for further chapters, case studies and effect of the GVCs, a global value chain in international business is defined as the “full range of activities that firms and workers do to bring a product from its conception to its end use and beyond”[2] (Gereffi & Fernandez-Stark, 2011). Later, Gereffi (2018) explained and highlighted how “big buyers” have shaped the production networks established in the world´s most dynamic exporting countries, especially the newly industrialized countries of the first wave (South Korea, Hong Kong, Taiwan and Singapore). The main characteristics of GVCs include:

[2] Typically, a value chain includes the following activities: design, production, marketing, distribution and support to the final consumer (Zábojník et al., 2020).

- The increasing fragmentation of production across countries. Global value chains link geographically dispersed activities in a single industry and help to understand shifting patterns of trade and production. Leading authors in the field stress the role of several layers of the countries participating in the industrial production (e.g., apparel industry in the US). (This concept was confronted by deglobalization tendencies since COVID-19 pandemics[3]).
- The specialisation of countries in tasks and business functions rather than specific products. This is caused by international division of labour and efficiency pressure on the production structure.
- Global value chain analysis gives insights on economic governance and helps to identify firms and actors that control and coordinate activities in production networks.

Several models express global value chains in practice, and they vary. Moreover, the GVCs models are very complex and vary significantly between products.

The fragmentation levels of product manufacturing depend on technical assumptions and product aspects. Multinational enterprises in OEMs play a crucial role in global value chains (Zábojník et al., 2020). Original equipment manufacturers (OEMs) provide only production services, while actual design manufacturers (ODMs) undertake production as well as design activities (OECD, 2013). Contract manufacturers are working with smaller suppliers (from tier 1 to tier 3), although the supplying pyramid in electronics is less developed than in automotive. Currently, success in global markets depends on the ability to import high-quality products, but above all, on export capacity. To increase corporate, but ultimately also national competitiveness, domestic companies must engage in GVCs in areas with the highest possible level of added value (Zábojník et al., 2020).

Export competitiveness[4] boosted within GVCs is due to outsourcing and offshoring, in the way that they provide access to more differentiated, cheaper and better inputs or optimize the processes needed to complete the product within the GVC. Competitiveness at the level of GVCs requires the continuous improvement of conditions for the use of factors of production which can be called "sticky" and are highly likely to cross national borders (Zábojník et al., 2020). Labour force, education and high-quality infrastructure can be considered as the so-called "sticky" factors of production to which continuous investment should be directed. The quality of institutions is also important, as it is a factor that, in the long run, influences the decisions of companies in the area of their involvement in the economic activities of a country. The activities in which a company or a country is involved today and what we "do today" is much more critical for economic growth and employment than what we "sell" (OECD, 2015). The issue of GVC

[3] For more recent research studies related to the impact of COVID-19 on GVCs, see Gereffi et al. (2021a) and Gereffi (2021).
[4] For more details of export competitiveness see Ružeková et al. (2020) and Kittová & Steinhauser (2020).

can be so complex that, in the end, the import can also contain the so-called "returned" value added originating in the importing country.

To quantify the level of foreign value added incorporated in the gross exports, especially OECD suggests using some new methodological approaches besides conventional international trade statistics. The measurement and involvement of countries' participation in the GVC can be quantified by the *participation index* and the *production chain* length index. The best-known measure of a country's position in GVCs was created by Koopman et al. (2010) who introduced the GVC *participation index*.

GVC participation = DVX/EXP + FVA/EXP

where DVX/EXP is the share of domestic value added embodied in foreign exports (intermediate export) in relation to the gross exports, FVA is the share of foreign value added (intermediate import) embodied in gross exports (for more detailed explanation see *Guide to OECD TiVA Indicators, 2021 Edition*, 2022).

The index summarises the domestic value added embodied in foreign export (forward participation) and foreign value added in domestic export (backward participation). The value goes from 0 to 100. The higher the value, the higher the country's participation in GVC, i.e., trade in intermediate products is more prevalent in total trade and the production process is more fragmented. The participation index is one of the oldest indices in the history of GVCs, which focuses on the characteristics of the import intensity of exports, i.e., the share of imported goods or services in the value of total exports. The participation index focuses on the "backward" and "forward" linkages. "Backward" analysis of exports characterizes the importance of foreign suppliers to the export capabilities of countries (Zábojník et al., 2020; Slušná & Balog, 2015). The involvement of countries in the GVC can also manifest itself in the fact that the export of one country is used as an input for future production in another country, which then exports them. Such a point of view is called a „forward" view. Looking ahead deals with the description of the share of exports that serve as imports for the subsequent production of exports in third countries. The participation index plays a characteristic role, with a country acting as a supplier of intermediate consumption to another country. The combination of backward and forward approaches points us to the possibility of gaining an overview of the country's involvement in the GVC. It is important to note that the indices are expressed as a % share of gross exports (Slušná & Balog, 2015).

European Union (EU) member states have different values of GVC participation. Luxembourg and Slovakia have the highest participation, and Croatia has the lowest. The values range from 35% to 70%. Some of the EU new member states have achieved very good interconnection with foreign partners, i.e., Slovakia, Hungary, Czech Republic, and they have GVC participation in line with, or even higher than the EU15 (Ambroziak, 2018, Kersan-Škabič, 2019)[5]. On the other hand, there are countries with weak performances in GVC participation, i.e., Croatia and Cyprus that have not reached high values of GVC participation and are lagging behind (Ambroziak 2018, OECD, 2018).

The second index, *index of the length of the production chain* points to the importance of vertical specialization, which is measured by the share of inputs from abroad and domestic outputs of intermediate consumption. However, this index does not provide information on how long the production chain is. The index may have a high value, but this may be due to the use of a one-time input in the form of precious metal, for example, within the production chain, but the chain itself may be short and ultimately relatively simple. The index mainly gives us information on how many industries contributed to producing a product or service. If the whole product in the production process is processed within one production phase, even within one industry, then the index has a value of 1. Of course, the growing participation of other industries in the production of a particular product causes an increase in the value of the index itself.

Nowadays, economists, more often than in the past, emphasise that global value chains are rather regional than global. The "Made in the world" catchphrase struck a chord, but in reality, value chains are rarely global. Instead, most of them are regional, with three centres consisting of North America, Europe and Asia, or – in other words – "Factory North America", "Factory Europe", and "Factory Asia" (Miroudot & Nordström, 2015; Meng et al.,2019). Moreover, the lengthening and branching of value chains came to a halt in the mid-2000s, reversed during the global crisis, curled up into more compact chains and has not fully recovered since. Since mid-2000s value chains have also become more regional and less global (Hanzl-Weiss et al., 2018, McKinsey Global Institute 2019). Additionally, slowbalisation – meant as the noticeable slowdown of globalisation during the last few years (McKinsey Global Institute, 2019; PWC, 2020) – together with the global crisis caused by the COVID-19 pandemic (COVID-19 crisis), probably has been making value chains even more regional. Thus, the regional value chains will be probably an essential topic in the following years.

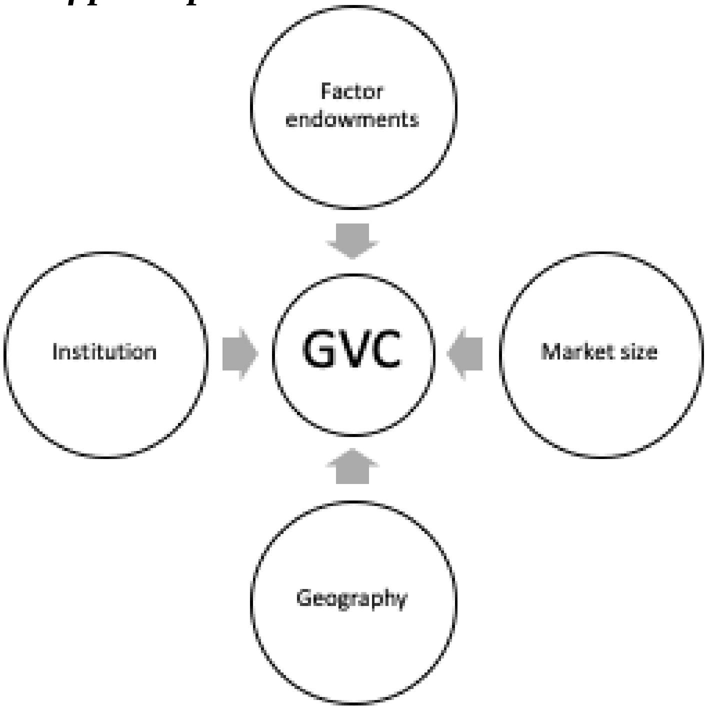
1.3 Drivers of participation in GVC

GVC participation is determined by the international division of labour observed, which is a consequence of the increase in the active involvement of enterprises in this process. In addition to producing finished goods for export that has existed for decades, the export of goods (components, services) has appeared to be associated with an increasing number of companies in international supply networks. Participation of companies in the international division of labour results

[5] Detailed analysis of V-4 participation in GVCs is carried in chapter 2.1.

from their fundamental need – to reduce production costs. This is facilitated by the traditional differences in the equipment of countries in production factors and the acceleration of technological progress, liberalization of international trade, and integration processes. Consequently, there are four significant drivers of participation in GVC: factor endowments, geography, market size, and institutions (World Bank, 2020).

Figure 1.1 Drivers of participation in GVC



Source: own elaboration based on World Bank (2020)

The type of involvement of enterprises in the international division of labour presented above can be explained using the concept of value chain developed by Porter (1998). Traditionally used in the management sciences, this concept describes the implementation of processes arranged in a specific sequence that allows a company to offer goods or services that find acceptance among buyers. The initial links in the value chain, such as research and design, are usually called pre-production processes. The acquisition of raw materials and components (intermediate goods), intermediate assembly, intangible inputs, and final assembly, which form the next group of links in the chain, are called production processes. The last links of the chain, i.e., distribution, sales and warranty service, are called post-production processes.

Transferring the value chain concept from the management sciences to the economic analysis, it is assumed that each of the processes comprising the value chain may be the subject of the international cooperation of enterprises. Such collaboration can be undertaken within global value chains, linking economies ever more closely together. Timmer et al. (2013) outlined global value chains (GVCs) as increasingly fragmented across countries, with each country playing a specialized role in particular stages in the production chain. The main determinants of such specialization in particular stages resulted from trade, transport, and communication costs. They were driven by the acceleration of free trade agreements, regional integration, the accessibility of less expensive labour, and communication technology developments.

The drivers of GVC participation are closely related to why firms participate in global supply networks, which should be linked to the most fundamental goal of doing business, which is to multiply value over time. Effective business activity is the profit achieved by increasing revenue or reducing production costs. Both effects can be achieved by entering an international market and fragmenting production.

There are four leading causes of the foreign expansion of enterprises. These are resource seeking, market seeking, efficiency-seeking, and strategic asset seeking (Dunning, 1993).

1.3.1 Factor endowment

The first group of reasons concerning the company's resource seeking refers to the country's natural resources (e.g., natural resources, agricultural commodities), the labour force (without taking into account the diversity of qualifications, labour force as a factor of production abundantly used in labour-intensive processes) or advanced technologies. The latter arises from the need to acquire knowledge and skills about combining factors of production that are not available in the home country of the company relocating processes.

The resource factors presented by J. Dunning refer to the first primary driver of GVC participation listed by the World Development Report (World Bank, 2020). The importance of endowment, especially regarding labour force availability and cost, was confirmed by multiple empirical studies, such as the Offshoring Research Network (ORN), conducted in the first half of the previous decade by the (2004-2011) (ORN 2011a, 2011b).

This research indicates that the most crucial factor determining the emergence of GVCs, as an effect of offshoring, is companies' desire to reduce costs (both labour and others). Thus, the most critical factor during the period of the world's most substantial growth in the relocation of value chain processes was costs, including labour costs. Thus, a country offering relatively cheap labour was able to attract the most processes and participate in GVCs.

The outcomes of many other empirical studies confirm that differences in labour costs significantly impact the emergence of GVCs (OECD, 2007, 2013a; Los et al., 2016). This effect has weakened considerably in recent years when there has been a marked increase in wages in countries traditionally considered to have low labour costs. The differences in labour costs between developed and developing countries are narrowing: the average real wage in China in the material production sphere is now more than ten times higher than in the mid-1990s. In the same period, wages in the United States have increased by 77% (ILO, 2016). However, the period of most remarkable wage change appears to have passed. As the latest International Labour Organization (ILO) report indicates, wage growth worldwide has slowed - since 2012, falling to its lowest level in four years. If China is excluded from the mix (that country had faster wage growth than elsewhere), global wage growth fell from 1.6% to 0.9% between 2010 and 2015 (ILO, 2016).

Another important factor from the resource element group is access to skilled labour. In the ORN study, no other reason for offshoring gained so much importance. Through offshoring, companies can acquire knowledge and skills that companies often lack and engage external resources (Manning et al., 2012). Access to skilled workers is causing fragmentation and transfer of processes in search of opportunities to take advantage of highly qualified scientists and engineers, which are becoming increasingly difficult to obtain in developed economies (Manning et al., 2008). It is pointed out that previously companies used to carry out knowledge-intensive processes, i.e., R&D work using internal human resources. The knowledge possessed by the firm was treated as an essential resource of the firm created using its skilled workforce. Over time, however, the concept of performing knowledge-intensive processes within the enterprise has changed. It turned out that many companies began to acquire knowledge resources by outsourcing the execution of knowledge-intensive processes to foreign contractors.

Access to resources of a highly skilled labour force is increasingly essential, especially for companies whose competitiveness of goods depends on their modernity. The analysis of the ORN research reports shows that before 2007 offshoring of knowledge-intensive processes was used mainly by high-tech companies. In recent years, an increasing interest in offshoring the processes can be observed in the group of other companies. This applies to consumer electronics, pharmaceuticals, electrical machinery and equipment, and automotive.

The analysis of the ORN research reports shows that before 2007 offshoring of knowledge-intensive processes was used mainly by high-tech companies. In recent years, an increasing interest in offshoring the processes can be observed in the group of other companies. Access to resources of a highly skilled labour force is increasingly essential, especially for companies whose competitiveness of goods depends on their modernity. This applies to consumer electronics, pharmaceuticals, electrical machinery, and equipment, automotive.

A significant shortening of the life cycle is observed in the case of the mentioned goods and some of their components. The transition of a company to the next product life cycle requires maintaining a high level of innovation.

The literature points to the declining stock of highly skilled workers in developed countries. However, two different opinions on this issue are visible. According to the first, companies in developed countries face difficulties filling specialised skills positions. One talks about the lack of resources for skilled workers in technical sciences (STEM - Science, Technology, Engineering, Mathematics). The authors of a report prepared by Manpower a decade ago (Manpower, 2012) and recently (Manpower, 2022) wrote about these problems, indicating the lack of technical knowledge as the most considerable difficulty in filling positions in the surveyed companies. As it turned out, American and European companies had the most significant problem in finding qualified employees for jobs requiring specialized knowledge. Asian companies experienced minor difficulties in this regard. The latest report emphasizes that technology-related roles continue in high demand – 69% of employers have problem filling jobs.

Another important observation of the Manpower report authors is that the most significant difficulties in recruitment are related to engineering positions. Employees with technical and engineering qualifications were the most difficult to find in the labour market, indicated by companies from the United States, United Kingdom, Poland, Bulgaria, Israel, Romania, Japan, New Zealand, and South Africa.

Moreover Goos et al. (2013) note that between 2008 and 2011, there was exceptional growth in employment in high-tech industries in EU countries. This growth was almost 20%, while total employment grew by 8%. They found that 60% of jobs in high-tech industries across the European Union (EU27) were created by only four countries in 2011, namely: Germany, France, Italy, and the UK (Goos et al., 2013). However, the age structure of the population in these countries is unfavourable for the development of the labour resource market. Therefore, companies are looking for skilled workers outside these countries, moving the knowledge-intensive processes abroad. Therefore, in some countries, high-tech employment grew much more than the EU average: Slovenia – grew by 52%, Spain – by 51%, Luxembourg – by 45%, Cyprus – by 40%, Slovakia, Latvia, Italy – by 30%. Above the average for EU countries were also: France, Greece, Czechia, Austria, Belgium, Portugal, and Hungary.

Low-skilled labour and foreign capital are key drivers for backward participation in GVCs. Countries highly supplied with low-cost labour participate in the labour-intensive manufacturing segments of GVCs. Consequently, skills enhance to more complex processes to be relocated.

Natural resources drive forward GVC integration when foreign investors seek needed resources in the host country. As a result, foreign capital boost host country integration in GVCs. It also stimulates upstream sectors developments, i.e., apparel in Bangladesh, electronics in Vietnam, and automotive in Morocco (World Bank, 2020).

1.3.2 Market size

In addition to differences in labour costs, the development of GVCs has been encouraged by the liberalization of international trade and the decline in transportation costs. All these factors are part of the concept of transaction costs (Venables, 1999b; Anderson, van Wincoop, 2004).

Participation in GVCs is also driven by trade liberalization, which expands the market size and promotes a country's openness. Elements affecting trade in intermediate goods are identified by Yi (2003), which examines the importance of tariff barriers to developing supply chains. His study proved that tariff reduction significantly affects trade in intermediate goods. The strong effect of tariff reduction on trade in intermediate goods was also noted by Egger and Egger (2006), observing the attractiveness of the Central and Eastern European market for the location of production processes by Austrian companies.

Lower tariffs on manufacturing goods foster backward GVC participation in manufacturing. Lower tariffs in destination markets reveal more robust GVC participation in backward and forward. However, the effects depend on rules of origin and their impacts on developing a local supplier base in the long run (World Bank, 2020).

1.3.3 Geography

Companies participating in GVCs also consider factors that determine the supply chain organization, such as distance from other branches, good infrastructure, and effective communication, i.e., geographical considerations. A study of apparel companies in the European Union identified labour costs, geographic proximity, and cultural similarities as the most important reasons for locating production (Baldone et al., 2001). This is also confirmed by the example of Brazil, described by Ruiz, as an attractive production location for American companies such as Whirlpool, Gap, and GE (Ruiz, 2007). These companies choose to locate in Brazil, among others, because of its geographical proximity (much closer than to Asian countries). However, labour costs are slightly higher here than in Asia, and above all, the size of the market (Ruiz, 2007). The importance of distance, thanks to which companies ensure timely delivery and efficiency of production organization, is also indicated (Evans & Harrigan, 2003; Razzolini & Vannoni, 2009). In the factors mentioned above, Alcacer (2005), for example, sees the main reason for the lack of interest in process outsourcing companies in African countries.

Regarding the importance of transportation costs on the development of trade in intermediate goods, a detailed study was conducted by Hummels et al. (1998). They found that as a result of transportation improvements, the speed at which goods are moved increased, and thus the cost, which these researchers call the tax equivalent of trade cost, decreased. In the case of the United States, this was a change from 32% to 9% of total transportation costs between 1950 and 1998 (Hummels et al., 2001).

World Development Report highlights the longer geographical distances to the significant GVC hubs (China, Germany, and the United States), the less backward and forward GVC participation in manufacturing. Moreover, trade in components within international production networks highly depends on logistics functioning and uncertainty in bilateral international transport times (World Bank, 2020).

1.3.4 Institutions

Preferential trade agreements (PTAs) can enhance institutional quality and increase GVC participation of a country. PTAs design legal and regulatory frameworks and harmonize customs procedures and IP protection rules. Weak contract enforcement deters traditional trade flows, and GVCs are particularly sensitive to the quality of contractual institutions. Sectors relying more on contract enforcement see faster growth in GVC participation in countries with better institutional quality (World Bank, 2020). Effective policies to attract FDI result in capital inflows, technology development, and management skills improvement. Liberalizing trade at home while negotiating trade liberalization abroad can overcome the constraints of a small domestic market, open them for foreign cooperation and develop the economy based on external values (capital/technology/skills).

1.4 Strategies and governance of the GVCs

Governance is the essential part of the GVC analysis, especially when trying to better participate in the higher value added activities of the smile curve. It shows how corporate power exercised by global OEMs actively shapes the distribution of profits and risks in a particular industry and how this alters the upgrading prospects of firms in developed and developing economies that are included and excluded from the supply chain that constitutes each industry (Gereffi, 2018). The shift of a company or country in the value chain refers to a set of activities aimed at improving the structure of production towards a higher share of added value (Éltető et al., 2015). As a result of this shift, companies and countries are gaining higher profits and raise wages, but also a "safer" position within the chain, and thus higher economic stability. The literature on the shift in the value chain (Humphrey & Schmitz, 2002) identifies four basic strategies:

1. **Product upgrading,** reorientation of the product portfolio or moving into more sophisticated product lines (e.g., production of higher value items, such as organic fruits and vegetables).
2. **Process upgrading,** transforms inputs into outputs more efficiently by reorganizing the production system or introducing superior technology

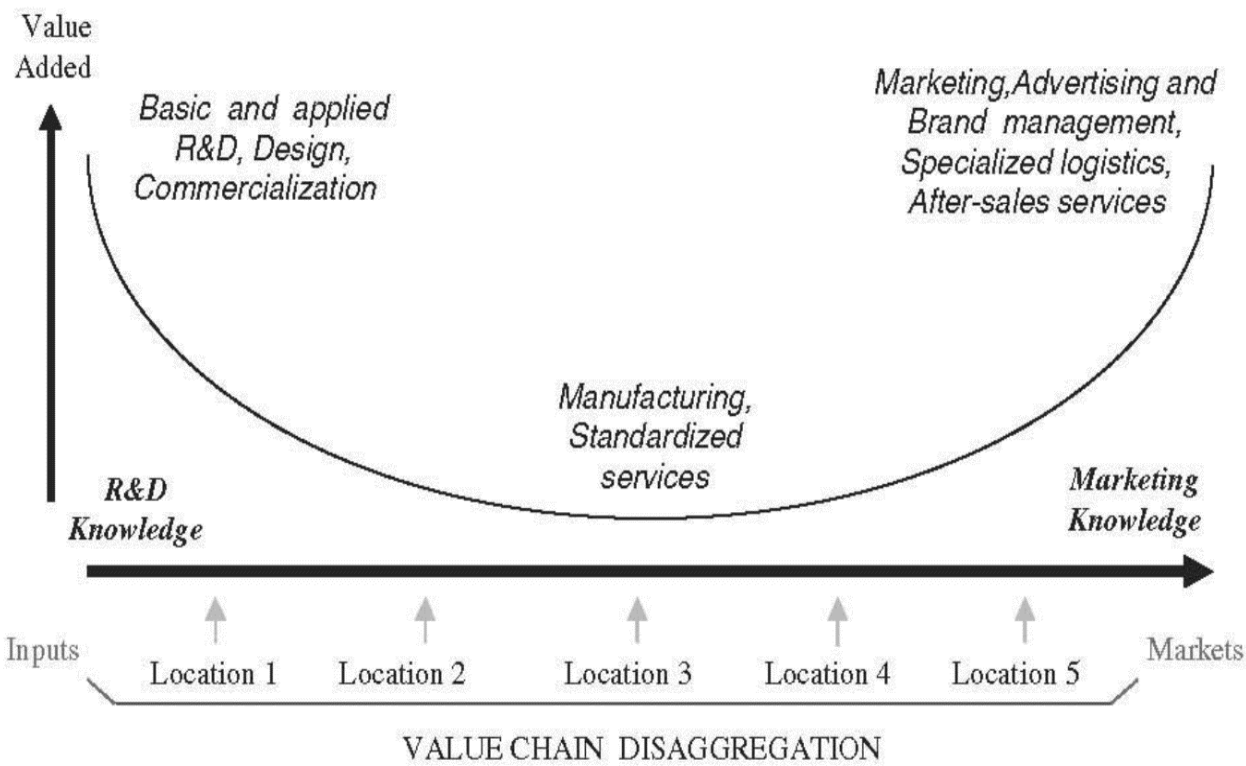
(e.g., automation or robotization that increases productivity and reduces factory lead times).

3. **Functional upgrading,** entails acquiring new functions (or abandoning existing functions) to increase the overall skill and value added content of the activities (e.g. in the mining sector, processing the mineral in addition to extraction).
4. **Chain or intersectoral upgrading,** where firms move into new but often related industries (e.g., television set manufacturers start producing computer screens).

Moreover, Fernandez-Stark, Bamber and Gereffi (2014) identified several additional types of upgrading. These add to Humphrey and Schmitz (2002) by also considering upgrading beyond the firms that already participate in GVCs: entry in the value chain, backward linkages upgrading and end-market upgrading. E.g., Gereffi (2018) characterizes social upgrading concept as related to, but more encompassing than, CSR (Corporate Social Responsibility). Social upgrading expands the scope of CSR by focusing not only on efforts by global companies to ameliorate labour conditions but also on other non-corporate measures initiated by NGOs and governments.

One of the most common diagrams showing the relationship between the phases of the value chain and the amount of added value is the "smile curve", authored by the founder of ACER, Stan Shih – see Figure 1.2.

Figure 1.2 The Smile Curve



Source: based on Fernandez-Stark & Gereffi (2019)

The scheme shows that for domestic companies to be more competitive they must be able to carry out activities that are at a higher rate of added value and thus ultimately increase export competitiveness in a network of global suppliers to OEMs. The curve illustrates the opportunities for higher value added production, mainly at the beginning and end of the value chain (Low, 2013). Commercial services usually have the highest value added comparing usual industrial sectors (Minárik et al., 2022). Most processes with higher added value are usually implemented in developed economies, whose companies are more innovative (better able to apply R&D expenditures commercially). Firms from developing countries are concentrated within GVCs, especially in activities with a lower rate of added value, where comparative advantage is applied such as cheap labour, free environmental burden, etc. As part of GVC activities carried out by companies in developed economies, spill-over effects occur in developing countries over time, and companies from developing countries subsequently "domesticate" innovations within their production processes as part of the catching-up process, which is in line with the product life cycle theory – explanation of high-tech production locations by R. Vernon. Naturally, activities involving a higher degree of added value within the pre-production phase are R&D knowledge-intensive, and in the second part - the post-production phase, marketing is essential.

Later, Fernandez-Stark, Bamber and Gereffi (2014) and Fernandez-Stark and Gereffi (2019) identified several additional types of upgrading. Besides those proposed by Humphrey and Schmitz (2002) by also considering upgrading beyond the firms that already participate in GVCs:

1. Entry in the value chain, where firms participate for the first time in national, regional, or global value chains. This is the first and one of the most challenging upgrading trajectories.
2. Backward linkages upgrading, where local firms (domestic or foreign) begin to supply tradable inputs and/or services to companies that previously used imported inputs.
3. End-market upgrading, where firms already in the chain move into a more sophisticated product or geographic markets that require compliance with new, more rigorous standards or call for production on a larger scale at accessible prices.

Competences in value chains and their distribution depend primarily on the characteristics of the production process. In general, we distinguish two basic types of global value chains, namely:

- Buyer-driven GVCs.
- Producer-driven GVCs.

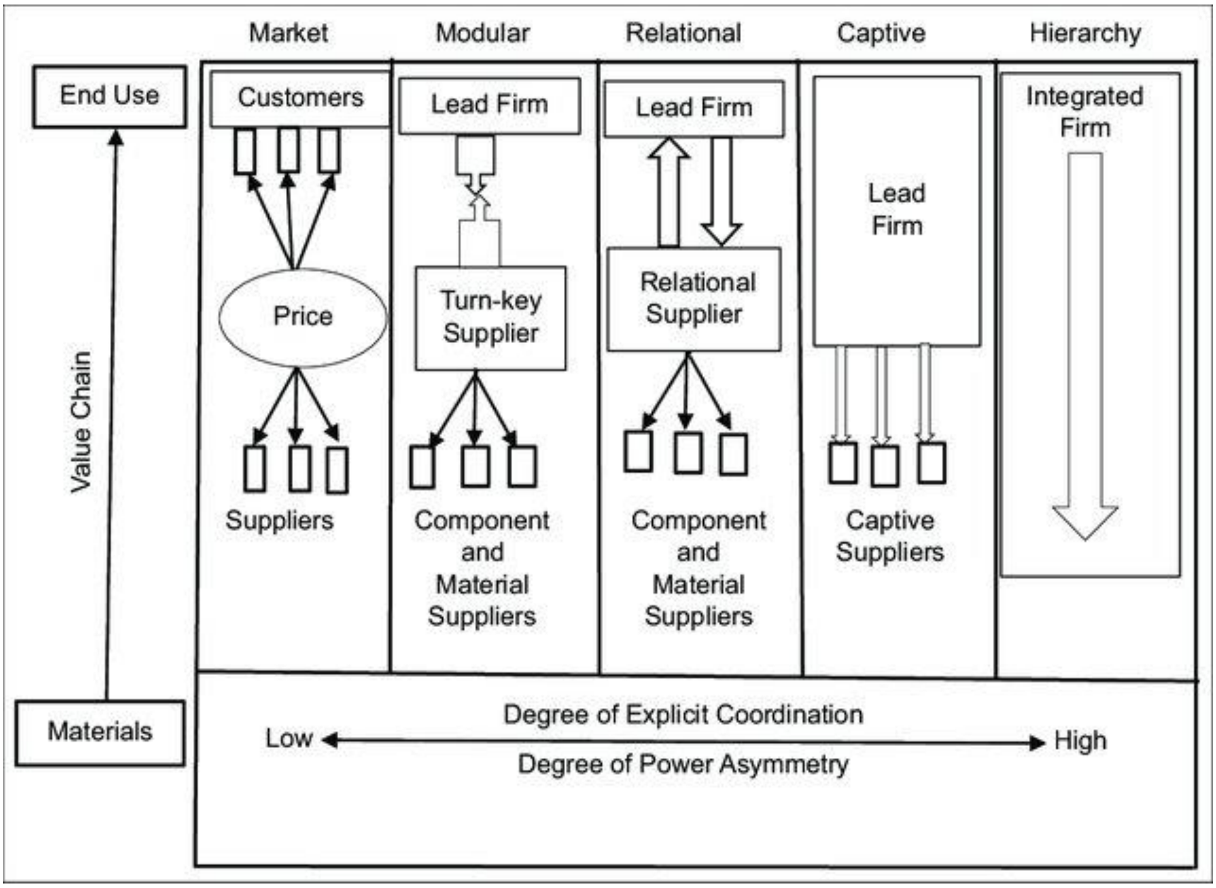
In buyer-driven chains, retailers and sellers of finished products are advantageous due to their ability to shape mass consumption through dominant market shares and strong brands (Frederick & Gereffi, 2009; Sturgeon, 2009). While buyer-driven chains are mainly chains with a horizontal management structure and simple products, manufacturer-driven chains are characteristic of complex products. Another characteristic of manufacturer-managed chains is the reporting of a higher degree of vertical integration. This type of chain is typical, for example, of the automotive industry[6].

Governance of the global value chains plays a key role in the development of the companies but also whole national economies (e.g., CEE countries dependent on foreign investors established in the region). A theory of GVCs governance is based on the following factors:

1. complexity of information and knowledge transfer required to sustain a particular transaction (determined by the product and process specifications)
2. the extent to which this information and knowledge can be codified and, therefore, transmitted efficiently and without transactions-specific investment between the parties to the transactions, and
3. the capabilities of actual and potential suppliers reflecting the requirements of the transaction (Gereffi, 2018).

Figure 1.3 GVCs governance types

[6] For more details regarding automotive industry see Luptáčik et al. (2013) and Lábaj (2017).



Source: Gereffi (2018)

As illustrated above, we distinguish five main types of management of global value chains, while the main criterion is the interconnection of a lead firm (key company) and its suppliers. This typology of value chain management structures seeks to mutually describe and explain the significant differences between different types of value chains (Gereffi et al., 2005). Between the two extremes of classical markets and hierarchical management (i.e., vertical integration), five network forms of management have been identified: modular, interconnected or relational, and direct management (Fernandez-Stark & Gereffi, 2019; Gereffi et al., 2005).

- **Market** – represents the most straightforward way of chain management, which is characteristic mainly for simple products. Markets linkages do not have to be entirely transitory transactions (Gereffi, 2018). In this way of management, the key company buys on the market from suppliers according to its current needs while not entering into long-term cooperation and cooperative relations with suppliers. The main criterion for selecting suppliers in this type of value chain management is usually the product's price. A supplier change is easily feasible if necessary or a more advantageous offer (Schmitz, 2006). According to Gereffi (2018), the essential point is that the costs of switching to new partners are low for both parties.

- **Modular** – suppliers in modular value chains make products to customers' specifications, which may be more or less detailed. Though, when providing "turn-key services", suppliers take full responsibility for competencies surrounding process technology, use generic machinery that limits transaction-specific investments, and make capital outlays for components and materials on behalf of customers (Gereffi, 2018). The supplier will process and deliver the product on his own and without the participation of a key company (with the exception of entering quality requirements). (Quadros, 2004).
- **Relational** – chain management applied mainly to processes and products with high information intensity, in conditions where it is not possible to ensure simple information sharing. Frequent personal contact is needed in order to share knowledge and information between partner parties. Many authors have highlighted the role of spatial proximity in supporting relational value chain linkages, but trust and reputation might well function in spatially dispersed networks where relationships are built up over time or are based on dispersed family and social groups (frequent in specific Asian GVCs settings). Emphasis is placed on relationships between partners, which are based on mutual trust between partners as well as on their reputation (Kishimoto, 2004).
- **Captive** – direct management of suppliers occurs primarily in cases where the competencies of local suppliers for activities with higher added value are not sufficiently developed. According to Gereffi (2018), in these networks, small suppliers are transnationally dependent on much larger buyers. As with the modular type of control, suppliers - manufacturers manufacture based on specifications from a key company. Unlike the modular type of control, the lead firm actively monitors and controls production and provides the necessary know-how to the manufacturer. Close relationships between the two partners are key to this type of governance. Possible change of suppliers or customers is difficult and expensive (Bazan & Navas-Aleman, 2004).
- **Hierarchy** – most often applied to highly complex products, where the majority of knowledge has the so-called silent nature and cannot be codified. In such cases, finding competent suppliers is extremely difficult. A typical feature of this type of chain management is the vertical integration of production activities – i.e., the effort of a key company to concentrate the entire process of design, development and production within its own hierarchical structure of departments and plants. We now encounter this type of value chain management less and less often (Barba-Navaretti & Venables, 2004; Slušná & Balog, 2015).

To understand how different forms of governance can affect economic and social upgrading, Gereffi (2018) suggests two distinct forms of governance in industrial clusters of GVCs: horizontal and vertical governance. Horizontal (cluster) governance refers to locality-based coordination of the economic and social relations between cluster firms and institutions within and beyond the cluster. On the other hand, vertical governance operates along to value chain, lining a series of buyers and suppliers in different countries, each of which adds value to the final product.

Table 1.1 Types of governance in clusters and GVCs by scope and actor

Actor	Scope	
	Horizontal (cluster) governance	Vertical (GVC) governance
Private governance	Collective efficiency (e.g., industrial associations, cooperatives)	GVC lead-firm governance (e.g., global buyers´ voluntary codes of conduct)
Social governance	Local civil society pressure (e.g., workers, labour unions, NGOs for civil society, workers, and environmental rights, gender-equity advocates)	Global civil society pressure on lead firms and major suppliers (e.g., Fair Labour Association) and multi-stakeholder initiatives (e.g., Ethical Trading Initiative)
Public governance	Local, regional, and national government regulations (e.g., labour laws and environmental legislation)	International organizations (e.g., the ILO, WTO) and international trade agreements (e.g., NAFTA, AGOA)

Source: Gereffi (2018)

A crucial meaning for the V-4 countries will be horizontal governance, particularly public governance, since the presence of the TNCs and quality of investment climate play a key role in further shaping the GVCs structure, particularly in the automotive sector. Public actors exercise public governance, including governments at various levels within nation-states and supranational organizations (Gereffi, 2018). Public governance in the cluster context (automotive cluster of V-4 countries) involves formal rules and regulations set by the governments at local, regional, and national levels. Finally, they can facilitate or hinder social and economic upgrading, directly and indirectly. According to Gereffi (2018), other public governance measures, such as industrial policy, trade and investment regulations, or competition policy, do not intend to address labour concerns but can indirectly affect social upgrading outcomes while directly impacting economic upgrading.

1.5 GVCs and trade in value added principles

Such analyses reach the end of the first decade of the 21st century. It is not only a new theoretical approach and a new method to examine international trade but also a tool important to conduct empirical research in international economic cooperation since analysing trade in value added differs substantially from analysing trade measured by gross value. Also, the results of trade analysis in value added differ from traditional studies and can give different economic policy recommendations.

"Made in the world" was the catchphrase when the WTO and OECD launched their joint trade in value added database (TiVA). It documented deep and broad economic relationships across international borders as firms sliced up their value chains and located production of intermediaries and accompanying services in multiple countries/continents. Subsequent research using the TiVA and World Input-Output Database (WIOD) proved that the drivers of GVCs were technical progress, especially in transport and communication, as well as trade liberalization (Gereffi & Fernandez-Stark, 2011; Baldwin, 2016). The GVCs research also revealed the importance of services in international trade both as a lubricant in coordinating and managing GVCs and as an intermediate input in goods production (Low 2013). Thus, services (earlier generally non-tradable) account for between a third and a half of value added trade (de Backer & Miroudot, 2013; Kuźnar, 2020) and are an essential part of GVCs.

Nowadays world input-output tables are available in databases such as: OECD Intercountry Input-Output Database, World Input-Output Database, Global Trade Analysis Project, EORA Multi Region Input Output Table, IDE-JETRO International Input-Output Tables, the Asian Development Bank's Multiregional Input-Output Tables and Multi-regional Environmentally Extended Supply and Use/Input-Output. That proves high demand for statistics necessary for studies on trade in value added and GVCs as well as big importance of research on these topics.

The "Made in the world" catchphrase struck a chord, but in reality, value chains are rarely global. Instead, most of them are regional with three centres consisting of North America, Europe and Asia, or – with other words – "Factory North America", "Factory Europe" and "Factory Asia" (Baldwin & Lopez-Gonzales 2013; Miroudot & Nordström 2015; Meng et al., 2019). Moreover, the lengthening and branching of value chains came to a halt in the mid-2000s, reversed during the global crisis curling up into more compact chains and has not fully recovered since. Since mid-2000s value chains have also become more regional and less global (Hanzl-Weiss et al., 2018, McKinsey Global Institute, 2019). Additionally, slowbalisation – meant as the noticeable slowdown of globalisation during the last few years (see The Economist 2019a-e; McKinsey Global Institute 2019, PWC 2020) – together with the global crisis caused by the COVID-19 pandemic ("corona crisis") probably has been making value chains even more regional. Nevertheless, international value chains still matter, or even give direction to international co-operation. This is true especially when we measure international activity by trade in value added rather than by gross trade in intermediaries (Timmer et al., 2015). Moreover, international values chains are drivers of trade in final goods, services, and intermediaries and of FDI, especially in innovative production processes (e.g., these connected with digitization). GVCs are quite well explored in the literature (studies mentioned in this text; for literature review, see Kano et al. 2020). Quite novel is the focus on three types of international networks: traditional trade networks, simple GVCs and complex GVCs proposed among others by Meng et al. (2019), which is derived directly from analysing the world input-output table.

An exemplification of the world input-output table for the global economy comprising *m* countries whose economies have *n* industries is shown in Table 1.2. Each industry is given one line (row) in which it stands for the manufacturer (supply-side) and one column, where it is the recipient of products (demand side). The middle, square part of the international table of inter-industry flows (shaded grey) contains inter-industry flows, both national (darker shade of grey) and international (lighter shade of grey). The first two digits in the subscript mean the numbers of countries, and the next two (in brackets), are the numbers of industries between which the flows occur. In the case of material outlays of the value added and the global product, the first digit in the subscript means the country number and the second (in brackets), the industry number. And when marking the demand for intermediate and final goods, the first two digits are the numbers of countries, and the last digit (in brackets) is the industry number. The first is the sum of inter-industry flows (sum of rows) like the material outlays (sum of columns).

Table 1.2 World input-output table (international table of inter-industry flows)

	Inter-industry flows													Demand for intermediate goods (intermediate consumption)				Demand for final goods (final consumption)				Global product
	Country 1, industry 1	Country 1, industry 2	…	Country 1, industry n	Country 2, industry 1	Country 2, industry 2	…	Country 2, industry n	…	Country m, industry 1	Country m, industry 2	…	Country m, industry n	Country 1	Country 2	…	Country m	Country 1	Country 2	…	Country m	
Country 1, industry 1	$x_{11(11)}$	$x_{11(12)}$	…	$x_{11(1n)}$	$x_{12(11)}$	$x_{12(12)}$	…	$x_{12(1n)}$	…	$x_{1m(11)}$	$x_{1m(12)}$	…	$x_{1m(1n)}$	$z_{11(1)}$	$z_{12(1)}$	…	$z_{1m(1)}$	$f_{11(1)}$	$f_{12(1)}$	…	$f_{1m(1)}$	$X_{1(1)}$
Country 1, industry 2	$x_{11(21)}$	$x_{11(22)}$	…	$x_{11(2n)}$	$x_{12(21)}$	$x_{12(22)}$	…	$x_{12(2n)}$	…	$x_{1m(21)}$	$x_{1m(22)}$	…	$x_{1m(2n)}$	$z_{11(2)}$	$z_{12(2)}$	…	$z_{1m(2)}$	$f_{11(2)}$	$f_{12(2)}$	…	$f_{1m(2)}$	$X_{1(2)}$
.	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Country 1, industry n	$x_{11(n1)}$	$x_{11(n2)}$	…	$x_{11(nn)}$	$x_{12(n1)}$	$x_{12(n2)}$	…	$x_{12(nn)}$	…	$x_{1m(n1)}$	$x_{1m(n2)}$	…	$x_{1m(nn)}$	$z_{11(n)}$	$z_{12(n)}$	…	$z_{1m(n)}$	$f_{11(n)}$	$f_{12(n)}$	…	$f_{1m(n)}$	$X_{1(n)}$
Country 2, industry 1	$x_{21(11)}$	$x_{21(12)}$	…	$x_{21(1n)}$	$x_{22(11)}$	$x_{22(12)}$	…	$x_{22(1n)}$	…	$x_{2m(11)}$	$x_{2m(12)}$	…	$x_{2m(1n)}$	$z_{21(1)}$	$z_{22(1)}$	…	$z_{2m(1)}$	$f_{21(1)}$	$f_{22(1)}$	…	$f_{2m(1)}$	$X_{2(1)}$
Country 2, industry 2	$x_{21(21)}$	$x_{21(22)}$	…	$x_{21(2n)}$	$x_{22(21)}$	$x_{22(22)}$	…	$x_{22(2n)}$	…	$x_{2m(21)}$	$x_{2m(22)}$	…	$x_{2m(2n)}$	$z_{21(2)}$	$z_{22(2)}$	…	$z_{2m(2)}$	$f_{21(2)}$	$f_{22(2)}$	…	$f_{2m(2)}$	$X_{2(2)}$
.	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Country 2, industry n	$x_{21(n1)}$	$x_{21(n2)}$	…	$x_{21(nn)}$	$x_{22(n1)}$	$x_{22(n2)}$	…	$x_{22(nn)}$	…	$x_{2m(n1)}$	$x_{2m(n2)}$	…	$x_{2m(nn)}$	$z_{21(n)}$	$z_{22(n)}$	…	$z_{2m(n)}$	$f_{21(n)}$	$f_{22(n)}$	…	$f_{2m(n)}$	$X_{2(n)}$
…..	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Country m, industry 1	$x_{m1(11)}$	$x_{m1(12)}$	…	$x_{m1(1n)}$	$x_{m2(11)}$	$x_{m2(12)}$	…	$x_{m2(1n)}$	…	$x_{mm(11)}$	$x_{mm(12)}$	…	$x_{mm(1n)}$	$z_{m1(1)}$	$z_{m2(1)}$	…	$z_{mm(1)}$	$f_{m1(1)}$	$f_{m2(1)}$	…	$f_{mm(1)}$	$X_{m(1)}$
Country m, industry 2	$x_{m1(21)}$	$x_{m1(22)}$	…	$x_{m1(2n)}$	$x_{m2(21)}$	$x_{m2(22)}$	…	$x_{m2(2n)}$	…	$x_{mm(21)}$	$x_{mm(22)}$	…	$x_{mm(2n)}$	$z_{m1(2)}$	$z_{m2(2)}$		$z_{mm(2)}$	$f_{m1(2)}$	$f_{m2(2)}$		$f_{mm(2)}$	$X_{m(2)}$
.	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Country m, industry n	$x_{m1(n1)}$	$x_{m1(n2)}$	…	$x_{m1(nn)}$	$x_{m2(n1)}$	$x_{m2(n2)}$	…	$x_{m2(nn)}$	…	$x_{mm(n1)}$	$x_{mm(n2)}$	…	$x_{mm(nn)}$	$z_{m1(n)}$	$z_{m2(n)}$		$z_{mm(n)}$	$f_{m1(n)}$	$f_{m2(n)}$		$f_{mm(n)}$	$X_{m(n)}$
Material outlays	$u_{1(1)}$	$u_{1(2)}$	…	$u_{1(n)}$	$u_{2(1)}$	$u_{2(2)}$	…	$u_{2(n)}$	…	$u_{m(1)}$	$u_{m(2)}$	…	$u_{m(n)}$									
Value added	$v_{1(1)}$	$v_{1(2)}$	…	$v_{1(n)}$	$v_{2(1)}$	$v_{2(2)}$	…	$v_{2(n)}$	…	$v_{m(1)}$	$v_{m(2)}$	…	$v_{m(n)}$									
Global product	$X_{1(1)}$	$X_{1(2)}$	…	$X_{1(n)}$	$X_{2(1)}$	$X_{2(2)}$	…	$X_{2(n)}$	…	$X_{m(1)}$	$X_{m(2)}$	…	$X_{m(n)}$									

Source: authors

The international table of inter-industry flows can also be written in a simplified version with a focus on countries between which flows occur rather than on specific industries (see Table 1.3). Then single inter-industry flows (marked in Table 1.3 as x_{ij} (*ij*)) are joined into flows among particular countries (record using a matrix). A similar aggregation will be made in the case of demand for intermediate and final goods and material outlays value added and global products.

Table 1.3 Simplified world input-output table

	Inter-industry flows													Demand for intermediate goods (intermediate consumption)				Demand for final goods (final consumption)				Global product
	Country 1, industry 1	Country 1, industry 2	…	Country 1, industry n	Country 2, industry 1	Country 2, industry 2	…	Country 2, industry n	…	Country m, industry 1	Country m, industry 2	…	Country m, industry n	Country 1	Country 2	…	Country m	Country 1	Country 2	…	Country m	
Country 1, industry 1	X_{11}				X_{12}				…	X_{1m}				Z_{11}	Z_{12}	…	Z_{1m}	F_{11}	F_{12}	…	F_{1m}	X_1
Country 1, industry 2																						
.																						
Country 1, industry n																						
Country 2, industry 1	X_{21}				X_{22}				…	X_{2m}				Z_{21}	Z_{22}	…	Z_{2m}	F_{21}	F_{22}	…	F_{2m}	X_2
Country 2, industry 2																						
.																						
country 2, industry n																						
…..	…				…				…	…				…	…	…	…	…	…	…	…	…
Country m, industry 1	X_{m1}				X_{m2}				…	X_{mm}				Z_{m1}	Z_{m2}	…	Z_{mm}	F_{m1}	F_{m2}	…	F_{mm}	X_m
Country m, industry 2																						
.																						
Country m, industry n																						
Material outlays	U_1				U_2				…	U_m												
Value added	V_1				V_2				…	V_m												
Global product	$(X_1)'$				$(X_2)'$				…	$(X_m)'$												

Source: authors

From the Table 1.3 we can reach the classical Leontief (1936) equation:

$$\mathbf{X} = \mathbf{B} \cdot \mathbf{F}$$

or

$$\begin{bmatrix} \mathbf{X}_{11} & \cdots & \mathbf{X}_{1m} \\ \vdots & \ddots & \vdots \\ \mathbf{X}_{m1} & \cdots & \mathbf{X}_{mm} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{11} & \cdots & \mathbf{B}_{1m} \\ \vdots & \ddots & \vdots \\ \mathbf{B}_{m1} & \cdots & \mathbf{B}_{mm} \end{bmatrix} \cdot \begin{bmatrix} \mathbf{F}_{11} & \cdots & \mathbf{F}_{1m} \\ \vdots & \ddots & \vdots \\ \mathbf{F}_{m1} & \cdots & \mathbf{F}_{mm} \end{bmatrix},$$

where $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$ is the well-known (global) Leontief inverse matrix representing the induced output by one unit of final demand through the whole global production network ($\mathbf{A}$ is also well-known matrix of cost structure stemming from the coefficient of direct material consumption).

Following Meng et al. (2019) and multiplying both sides of Equation by $(\mathbf{I} - \mathbf{A})^{-1}$, we get:

$$\begin{bmatrix} \mathbf{I}\text{-}\mathbf{A}_{11} & \cdots & \text{-}\mathbf{A}_{1m} \\ \vdots & \ddots & \vdots \\ \text{-}\mathbf{A}_{m1} & \cdots & \mathbf{I}\text{-}\mathbf{A}_{mm} \end{bmatrix} \cdot \begin{bmatrix} \mathbf{X}_{11} & \cdots & \mathbf{X}_{1m} \\ \vdots & \ddots & \vdots \\ \mathbf{X}_{m1} & \cdots & \mathbf{X}_{mm} \end{bmatrix} = \begin{bmatrix} \mathbf{F}_{11} & \cdots & \mathbf{F}_{1m} \\ \vdots & \ddots & \vdots \\ \mathbf{F}_{m1} & \cdots & \mathbf{F}_{mm} \end{bmatrix}$$

what can be rewritten as:

$$(\mathbf{I} - \mathbf{A}_{ss}) \cdot \mathbf{X}_{sr} - \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \mathbf{X}_{tr} = \mathbf{F}_{sr},$$

where *r, s, t* denotes countries.

Multiplying both sides of the last equation with $\mathbf{L}_{ss} = (\mathbf{I} - \mathbf{A}_{ss})^{-1}$, which represents the domestic Leontief inverse of country *s* (induced output of domestic products by one unit of final demand), we get:

$$\mathbf{X}_{sr} = \mathbf{L}_{ss} \cdot \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \mathbf{X}_{tr} + \mathbf{L}_{ss} \cdot \mathbf{F}_{sr}.$$

Finally, we can decompose the global product of country *s* to:

$$\mathbf{X}_{s} = \mathbf{X}_{ss} + \sum_{r \neq s}^{m} \mathbf{X}_{sr} = \mathbf{L}_{ss} \cdot \mathbf{F}_{ss} + \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{F}_{sr} + \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr} + \mathbf{L}_{ss} \cdot \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{us} + \mathbf{L}_{ss} \cdot \left(\sum_{r \neq s}^{m} \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{ur} - \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr}\right).$$

In this decomposition we can find partner countries (r, t and u denote partner countries) of a country s (country s is the reporting country). Multiplying both sides of equation illustrating the global product of country s with the value added diagonal matrix we will get:

$$(\mathbf{V}_{s})' = \widehat{\mathbf{V}_{s}} \cdot \mathbf{X}_{s} = \widehat{\mathbf{V}_{s}} \cdot \mathbf{L}_{ss} \cdot \mathbf{F}_{ss} + \widehat{\mathbf{V}_{s}} \cdot \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{F}_{sr} + \widehat{\mathbf{V}_{s}} \cdot \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr} + \widehat{\mathbf{V}_{s}} \cdot \mathbf{L}_{ss} \cdot \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{us} + \widehat{\mathbf{V}_{s}} \cdot \mathbf{L}_{ss} \cdot \left(\sum_{r \neq s}^{m} \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{ur} - \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr}\right),$$

where:
$\widehat{\mathbf{V}_s} \cdot \mathbf{L}_{ss} \cdot \mathbf{F}_{ss}$ is the domestically (in country *s*) produced and consumed value added (with no internationalization),
$\widehat{\mathbf{V}_s} \cdot \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{F}_{sr}$ is the production of domestic value added (in country *s*) embodied in final product exports (traditional trade networks),
$\widehat{\mathbf{V}_s} \cdot \mathbf{L}_{ss} \cdot \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr}$ is the production of domestic value added (in country *s*) embodied in exports of intermediate goods and services but the domestic value added absorbed by the trading partner country without further border crossing (simple GVCs),
$\widehat{\mathbf{V}_s} \cdot \mathbf{L}_{ss} \cdot \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{us} + \widehat{\mathbf{V}_s} \cdot \mathbf{L}_{ss} \cdot (\sum_{r \neq s}^{m} \sum_{t \neq s}^{m} \mathbf{A}_{st} \cdot \sum_{u}^{m} \mathbf{B}_{tu} \cdot \mathbf{F}_{ur} - \sum_{r \neq s}^{m} \mathbf{A}_{sr} \cdot \mathbf{L}_{rr} \cdot \mathbf{F}_{rr})$ is the production of domestic value added (in country *s*) embodied in exports of intermediate goods and services but the domestic value added absorbed by the trading partner country with further border crossing (complex GVCs).

2 Recent trends in GVCs

2.1 Impact of COVID-19 on GVCs

The impact of the COVID-19 crisis has been tremendous and uneven at the level of individual companies and employees. Baldwin and Freeman (2020) point out two mainshocks of the pandemic on GVCs: the people's restricted ability to work and the decreased demand for manufactured goods. We also analyse the effects of pandemics in terms of disrupted transport and distribution networks.

2.1.1 GVCs in the pre-pandemic era

Global supply chains are a central feature of today's global economy (Pinna et al., 2021). This means that every part of the supply chain is essential for proper functioning because if in any section, from research to sales, an error occurs, the whole global chain will be disrupted. We can see this in a recent case in the tanker industry, which is particularly important (Poulsen et al., 2020) in transporting goods. On March 23, 2021, a vast container ship of a Japanese company was stranded in the Suez Canal, where it blocked traffic in both directions for a week, which caused a significant delay in deliveries. Oil suppliers announced an increase in oil prices, to which world trade responded with a real increase. Oil refiners began to hesitate in further orders, and after unblocking the canal and evaluating the reactions of refiners and individual governments, suppliers were forced to announce a drop in oil prices.

The end of the nineties and the years 2000 were a kind of “golden era” for the global value chains (Sako, 2022). The decreasing costs of telecommunication and the dismantling of trade and investment barriers strengthened globalisation. The offshoring of several production phases increased the fragmentation of production (Chilimoniuk-Przeździecka, 2018). All this slowed down after the financial crisis of 2008. Expansion of GVCs stopped, and GVC-length has shortened. Among the reasons for this process are: rising labour costs in the developing areas, the application of automation and protectionist pressures. However, just before the COVID-19 pandemic, there have been signs of GVC growth picking up again.

The adoption of Industry 4.0, automation, and digitalisation in global production chains has already begun well before the pandemic. Digital technologies reduce coordination and transaction costs and increase the integration and visibility of GVC participants. Automation allows for higher production and leads to higher demand for inputs and higher GVC trade (Simola, 2021). At the same time, big data and artificial intelligence have raised cybersecurity risks, rendering national borders important when deciding where to store data (Sako, 2022). Industry 4.0 is mostly applied in the automotive industry, where just-in-time delivery and lean manufacturing are typical. This led to highly efficient supply chains but also increased vulnerability to disruptions.

2.1.2 Direct and indirect impact of the pandemic on GVCs

The potential impacts of the COVID-19 shock on global value chains may be direct or indirect. This directly impacts when companies stop producing products due to health and distance measures. For example, if some employees were ill, they had to comply with the mandatory state-imposed quarantine, typical in many virus-affected countries and businesses. In terms of indirect impact, several aspects can significantly affect global value chains. Supply chain impact is among indirect ones. It occurs when companies in one location are affected by supply shortages of production inputs from locations directly impacted. Another one is a disruption in international transport networks when not the production of inputs involved but rather the means of transportation. First of all, workers in the transport industry and border agencies could not provide their services. Secondly, there were restrictions on the movement of people and additional requirements at the border introduced, which made the transport of goods impossible (e.g., air cargo could no longer be shipped via (cancelled) passenger flights). The third indirect impact of COVID-19 on GVCs is a demand impact. It is the case when fewer consumers are willing to buy the products, or when a surge in demand occurs, as was observed for critical medical supplies, or when there is a shift in demand (e.g., for some food products when the restaurants were closed). GVCs transmitted economic shocks from countries with lower demand for final products to countries producing semi-finished goods. The OECD study underlines that due to COVID-19, demand has increased dramatically for medical supplies. There has been a significant shift in the composition of demand for food, and demand has decreased for all other manufacturing GVCs (COVID-19 and Global Value Chains, 2020). The fourth indirect impact is related to trade and investment policy risk. Some countries introduced export bans for key medical products to secure supplies of them domestically. There is also some uncertainty about the future trade and investment regime as in crisis times; there is a tendency to increase protectionism measures.

2.1.3 Transport and distribution disruptions

GVCs generate trade interdependencies that make countries vulnerable to external shocks. The COVID-19 pandemic has made it evident that complex and lengthy GVCs can especially be a source of difficulties (Panwar et al., 2022). The total or partial closing of borders, and limitations on the free movement of people disrupted the transport of goods. The GVCs found themselves in a “perfect storm” arising from pre-existing trends (like the mentioned automation and protectionism) and the immediate and long-term impacts arising from the pandemic (Kersan-Škabić, 2021). Multiple businesses changed their approach from just-in-time to just-in-case, while respecting supply distortions and transportation disturbances.

Unnecessary fluctuations in supplier relationships also affect distribution, whether basic raw materials, components, or finished products. The changes are caused by a limited workforce and government regulations to combat the spread of the COVID-19 pandemic (Pinna et al., 2021). Marketing is indirectly affected by the pandemic. It can be said that the marketing sector is directly dependent on developments in world trade. The sales to the final consumer were significantly reduced in individual countries, and during strict anti-pandemic lock-downs. It was only allowed for a limited range of essential consumer goods, medicines, medical supplies, and food. The reason was to minimize possible limitations of the construction, service, and maintenance work required to operate other manufacturing and non-manufacturing industries and state institutions (Waldkrich, 2021). The impact of the COVID-19 pandemic on overall product sales and their subsequent export to customers is significant.

Transport disruptions lasted in the second half of 2020, too. A key reason for logistical disturbances was that major economies had a quick bounce back from the decline. Most companies were not ready to produce at the level needed to meet new demand. Containers got stuck, and container unavailability quickly increased shipping costs (Panwar et al., 2022).

One of the reasons for disruptions was the shortage of semiconductors. Their production process takes 4-6 months and requires very high precision, plants are extremely costly, and they must run nonstop to compensate for investment costs. The semiconductors manufacturing process also consumes enormous amounts of water and electricity and is highly vulnerable to disruptions. The largest semiconductors producers are based in Asia (the largest being Taiwan Semiconductor Manufacturing Co.).7 Adjusting to the demand shift came with a lag. Planning and adjusting semiconductor production volumes requires time, particularly when suppliers practice low-inventory just-in-time supply and production (Sako, 2022).

By 2021, the shortage of semiconductors and certain base metals will be long-lasting. Policymakers and automotive companies reacted with strategic measures. The Asian foundries expanded their facilities further. The American government and the European Union encouraged the building of advanced semiconductor factories in the US and Europe. The European program intends to increase semiconductors research, production capacity and international cooperation (the aim is to increase the EU's share of the global semiconductor market to 20% by 2030), and even establish a European Semiconductor Fund8. Labour costs are high in Europe, however, so labour-intensive production parts will remain in Asia. The EU's semiconductor strategy has been criticised because companies had not invested in cutting-edge firms for almost two decades, and the EU lacks semiconductors design capabilities (Kleinhans, 2021).

[7] https://www.cnbc.com/2021/03/16/2-charts-show-how-much-the-world-depends-on-taiwan-for-semiconductors.html

[8] https://techmonitor.ai/silicon/european-chips-act-eu-infineon

COVID-19 was a crucial period for modifying the strategies of multinational companies and decisions regarding the location of FDIs and their key suppliers (Kalotay and Sass, 2021). The reason was the supply shock brought about by the pandemic and the related increase in transport costs in international logistics, but also, in principle, the shortage of the strategic components, which began to be felt in December 2020, but in the V-4, it was more pronounced in March 2021. Given the trend of electromobility, autonomous vehicles, and connectivity, their share and the automotive industry was already about 4% in 2019 and should grow to 20% by 2030. The negative impact of this outburst is expected even in 2022, while, e.g., the management of Volkswagen AG expects the problems associated with the supply of these parts in the next few years.9

This trend was exacerbated by the military aggression of the Russian Federation in Ukraine, which brought both a demand shock (production slowdown or the exit of car lead companies from the Russian market) and a supply shock (production of cables and other automotive components in Ukraine). The conflict in Ukraine can be seen as an accelerator of the supply shock in the automotive industry caused by COVID-19 and, to a lesser extent, as a new demand shock. In the V-4 region, the structural shortage of skilled labour and, above all, the innovative activity of domestic companies that would better respond to ACES trends (especially electromobility) remain still a more serious problem in the medium and long term.

2.1.4 Production disruptions

Baldwin and Freeman (2020) suggest a "triple hit" on global production due to pandemics:

Direct supply disruptions hindered production as the disease began to spread at the heart of the production, i.e., in East Asia, and subsequently spread rapidly to other industrial giants, such as the United States.

Supply chain "contagion" exacerbates their direct shocks, as it is more difficult or costly for manufacturing companies in less affected countries to obtain the necessary imported industrial inputs from severely affected countries, whether by a pandemic or natural disaster.

Interruptions in demand due to macroeconomic declines in aggregate demand, i.e., recessions, waiting for consumer purchases and delays in corporate investment.

The pandemic has disrupted production and supply chains, causing global recession and, in the longer term, it has created the need to increase the resilience of supply chains and security of production. Today resilience is a multidisciplinary topic concerning a great variety of complex systems of

[9] The problem of chip supply failure has significantly affected automotive producers in the V-4 region. E.g., in the Slovak Republic, the chip supply failure caused an estimated loss of 1.2% of GDP (equivalent to € 1.3 billion) for 2021 (IFP, 2022).

individuals, ecosystems, organizations, communities, supply chains, computer networks, and building infrastructures (Fraccascia et al., 2018). The resilience dimensions are stability, robustness, vulnerability, safety, and adaptability. Stability refers to the ability to preserve or return to the same equilibrium state when a failure occurs. Robustness is maintaining basic functionality; vulnerability concerns the sensitivity of the system to threats. Safety is a condition of no or small damage with a defence process. Adaptive capacity involves transformation, learning, self-organization, and positive feedback (Fraccascia et al., 2018).

Panwar et al. (2022) show that an unprepared company will suffer a 35% decline in sales from a normal year. However, a well-prepared firm in the semiconductor supply chain will experience only a 5% decline in sales due to a supply-chain disruption. Well prepared is a firm that applies multiple sourcing; increases supplier resiliency and collaboration with suppliers; puts in place best-practice emergency procedures; and discounts cross-selling of substitute products (e.g., premium models or older product versions) to end consumers. Evidently, preparedness, as well as supply-chain planning and governing, could make a difference.

Regarding governance, Javorcik (2021) discusses producer and buyer-driven GVCs and assesses that their reshaping will take time because this process requires substantial FDI flows. Verbeke (2020) discusses the possible impact of the COVID-19 pandemic on the governance of GVCs and identifies four areas of action: investments in safeguards, less irreversible investments abroad, relational contracting with key partners and diversification. He concludes that firms will adjust their governance systems to respond to challenges and create a governance context of sustained value creation.

Building robustness typically implies diversification of suppliers. For some companies, however, it can be less costly and enable faster recovery to have a long-term relationship with a single or few suppliers. Risks may differ substantially for sectors and companies, thereby requiring differing risk management strategies.

2.1.5 Ambiguous impact of anti-pandemic measures on different sectors

Anti-pandemic measures have significantly changed consumer behaviour and demand for certain commodities, with serious existential to fatal consequences for a large number of producers. Governments seek to mitigate these shocks through various combinations of macroeconomic stimulus packages, such as lower interest rates or direct support for businesses, employees, and the self-employed (Strange, 2020).

Governments, especially in developed countries, use targeted marketing to protect the COVID-19 pandemic from influencing as large a population as possible. The pandemic significantly affected the demand for various services and products, and services with vaccination itself. Measures to prevent coronavirus spread, with consequent restrictions on movement and encounters, have also increased the demand for computer electronics, especially mobile phones, smartphones, tablets, laptops, and game consoles. On the other hand, there was a considerable decline in overall demand for luxury goods and services during the pandemic for various reasons (Qin, M. et al., 2020). The main reason was working from home and teaching at all levels of education in electronic form via Internet networks.

The departments of non-food retail stores, refreshments and catering, all services, sports and culture, construction, the holiday sector, and the transport sector were significantly affected by minimizing the transfer of persons and their collection. Paradoxically, these departments were not directly affected by COVID-19, or not by demand, but by government regulations in virtually every country to stop the spread of the disease.

Anti-pandemic measures have severely affected demand for industrial production (Qin, X. et al., 2021). Increased demand for medical devices initially reduced their availability and increased the selling price. With the operational approach of the producers of these commodities, the market became saturated, and prices fell by a sharp increase in production or by shifting their capacities to produce scarce goods. Increased year-end stocks in retail chains offset increased interest in purchasing consumer computer electronics. Measures with consequent restrictions on movement and meeting have increased the demand for sports equipment and fitness equipment suitable for the home.

Electronic orders or delivery services played an essential role during the pandemic and closed retail stalls, which recorded a significant increase in goods transported. The acceleration of order processing and dispatch of goods with relatively reliable delivery to the consumer also contributed to this. Of course, the consumer reacts to the longer delivery times of some products and is looking for others similar to other manufacturers with a significantly shorter delivery time. Suppliers and transporters for industry and production are severely affected by reduced considerably production, uneven transport requirements, and, consequently, uneven consumption of transported products.

Global measures against the spread of COVID-19 and measures to manage it have led to an increase in variable costs in the supply and demand value chains, which has been reflected in the price of products. Government measures in economically advanced and, in some cases, developing countries dampen the increase in fixed costs and subsidize the increased value added costs (Barkman, 2021). These measures have significantly affected the final price of critical products and commodities.

In the case of small products, payment for the ordered goods takes place in electronic form, mainly in two ways. In the first, payment in advance is used when ordering goods, and in the second method, payment is made upon delivery via a payment terminal (card). The form of payment by direct payment in real money has been significantly minimized, and some retail chains do not even allow it. In international trade, payment discipline in industrial and wholesale companies is highly unstable due to anti-pandemic measures. After managing COVID-19, significant changes in the direction of demand are expected, which will be affected by the need to repay the so-called bridging loans and the purchasing power of final consumers.

The takeover of the product at the retail stage is carried out by direct import through consignment services and the rest through fixed dispensing points at sales stands, which are closed for average sale by state regulations. The system of taking over products and commodities wholesale and from manufacturers is affected by the pandemic in need to ensure increased storage capacity to cover supply unevenness (Pinna et al., 2021).

2.1.6 Prospects of reshoring activities

The effects of the coronavirus crisis and the dependence of global manufacturing on Asia have caused multinational companies to consider shifting their sourcing and production locations from China (Tan, 2020). The most-mentioned expectations of GVC restructuring are the reshoring or nearshoring GVC production and shortening of the chains. The US government has also promoted backshoring, which will probably continue (Gruszczynski, 2020). European (German) multinational companies' reshoring and nearshoring can benefit the Central European countries that have already built capacities and can accept new investments.

Observing the impact of the pandemics on international business, economists analyzing FDIs and the structure of the GVCs stress a greater focus on the regionalization of the production networks. For example, Baldwin and Freeman (2020) show that trade in intermediate products is more regionalized than in final goods.

The COVID-19 pandemic accelerated the trend of de-globalization, as many companies lacked input from the other end of the world or were unable to deliver goods to another point of collection leading businesses and consumers to think more locally (Enterprise, 2020). This was partially caused by a more than 600 % y/y transportation costs increase from the Asian ports but also a lack of semiconductors for the automotive industry. In other words, the importance of de-globalization was first realized by large companies, which, due to anti-pandemic measures, cut off supplies of crucial components from another part of the world and, conversely, due to anti-pandemic measures and closure of their assembly plants. Vast quantities of goods stuck in the transmission networks lost their value, others completely depreciated, and others lost customers. De-globalization and the shortening of key transport chains will directly increase the profitability of many companies and trading companies. Due to the economic complexity of the whole process of de-globalization, such a process cannot be done without the support of individual states in which companies capable of benefiting from de-globalization are located.

While possible for some GVCs, the implications of reshoring are generally not so straightforward, however. According to a survey from 2020 to 2021, not many executives could pursue regionalization and reshoring. However, 60% of the executives surveyed from the health care sector said that they had regionalized supply chains. Regionalization trends were much less common in the automotive industry (about 22%) and even lower in the chemicals and commodity sectors. (Alicke et al., 2021). In a survey by the Bank of Italy between September and October 2020 on about 4,200 Italian firms, 62% said they had not closed any production facilities abroad over the last three years, nor do they intend to do so over the next year. Only 1.9 per cent of the firms planned to restore production to Italy. Firms' decisions are sticky because of contractual arrangements and high initial sunk costs (Di Stefano, 2021).

More regionalisation instead of globalisation cannot be an optimal solution. Localized systems with less trade, less internationalization, and lower levels of economic activity produce lower incomes and result in an economic slowdown and lower GDP. In addition, it is more vulnerable to shocks due to the limited area of adjustment (Kersan-Škabić, 2021).

2.1.7 Opportunities

The COVID-19 crisis shocked supply chains and offered unprecedented opportunities for a transition to a sustainable post-pandemic environment (Sarkis, 2020). Supply chain design requires a different trade-off among various stakeholders' objectives. The geographic concentration of manufacturers has several advantages (clusters) but puts production at risk from local disasters and events. Each stakeholder group should evaluate its trade-off to be better prepared for the future (Sako, 2022). Miroudot (2020) argues that there is no trade-off between efficiency and lower risk but between different types of risks, and firms have to balance the costs and benefits of risk management.

The coronavirus strengthens the trend towards automation and robotization of work. After managing COVID-19, the trend direction of research capacities is focused on robotization in the manufacturing spheres of industrial sectors, but increasingly also in the mining and less common agricultural sector. The latter sector has a huge unused space, especially for crop treatment and harvesting. Appropriate robotization is expected to increase production and crop quality, positively affecting the supply chain from its processing to distribution. These development trends are temporarily dampened by the global priority of managing COVID-19 (Pinna et al., 2021). In the field of product design, modern manufacturing companies emphasize the quality design of final products, including their packaging. Economic design is focused mainly on minimizing the so-called empty spaces in the packages, thus increasing the number of products in the same transport volume, and the same result is the achievement of suitable product shapes. Robotization support begins at the first product design by meeting the specified conditions: sufficient computer-controlled stock of all necessary components for product finalization, simple robotic assembly, robotic packaging with minimal storage and removal, or loading of the customer's vehicles, all without the need or with minimization manual labour by man (Magableh, 2021).

Pandemic also stimulates the process of technological change, which contributes to the efficiency of the production process (Barkman, 2021). Automated production helps avoid direct physical contact and crowding, thus significantly reducing the risk of infection and enabling uninterrupted production during a pandemic. Due to the COVID-19 pandemic, the direction of automation began to focus on replacing the physical operators of in-house handling of materials and production components. Good results are especially in warehouse management, wherewith the appropriate software automation provides accurate warehouse data at the current time. The expansion of warehouse automation can order deliveries of below-limit stocks of production components, prepare the manufactured goods for distribution and inform them about shortcomings in deliveries. The practical introduction of automation in manufacturing industries does not mean an enormous reduction in the human factor but its use in the processes that still require it. The best economic results in the implementation of automation are in series production, and companies that have staff shortages due to anti-pandemic measures are working intensively to implement this production system.

The COVID-19 crisis is just the culmination of pre-existing challenges in the international production system based on the new industrial revolution, the necessary sustainability (Friedt, 2021), and the regulatory framework in place since the early 1990s (UNCTAD, 2020). World trade, whether global value chains are currently undergoing and will continue to undergo a radical transformation in the next decade (Zhan, 2020).

2.2 Innovation in and innovation-driven transformation of global value chains – implications for the Visegrad countries

Over the past decade, since the accelerated diffusion of digital technologies, global value chain actors have been witnessing a fundamental transformation of their business environment (Petricevic & Teece, 2019; Strange & Zucchella, 2017). They have to cope with an unprecedented degree of uncertainty caused by frequent exogenous shocks (such as natural disasters, the COVID-19 pandemic, geopolitical shocks, and trade disputes), the emergence of new industries, and entry of new actors in established ones. Some of the new entrants are surprisingly powerful: they challenge the prior dominant position of actors in established industries[10] and exhibit such a high growth that was previously unimaginable.[11]

Most scholars subscribe to the view that the growing speed, scale, and scope of change in the business environment, driven by accelerating technological progress, will exert a substantial impact on GVCs (Porter & Heppelmann, 2014; Rehnberg & Ponte, 2018; Strange & Zucchella, 2017, Szalavetz, 2016). A recent, albeit well-documented development is the consolidation of GVCs, specifically, the rising concentration of markets and the emergence of winner-takes-all structures[12] (Autor et al., 2020; Bajgar et al., 2019; Van Reenen, 2018).

Another, though less straightforward and intensely debated, transformation is the diminishing length of GVCs (e.g., Antrás, 2020; Gaulier et al., 2020), and relatedly that the affordances of labour-saving digital technologies will mitigate the offshoring imperative stemming from significant cross-country differences in unit labour costs. Accordingly, digitalisation may prompt backshoring, that is, the relocation of production to high-cost economies (Dachs et al., 2019; Kinkel, 2020; Strange, 2020). These developments, if materialized,[13] jeopardise factory economy actors' prior achievements in terms of GVC integration-based growth and upgrading (Hallward-Driemeier & Nayyar, 2017).

However, several predictions in the opposite direction stress that digital technologies could improve the production capabilities of factory economy actors and even foster the upgrading of their technological and R&D capabilities by enabling the decentralisation of corporate technical and R&D activities (Drahokoupil, 2020; Schwab, 2016). Accordingly, the foreign direct investment (FDI) driven GVC integration of factory economy actors is not necessarily threatened by digitalisation and these actors may even benefit from new opportunities for upgrading.

To help reconcile these controversial claims, there is a need for an in-depth understanding of the digitalisation-induced new developments in GVC actors' innovation activities that in turn, will shape the structure and the imminent evolution of GVCs themselves. This section will elaborate on these issues, more specifically, on 1) the increasing knowledge- and innovation-intensities of value creation, and 2) the new structure of knowledge creation within GVCs. Both individually and collectively, these two developments have far-reaching implications for the upgrading perspectives of factory economy actors, such as

[10] This is referred to as digital disruption (Skog et al., 2018).

[11] Digitalisation prompted the emergence of unicorns: technology-based, high-growth start-ups valued at $ 1 billion or more. As of March 2022, there were more than one thousand unicorns worldwide – cf. the list at: https://www.cbinsights.com/research-unicorn-companies

[12] 'Winners take all' refers here to the increasing differences across firms in terms of productivity and profitability, that is, a growing gap between top performers (superstar firms) and the rest (see also Manyika et al., 2018).

[13] The automation-enabled reshoring of previously offshored manufacturing activities is subject to hot discussions. While Krenz and Strulik (2021) provide evidence of a significant increase in reshoring, caution is required because of the standard statistical fallacy behind data (reshoring started to increase from a low basis). Consider also that regaining the production competencies lost as a consequence of prior offshoring decisions may prove more difficult than expected (Kinkel, 2020; Tassey, 2014).

the Visegrad countries. Since these countries are integrated into GVCs on the basis of low labour costs, and given the declining share of trade based on labour cost arbitrage (Lund et al., 2019), the knowledge-based upgrading of factory economy actors is more important than ever.

Discussion of these two developments will enable us to develop predictions regarding factory economy actors' upgrading perspectives, specifically, whether lead firms' increased innovation efforts can prompt a further organisational decomposition of innovation (Schmitz & Strambach, 2009) and if yes, whether captive manufacturing facilities in the Visegrad countries could benefit from this trend.

2.2.1 Increased knowledge- and innovation-intensities of GVC activities

Like globalisation, which is accelerating in several consecutive waves (e.g., Baldwin, 2016; Nayyar, 2006), the increase in the knowledge and innovation intensities of value creation started several decades if not a century ago. In line with new general-purpose technologies, knowledge intensity has also increased progressively. In hindsight, it seems fair to claim that it took centuries for the global economy to become rightly described as globalised. In a similar vein, the advent of digital technologies prompted such an order-of-magnitude increase in the knowledge and innovation of products and production technologies that value creation (and GVCs themselves) can only now be aptly conceived as knowledge-based. Madrak-Grochowska (2015) conceptualised the knowledge-based economy as a particular stage in economic, social, and institutional development. Analogously, we can speak of 'knowledge-based GVCs', as a specific stage in the evolution of GVCs.

This sub-section discusses what the concept of 'knowledge-based GVCs' means. To understand why digitalisation is considered the trigger of an order-of-magnitude increase in the knowledge intensity of value creation, consider the ubiquity of digital technologies. These technologies, more specifically, a multiplicity of individual solutions that rely on digital technologies, are now present in all industries, products, and business functions. They have permeated *each and every tangible and intangible activity that together comprise the value chain* from conception to production, end-use, and beyond (Szalavetz, 2022).

Consequently, the knowledge- and innovation-intensities of (a) operations, (b) business management, and (c) products have dramatically increased since each solution that enhances or optimises a component of value creation is based on a series of innovations.

Consider, for example, the case of products. Digitalisation prompted the multiplication of product-embedded services inducing the emergence of 'industrial product–service systems' or 'smart, connected products' (Meier et al., 2010; Porter & Heppelmann, 2014). Today's digitally enhanced products comprise a number of modularly integrated digital subsystems (each of them is the outcome of a series of innovations) that account for specific functionalities or deliver specific services.

This feature is associated with the multi-invention context of today's value creation. Teece and Linden (2017, p. 3) point out that: "Textbook treatments of innovation often assume that products depend on one, or a few, patented inventions, trade secrets, and trademarks. It has, however, been true for years that products of any complexity—either because of the number of parts or the number of functions—may read on hundreds, if not thousands, of patents, as well as numerous trade secrets."

Consider, for example, the patents that protect the intellectual property of a Tesla car. Tesla has a total of 2,147 active patents that belong to 986 patent families. They protect, among others, innovations in the field of design, energy generation, storage, battery, charging, and autonomous driving technologies. There are several patents protecting Tesla's computer systems and electric motor. In the field of manufacturing automation alone, Tesla possesses 58 patents14.

Similar examples can be listed in the case of operations. To name a few, consider the innovations that enhance the efficiency of production planning and scheduling, enable the remote monitoring of processes, collect production data and conduct big data analysis for predictive maintenance. Production system-embedded technologies (outcomes of individual innovations that are customised to meet the specific requirements at the given plant) allow for real-time asset tracking, energy optimisation, or paperless manufacturing (digital work instructions). Advanced manufacturing technologies comprise not only the ever more developed and dexterous robots but also technologies that automate quality control, reporting (e.g., shift handover reports), and provide smart assistance to frontline workers ('operator 4.0' technologies – Ruppert et al., 2018).

Over and beyond these targeted innovations15, there is always a need for complementary innovations enabling the integration of each individual solution in the ever more complex production/business system. A plant manager interviewed explained: "I receive several propositions pointing out the need to develop digital solutions that solve emerging operations issues. Although the development of most of these solutions would require only a couple of weeks, I must be very cautious when deciding on them. After a couple of such new use cases that have been successfully resolved by newly developed algorithms, I am aware that although development takes only a couple of weeks, the integration of the given solution takes several months. Since everything is connected within the production system, if you modify a part (e.g., integrate new software) this

[14] Tesla Patents – Key Insights and Stats. Available at: https://insights.greyb.com/tesla-patents/ (Accessed on 22 March 2022). See also: Fukuoka and Shiraishi (2021).

[15] Targeted innovations refer here to innovations developed and deployed to address specific use cases in the production or support processes or to develop new products or enhance the functionality of existing ones. Targeted innovations are mentioned in contrast to complementary innovations.

modifies several related parts. Integration requires far more resources (the valuable working time of the IT staff) than the development of the solution itself."

Furthermore, the deployment of each targeted innovation (e.g., the automation of individual activities or the installation of predictive maintenance) requires complementary organisational and management innovations, such as adjustment of the organisational structure and/or improvement of workflows to ensure that the expected operational/business benefits are realised (Szalavetz, forthcoming).

Regarding non-manufacturing business functions, again, there are innumerable innovations optimising the reconfiguration of the factory (in case of shifting to new products or installing new equipment), enhancing in-plant and inbound/outbound logistics, procurement, order management and deliveries, and supporting strategy development, new product development, marketing, sales and a range of other functions.

This far-from-exhaustive list illustrates the proliferating number of innovations within individual GVCs demonstrates

- the multi-invention context (Teece & Linden, 2017) of today's business,
- the radically increased technological scope of firms' innovations, and
- the diversity and magnitude of highly specific knowledge elements that need to be developed and integrated in any kind of value creation, at any stage of the GVC.

Altogether, it seems safe to conclude that value creation has become increasingly knowledge-based, digital, and intangible.16

The radical changes in the scale and scope of knowledge and innovations that are required for value creation are transforming GVCs themselves. For example, the increased knowledge intensity of each individual value-adding activity is closely related to the concentration and consolidation of markets in different industries that together compose the given global value chain. Take the example of a tiny stage (or industry component) of the automotive value chain, the servicing and repair of electric vehicles (EVs). Servicing EVs has become much more knowledge-intensive than previously: it requires specialist equipment (e.g., high-voltage tools and computer diagnostics) and, perhaps more importantly, high-level skills that are possessed only by electric engineers and software programmers. Consequently, this – previously SME-specific – the industry is bound to undergo a radical concentration since existing garages – typical SME ventures – will not be able to invest in the required expensive equipment and cannot acquire, retain, and pay the necessary skilled employees.17

[16] According to recent OECD calculations (OECD, 2020), in 2015, after a significant decade-long growth in importance, intangible capital accounted for 27 % of income in manufacturing GVCs in OECD countries. Although the most recent published data refer to 2015, it is safe to assume that the declining share of labour income (Autor et al., 2020) that is, besides income from the returns on tangible capital, the other key component of total value added has been accompanied by further significant increases in the share of intangible capital since 2015.

[17] Farewell to the grease monkey. (The Economist, October 23, 2021)

Furthermore, the above discussed changes in the knowledge- and innovation-intensities of GVCs transform the patterns of innovation activities in GVCs. This is the subject of the following subsection.

2.2.2 New patterns of innovation within GVCs

One of the far-reaching consequences of digitalisation was that the scientific and technological bases of competitive advantage increased up to a level that is already hardly achievable for the individual firm (Szalavetz, 2022). Given the growing scope of technological competencies that firms have to acquire and master, they have no choice but to open up innovation and integrate external technology and knowledge in their value creation processes (Chesbrough, 2003). The involvement of external actors whose competencies and technology complement firms' existing intangible assets gave rise to new organisational forms of value creation, referred to as ecosystems. Ecosystems are characterised by interdependent albeit loosely connected actors whose knowledge fields complement each other and align resources and capabilities to co-create value (Adner, 2017; Jacobides et al., 2018).

While the emergence of ecosystems and the diversity of innovation collaboration (with suppliers, competitors, universities, and technology-oriented start-ups) represent the most spectacular development in terms of the transformed nature of innovation in GVCs, the dispersal of innovation cannot be limited to the multiplication of external ties. Knowledge creation has become more decentralised internally as well: within lead firms' global organisation. Again, this is not a new development: the internationalisation of R&D and the concepts of home-based augmenting or competence-creating subsidiaries have been present in the literature for decades (Kuemmerle, 2002; Cantwell & Mudambi, 2005). Digitalisation has, however, added impetus to the organisational decomposition of innovation (Schmitz & Strambach, 2009), and captive subsidiaries do their best to exploit the related opportunities, in order to stay abreast in the intensifying intra-organisational competition (see Birkinshaw & Hood, 1998 for a discussion of inter-subsidiary competition).

2.2.3 Implications

In this section, we argued that digitalisation reinforced several ongoing developments, such as the internationalisation, ecosystem-like evolution, and organisational decomposition of R&D. Digitalisation has further increased the knowledge- and innovation intensities of value creation, since shifting to smart manufacturing and smart (data-driven) business requires innumerable innovations to be developed, customised, and integrated. GVCs have become genuinely knowledge based. Consequently, the structure of value creation has substantially changed, which has dramatic implications for the upgrading perspectives of GVC actors specialising in activities represented at the bottom of the smile curve of value added (Kalotay & Sass, 2021; Pelle et al., 2020; Szalavetz, 2016)

These actors have to survive the significant concentration and consolidation of GVCs and seize the opportunities offered by the fact that innovation in knowledge-based GVCs will be more decentralised than previously for R&D-based upgrading.

These twin challenges can be met only by investing in human capital, specifically, in distinctive local knowledge-based competencies. However, this is a long, cumulative process: firms and countries that have procrastinated on this requirement will mostly face the adverse consequences of GVC consolidation.

Investing in human capital, that is, developing and accumulating technological competencies are paramount for local manufacturing subsidiaries. The knowledge-intensity of their activities increases even if they are not assigned any partial R&D tasks since they have to absorb and customise the technologies enabling smart manufacturing (and execute all the related complementary innovations). However, even in the best-case scenario, when the captive offshoring of specific R&D activities and the co-location of production and R&D foster the R&D-based functional upgrading of GVC actors in factory economies, industrial upgrading in host locations is bound to remain limited. Local subsidiaries may increase the unit value added of their activities by taking up higher value assignments than previously, but their value capture will not necessarily increase, since lead companies, that survive the concentration of GVCs and forge ahead in winner-take-all markets usually increase their value added even more than local subsidiaries and become more powerful than previously. Hence, best-case scenarios (from the perspective of manufacturing subsidiaries) are characterised by a mere Red Queen effect: local subsidiaries undergoing R&D-based upgrading may at best sustain their position within their parent companies' global ecosystem.

2.3 Development and current status of GVCs participation within V-4

2.3.1 Trade relations between V-4 countries

There are two ways of measuring trade relations between countries. One is to measure trade in the traditional way, i.e., in gross terms. The other takes into account trade in value added.

Table 2.1 illustrates the evolution of trade relations between V-4 countries in gross terms. It shows the share of international trade (average of exports and imports) of each V-4 country (reporters) with other members of the group (partner countries) as a percentage of total trade of analysed countries in 1995 and 2020.

Table 2.1. Mutual trade relation between V-4 countries, 1995 and 2020, in % of their total trade (average of exports and imports)

Reporter	Partner country			
	Czechia	**Hungary**	**Poland**	**Slovakia**
	1995			
Czechia	--	1.3	3.5	12.8
Hungary	2.0	--	2.1	2.0
Poland	3.1	1.2	--	1.3
Slovakia	32.4	3.5	3.6	--
	2020			
Czechia	--	3.0	7.0	6.0
Hungary	4.5	--	4.8	4.5
Poland	4.5	2.1	--	2.2
Slovakia	10.4	5.5	6.9	--

Source: own elaboration based on *UNCTADstat* (2022)

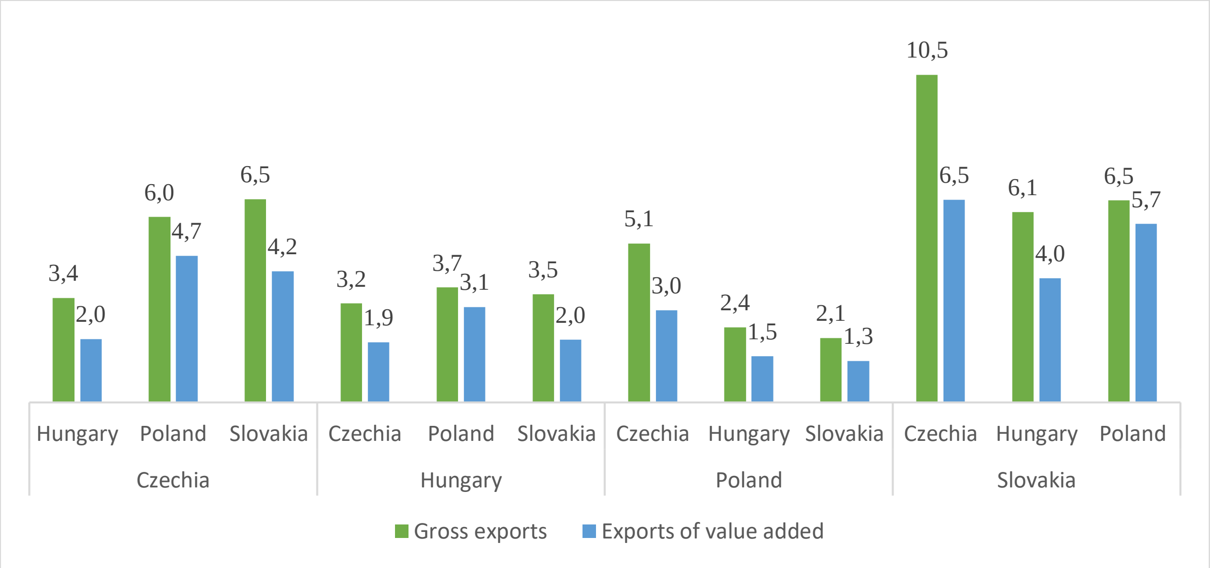
The data indicate that the most intense trade relations are observed between Czechia and Slovakia, but they have dropped significantly between 1995 and 2020. At the beginning of this period, the share of Czechia in Slovakia's total trade was 32.4%, while at the end of the period, it decreased to 10.4%. A similar process can be observed in Czechia's trade with Slovakia – while in 1995, 12.8% of Czechia's trade was with Slovakia, in 2020, it decreased by half, to 6%. It is well visible that the dissolution of Czechoslovakia resulted in the weakening of ties that had not deepened significantly even when both states joined the EU. At the same time, all other countries have slightly strengthened trade with each other, but these are shallow values.

Another way of presenting the extent of trade relations between countries is by measuring trade in value added. In general, this measure allows to determine how much value added in each country is directed to another country where it is consumed. We may find out what share of domestic value added is embodied in foreign final demand to illustrate exports of value added and what the share of foreign value added embodied in domestic final demand is to present imports of value added (Ambroziak, 2018, p. 10; Folfas, 2016, p. 18). These measures reflect connections between domestic industries and consumers in other countries (in case of exports) and between foreign industries and consumers at home (in case of imports), even where no direct trade relationship exists (OECD, 2021a, pp. 35–38). The most recent data allow comparing the situation in foreign trade of V-4 countries in 2018.

Fig. 2.1 presents exports of V-4 countries expressed both in gross and value added terms. In each case, the share of partners in gross exports, even though low, is still higher than when expressed in value added. This situation may be explained by the relatively strong position of V-4 countries in their value chains. It is particularly well visible in case of Czech-Slovak relations. In 2018 share of

Czechia in Slovakia's gross exports accounted for 10.5%, while when measured in value added it was just 6.5%. The share of Slovakia in Czechia's gross exports was around 2 pp more than in value added (6.5% vs 4.2%). It is an indicator of exporting intermediate goods from one country to another, where they are used for producing final goods consumed in yet another country.

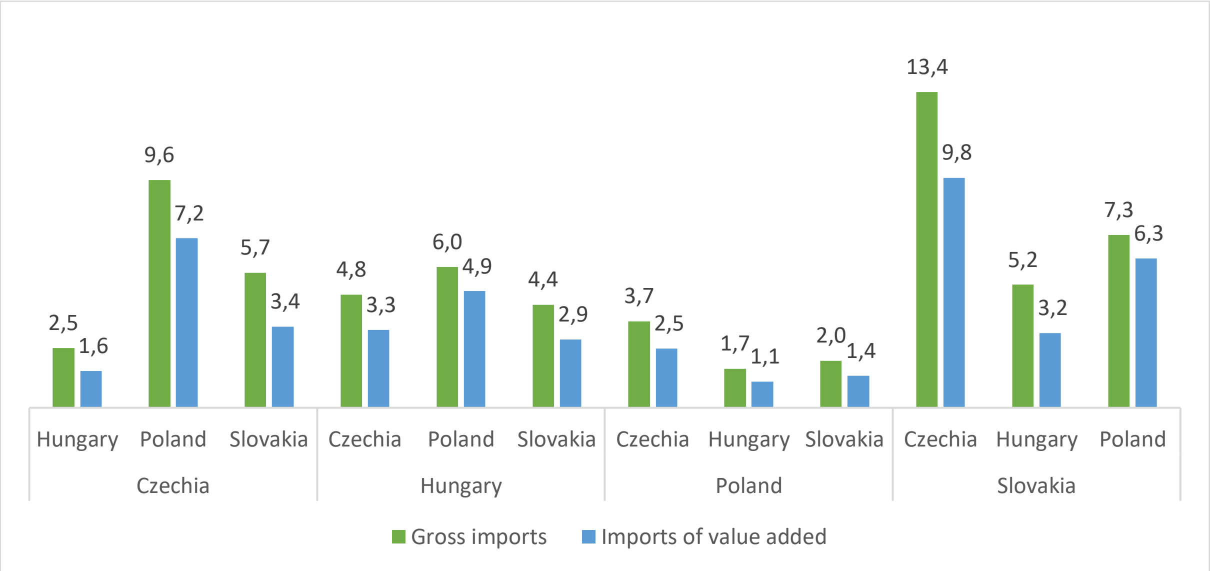
Figure 2.1 Exports of V-4 countries in 2018 (in %)



Source: own elaboration based on OECD (2021b)

Similar situation is observed in imports of these countries (fig. 2.2). Part of value added embodied in imports of V-4 from other V-4 countries is not consumed there, but processed and exported further, which explains relatively lower share of imports in value added compared to gross imports.

Figure 2.2 Imports of V-4 countries in 2018 (in %)



Source: own elaboration based on OECD (2021b)

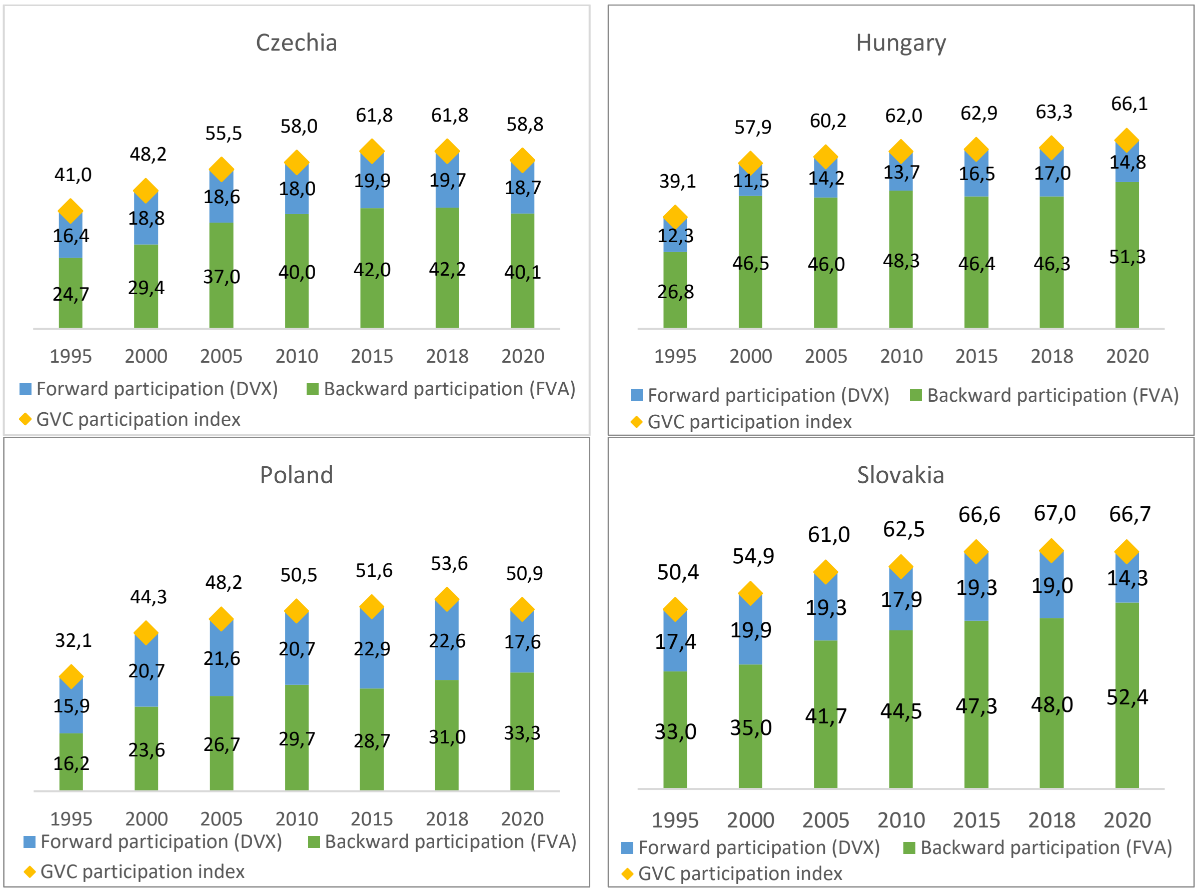
Even though the current trade ties between the countries of the V-4 are relatively small, their participation in global value chains (GVCs) can be a factor that makes their cooperation bigger and tighter. Therefore, what follows is the assessment of the involvement of Czechia, Hungary, Poland and Slovakia in GVCs. Their backward and forward participation in GVCs is analysed both at the general and sectoral levels.

2.3.2 The V-4 participation in global value chains

The acceleration of fragmentation of production processes has technological grounds (Baldwin, 2011) and lies in the policy of multinational enterprises. They focus on core competencies, concentrating on these stages of the value chains that create high value added (Geodecki & Grodzicki, 2015, p. 21). The remaining stages are outsourced (Chilimoniuk-Przeździecka, 2018). The most lucrative are the initial and final stages of value chains (the concept of "smiling curve"). Thus, the most added value can be expected in the development of new concepts, R&D, production of key parts and components (upstream in the value chain) and marketing, branding, and customer service (downstream in the value chain). The mid-stream activities, where the actual manufacturing and assembly take place, create relatively little value added (Shin et al., 2012).

As a result of the fragmentation of production, exported goods and services contain not only the contribution of domestic value added, but also the imported input, which is then included in the exported final good or component. Using data gathered in TiVA, the country's GVC participation index is calculated. It is the sum of the FVA – foreign value added embodied in a country's exports (measuring backwards participation in GVC, i.e. linkages with suppliers of components used for production and exports, in other words it is value added originating in GVCs) and DVX – domestic value added embodied in foreign exports (indicating forward participation in GVC, i.e. linkages with foreign clients of goods and services used in their production and exports, or value added sent to GVCs) in relation to the gross value of the country's exports. The result is an indicator of participation in international production networks.

Figure 2.3 GVC participation index of V-4 countries in 1995-2020, in % of gross exports



Source: own elaboration based on OECD (2021b). Data for 2020: *Asian Development Bank MRIO* (2022)

The data presented in figure 2.3 indicate that the countries of the Visegrad Group are becoming more and more involved in GVCs. It has both advantages and disadvantages. A higher degree of participation in GVCs allows benefiting more from international trade, since the individual stages of production can be located where the comparative advantages can be utilized in the most effective manner. At the same time, more significant participation in GVCs exposes the country to economic fluctuations and make it more vulnerable. Recession in some countries causes a relatively more considerable decrease in exports and transmission of crisis (Ambroziak, 2018; Cattaneo et al., 2010). Pavlínek (2015) claims for example, that the 2008–2009 crisis in the automotive industry revealed the dependence of the Czech and Slovak automotive industries on the West European automotive industry.

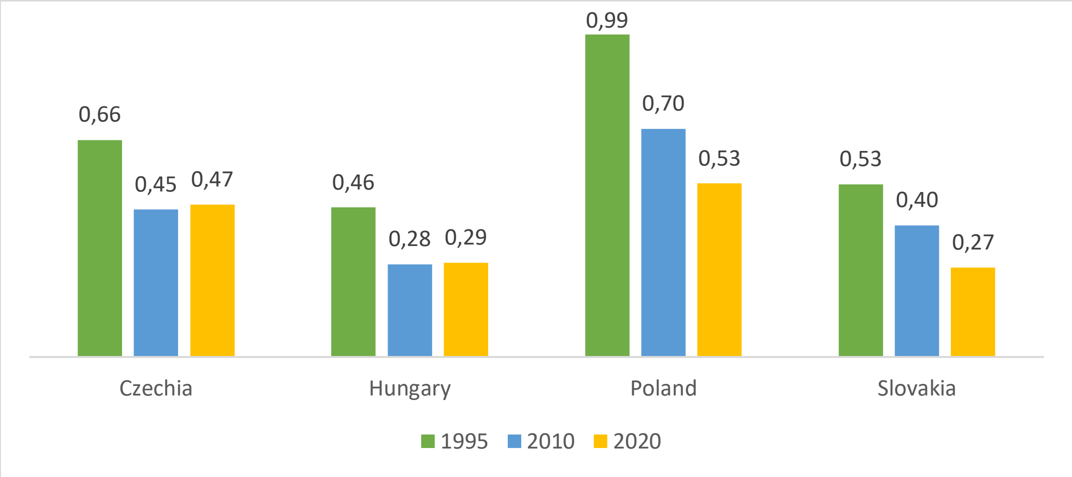
There is a difference between Czechia, Slovakia, and Hungary; on the one hand, and Poland, in terms of their participation in GVCs. In the first three mentioned countries, the GVC index in the second decade of the XXI century reached values of over 60%, with 66-67% of Slovakia's and Hungary's exports in

2020 and 62% of Czechia's exports in 2018 occurring within global value chains. In Poland, the maximum value reached in 2018 was much less – 54%. The high level of integration with global production networks of smaller countries, i.e., Czechia, Slovakia and Hungary, is a natural phenomenon, resulting from the high degree of openness of these economies, which in turn results from small domestic markets. Comparably high levels of participation in GVCs occur in other small EU countries, i.e., Luxemburg and Malta, while larger countries score even lower than Poland (e.g., Germany, Italy, Spain). Poland's lower value of GVC participation is the result of relatively low values of backward participation rates than in Czechia, Hungary and Slovakia.

In the analysed period, in the case of Poland, the backward participation doubled (the share of imported components in exports of intermediate or final products from Poland increased from 16% of gross exports in 1995 to 33% in 2020) and a moderate increase occurred in forwarding participation (an increase in the domestic value added in exports of other countries from16% to 18% of gross exports). The same direction of changes, but with lower dynamics, occurred in other countries of the V-4.

In all V-4 countries, there are clearly more backward than forward linkages. However, in Poland, which is a relatively large economy, there is a natural tendency toward lower linkages with foreign suppliers of goods and services (lower FVA), as more inputs to production may be obtained locally and therefore, imported value added is relatively less important than in smaller economies of the region. In this respect Poland is more similar to EU15 countries than to other V-4 economies (Kuźnar, 2017). Usually, higher rates of forward participation are typical for countries that are located upstream the value chain (Vlčková, 2015, p. 18). These could be R&D activities (as for example in the USA, where the ratio of forward to backward participation rate in 2018 reached 2.74), but also the extraction of raw materials (as in Saudi Arabia with this ratio amounting 11.13). In V-4 countries the ratio of forward to backward participation is quite low and decreasing, with the highest result achieved by Poland (0.53 in 2020). The result of Czechia is coming close to that in Poland (0.47 in 2020), while in Hungary and Slovakia, the ratio is below 0.3 – fig. 2.4. In all V-4 countries, the percentage has decreased since 1995, indicating growing fragmentation of production.

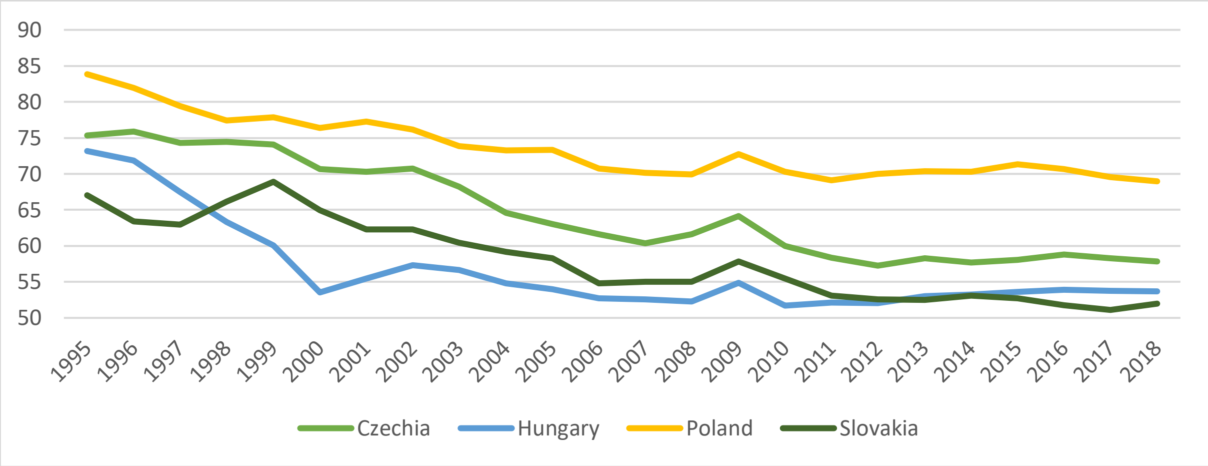
Figure 2.4 Ratio of forward to backward linkages in V-4 countries, 1995-2020



Source: own elaboration based on OECD (2021b). Data for 2020: *Asian Development Bank MRIO* (2022)

The obtained results may be interpreted as follows. Firstly, V-4 countries are relatively more attractive for processing intermediate goods than as producers and exporters of intermediate goods subsequently used in production and exports of other countries, which is indicated by the low ratio of forward to backward linkages. Secondly, the import intensity of exports is increasing, as is shown by the rising share of foreign value added in gross exports. This can also be interpreted as a sign of deepening integration of these economies into the world economy. To produce attractive goods that are sold on demanding international markets, it is necessary to import at least some relevant intermediate products (Ścigała, 2013). Thirdly, because gross exports are the sum of foreign and domestic value added – there is a systematic decline in domestic value added in exports of V-4. Compared to other countries of the V-4, the share of domestic value added in Poland's exports is relatively high, and in 2018 it was 69%, while in the rest of the countries, it amounted to far below 60% (fig. 2.5).

Figure 2.5 Share of domestic value added in gross exports of V-4 countries, in 1995-2018, in %



Source: own elaboration based on OECD (2021b)

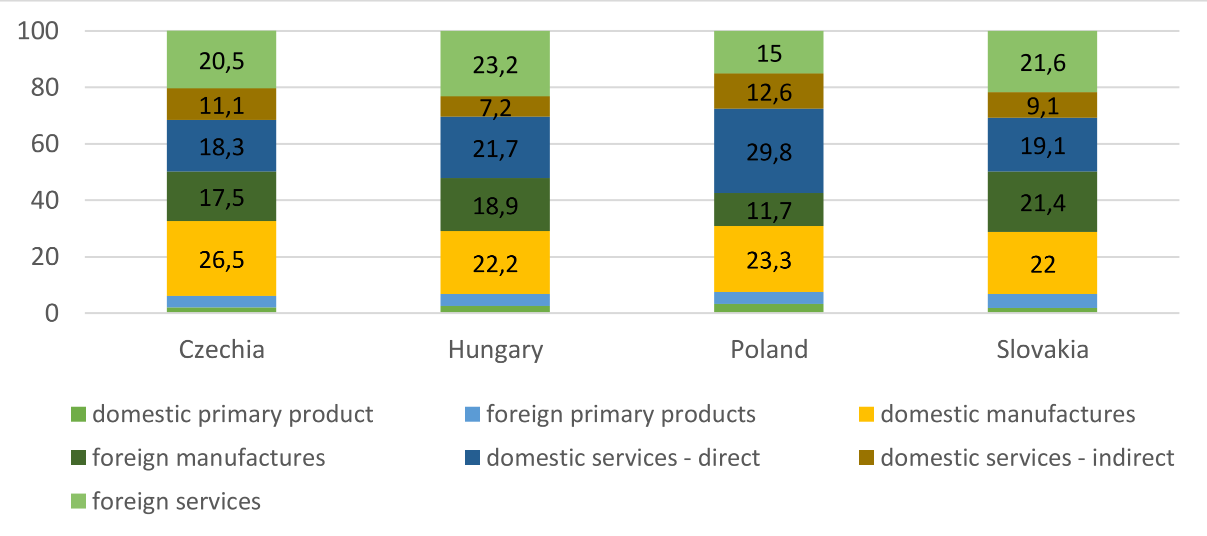
Of course, it is not so much about the share of domestic value added in gross exports, but about participation in the production stages that are the most valuable (meaning, according to the "smiling curve" concept, that they are at the beginning or the end of the chain). Ambroziak (2018, pp. 100–103) examined changes in the position of new EU member states in GVCs over the last years. According to him, since 2000, the position of Czechia, Slovakia and Hungary on the "smiling curve" changed unfavourably, as they moved towards more import-intensive manufacturing of goods further exported. It is clearly indicated by the growing share of foreign value added in gross exports.

2.3.3 The structure of GVC participation of V-4 countries

The next step of analysing V-4 countries' involvement in GVCs is the sectoral contribution to gross exports. Thanks to data based on value added, it is possible to indicate which sectors contribute most to gross exports. Traditional trade data (exports and imports by gross value) do not consider the value added, produced in particular sectors and industries, which make up the value of the final product. Services such as research and development, design, transport, insurance, and finance are widely traded and essential for creating most manufacturing and agricultural products. However, this is not properly reflected in trade data. Thanks to the measurement of value added trade flows, it is possible to better reflect the actual contribution of the sectors to exports. While traditional trade statistics indicate that services account for less than a quarter of world export, the statistics based on value added indicate that service share increases to half of the world exports. Similar situation is observed in all Visegrad Group countries. Services account for almost 50% of gross exports in Czechia and Slovakia, 52% in Hungary and 57% in Poland (figure 2.6). In all cases, but especially in Poland, there is more contribution of domestic than foreign services to gross exports.

Domestic services are either directly or indirectly contributing to exports. For example, if R&D services are used to produce pharmaceutical products exported abroad, this is the indirect contribution of services to exports (service provided to another sector). If R&D services are used for constructing a tool for monitoring social media and later exported, this is a direct service contribution to exports (service supplied by the service industry). In 2018 in Poland, 29.8% of total exports was created directly by domestic services, while 12.6% – were indirectly. This structure is different from other V-4 countries. It resembles more developed economies (e.g., in France direct domestic services account for 38.5% of exports, and indirect for 13.9%, in Austria it is respectively 31.2 and 10.9%). Poland also differs from other V-4 countries in the lower contribution of foreign manufacturing to gross exports. In 2018 the value reached 11.7%, which is around half of the share in Slovakia.

Figure 2.6 Domestic and foreign sectoral value added contribution to gross exports, in 2018 (% share in industry total gross exports)



Source: own elaboration based on *Trade in Value added and Global Value Chains: Statistical Profiles* (2022)

In total, the data presented in figure 2.6 reflect the situation described in the previous section, where we indicated that Poland distinguishes itself in the share of domestic value added in exports. Now we can point out which particular sectors are mainly responsible for that.

Participation in GVC, as it was explained earlier, involves backward and forward linkages. The GVC participation index has been analysed before at the general level in all V-4 economies, what follows is the analysis on the sectoral level. As data gathered in table 2.2 indicate, the manufacturing sector is more involved in global value chains than services in all V-4 countries. In Slovakia in 2018 73% of manufacturing exports were involved in GVCs – 57.8% came from GVC and 15.2% was sent to GVC. Similarly high results were achieved in

Hungary (69.3%) and Czechia (64.6%). The V-4 countries differ significantly from the EU average in this respect, as the EU15 reported a GVC participation rate of 31.4% and EU27 – 28.7%.

Tabela 2.1 Sectoral GVC linkages in V-4 countries and in EU, in 2018, in %

	Manufacturing			**Services**		
	Backward participation (FVA)	Forward participation (DVX)	FVA+DVX	Backward participation (FVA)	Forward participation (DVX)	FVA+DVX
Czechia	49.4	15.3	64.6	20.9	3.8	24.7
Hungary	56.9	12.5	69.3	23.8	4.0	27.8
Poland	40.0	16.6	56.5	17.7	5.2	22.9
Slovakia	57.8	15.2	73.0	19.8	3.3	23.1
EU27	18.6	10.1	28.7	11.8	3.8	15.6
EU15	18.7	12.7	31.4	10.2	4.2	14.4

Source: own elaboration based on OECD (2021b)

In all Visegrad Group countries, the high rate of GVC participation in manufacturing is related to larger backward than forward linkages. The largest foreign valued added share in gross exports of manufacturing occurred in Slovakia and Hungary (over 50%). Poland had the highest forward linkages in manufacturing among V-4 countries (16.6%), but a much lower backward participation rate (40%). In the EU, on average, there is an entirely different situation; only 19% of manufacturing exports involve previous imports of foreign components.

Services participation in GVC is much lower both in V-4 and EU. In all cases there is an overwhelming predominance of backward linkages over forward ones. This is in line with world tendencies, as services share in terms of imported content of exports is usually low as they use fewer intermediate inputs and their involvement in GVCs typically occurs through value added incorporated in exported manufactured goods (Global Value Chains and Development, 2013, p. 8). Foreign value added in services exports was the greatest in Hungary – in 2018 almost 24% of Hungarian services exports originated from GVC. In other V-4 countries the results were closer to 20%. In EU it was about half of this value (10-12%). None of the countries is particularly involved in forward linkages in services exports, i.e., they export little services (4-5%) that are subsequently exported to third countries.

The industries that were most involved in GVCs in Visegrad countries include in forward linkages: wholesale and retail trade (no. 1 in all V-4), motor vehicles (no. 2 in three countries), scientific/technical activities (no. 3 in three countries). As far as backward linkages are concerned, the top GVC-importing industry in all four countries are motor vehicles, no 2 are computer/electronic products and no 3 is other machinery and equipment (in three countries) – table 2.3.

Table 2.2 Top-3 industries involved in GVC in V-4 countries, in 2018, in %

	Forward (% share in total exports of domestic inputs sent to third economies) Top export industries to GVCs		**Backward (% share in total foreign content of exports) Top GVC-importing industries**	
Czechia	Wholesale and retail trade	14.6	Motor vehicles	34.8
	Motor vehicles	11.1	Computer/electronic products	9.6
	Metal products	6.9	Other machinery and equipment	6.9
Hungary	Wholesale and retail trade	12.1	Motor vehicles	31.6
	Motor vehicles	11.4	Computer/electronic products	14.6
	Scientific/technical activities	8.4	Other machinery and equipment	5.4
Poland	Wholesale and retail trade	19.9	Motor vehicles	16.3
	Land transport	9.3	Land transport	6.8
	Scientific/technical activities	8.1	Food and beverages	6.7
Slovakia	Wholesale and retail trade	13.9	Motor vehicles	42.6
	Motor vehicles	8.5	Computer/electronic products	7.8
	Scientific/technical activities	8.1	Other machinery and equipment	6.2

Source: own elaboration based on *Trade in Value added and Global Value Chains: Statistical Profiles* (2022)

Summing up, in the past decades, Poland, Czechia, Slovakia, and Hungary have been increasing their participation in global production networks. It can be seen by analysing the indicators of the participation of V-4 countries in global value chains. The V-4 countries are relatively more attractive as a place of processing components than as producers and exporters of intermediate goods used subsequently in further production and exports of other countries. It may be feared that delocalisation, the beneficiaries of which are V-4 countries, does not mean that production will remain there for a longer period. Production will probably be moved to countries with lower labour costs and environmental protection standards. It will also return to home countries (so-called *boomerang effect*) in case of decreasing share of labour costs in total costs of production or if barriers to trade are lowered. There is no proof of relocation of GVC to Central European countries as an effect of COVID-19, too. The impact of Russia's aggression on Ukraine on the economies of the V-4 countries is currently unpredictable.

3 Characteristics of the automotive sector in V-4 countries

The automotive industry in the V-4 countries has its historical background and past, as well as current specifics, which are undoubtedly worthy of more profound economic research. The first significant circumstance was the presence of major car manufacturers in the region, who, before the fall of the Iron Curtain, produced their cars and were an essential part of GDP creation (e.g. Skoda in the Czech Republic) or companies that immediately after the fall of the Iron Curtain started transformation with the involvement of a major foreign partner sharing strong know-how in the industry and sufficient capital equipment (e.g. VW and its strategic entry into an uncompetitive company in Bratislava).

However, the actual trigger and accelerator of the importance of the automotive industry for the V-4 countries were the reforms (before accession the EU) and the subsequent creation of a single market with the EU15. After stabilizing the investment climate, it gave multinational companies a unique opportunity to produce for more than 500 million market with high labour productivity but low labour costs. Although these unique circumstances are diversified, major automotive manufacturers of international importance have established themselves in each country. The industry has made a significant share of GDP, either directly or by stimulating support industries and subcontractors.

There was a clear trend in the V-4 countries in the pre-pandemic period – a decline in domestic value added in gross exports. It was in the automotive industry that this trend was even more critical, and, e.g. Slovakia or Hungary achieved one of the highest parameters of foreign value added in the export of the automotive industry, which has reduced the benefits for economic growth of these countries.

Within this same era, the final vehicle assembly and parts production has been located in the markets of robust demand. In the case of V-4 countries, the final consumption markets could be identified mainly with EU27 countries. The automotive industry has characteristic features such as a few fully generic parts or subsystems that can be used in various final products without extensive customization (Calabrese, 2018). This idea is consistent with the push strategy within logistics (Minárik et al., 2022). The COVID-19 economic effects accelerated the integration of such technologies. Therefore, companies could increase the usage of IT, telecommunication, and transportation services to bridge geographically dispersed production points and overcome space and time issues for trade (Börjesson & Eliasson, 2019). V-4 countries are particularly addressed with the issue of lower domestic added value in gross export, primarily within automotive and supplying sectors.

Therefore, the following sections analyse the automotive industry's basic parameters in the individual V-4 countries and point out the specifics of recent development (2010–2021) and the importance of the industry for a GDP creation, employment, importance in terms of involvement in international trade, but especially in possible growth in value added of gross exports. Although each country examined has different market attributes, investment environment parameters, and the structure and competitiveness of domestic subcontractors, this characteristic implies certain common denominators, which can be used in other parts of the monograph to formulate policies and recommendations for public administration and also the business sector practices.

3.1 Czechia

In the subchapter, we will first consider the position of Czech motor vehicle production in the total world and EU productions. Secondly, we will concentrate on the economic footprint of the automotive sector in the Czech economy. We will pay special attention to the value added (VA) generated by the said industry and the position within automotive GVCs. The impact of the COVID-19 pandemic is assessed through the number of produced cars and the turnover of car producers.

3.1.1 Position in the EU and world production

Over the investigated period of 2010-2021, Czechia gained more ground. It attained a higher share in the EU production in motor vehicle production (from now on, referred to as MV) and passenger car (PC) production. However, at the world level, its share remained more or less stable, Table 3.1. This evolution over time resulted from the decreasing share of the EU in world production of both MV in general and PC in particular; (ACEA, 2011) to (ACEA, 2021a). On the contrary, the Czech MV production mostly rose between 2010 and 2019. The peak in 2019 exceeded the amount of MV and PC production in 2010 by 32% and more than 33%, respectively. Given the outbreak of the COVID-19 pandemic and related worldwide supply chain disruptions, the data related to the Czech production in 2020 stated in absolute terms shrank. Nevertheless, they remained unaltered or even slightly increased in relative terms, for the Czech production decreased at a lesser pace.

Indeed, PC production represents the backbone of the Czech MV production, with the share exceeding 99% of all MVs produced in 2020. There are five major production sites of PVs, all resulting from foreign direct investments – three production sites of Škoda Auto (a subsidiary of the Volkswagen group) based in Mladá Boleslav, Vrchlabí, and Kvasiny with a 65% share in the total number of PVs produced in Czechia; Hyundai in Nošovice (20.7%), and Toyota-Peugeot-Citroen Automobile Czech in Kolín (14.3%) in 2020; (Sdružení automobilového průmyslu, 2021). Over the respective time, Czechia outnumbered France in units produced and, in 2020, became the third-largest EU producer of PCs (behind Germany and Spain); (ACEA, 2021a, p. 15).

Table 3.1 The position of Czechia in the EU and worldwide automotive production (MV=motor vehicles, PC=passenger cars)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MV production (units)	1,076,385	1,199,834	1,172,342	1,132,931	1,162,017	1,256,332	1,344,137	1,419,993	1,345,846	1,428,620	1,135,447
Share in EU MV production	6.4%	6.8%	7.2%	7.0%	6.8%	6.8%	7.0%	7.2%	7.0%	7.7%	8.7%
Share in world MV production	1.4%	1.5%	1.4%	1.3%	1.3%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%
PC production (units)	1,069,518	1,191,968	1,171,774	1,128,473	1,157,371	1,244,406	1,342,920	1,413,881	1,345,041	1,427,563	1,129,184
Share in EU PC production	7.1%	7.6%	8.0%	7.7%	7.7%	7.8%	8.2%	8.3%	8.1%	9.0%	10.4%
Share in world PC production	1.8%	2.0%	1.8%	1.7%	1.6%	1.7%	1.7%	1.8%	1.7%	1.9%	1.8%

Sources: own calculations based on data from (ACEA, 2011) to (ACEA, 2021a), (UNCTADstat)

Although worth merely ca. 5 thousand units, the production of buses accounted for 20.4% of the total EU production of buses in 2020. Hence behind Poland, Czechia is the second-largest producer of buses within the EU (ACEA, 2021a, p. 15). As of January 2021, there were four bus producers – Iveco Czechia (city and intercity bus ranges) with more than 89% share and three Czech producers - SOR Libchavy (low-weight and eco-friendly buses for public transport and such), KH motor centrum Opava and Škoda Transportation. The production of trucks was in the hands of Tatra Trucks company (heavy-duty off-road vehicles and trucks) and AVIA company (Sdružení automobilového průmyslu, 2021) and (CzechInvest, 2022). Yet the share of the companies mentioned above in the total respective EU production branches is negligible.

In terms of powertrain, the electric vehicles (EVs), irrespective of whether BEV (battery electric vehicle) or PHEV (plug-in hybrid electric vehicle), represented only 11% of the total production of PVs (the only producers being Škoda auto and Hyundai) and 1.2% of buses (produced reportedly by SOR Libchavy only) manufactured in 2020 (Sdružení automobilového průmyslu, 2022a). As of 2021, unlike in other countries in the region, there was no giga factory of EV battery production in the Czechia, although there were already plans to build one (Deloitte, 2021).

3.1.2 Economic footprint

Table 3.2 details the main economic indicators related to the NACE 29 (Manufacture of motor vehicles, trailers, and semi-trailers). The automotive industry plays a prominent role in the Czech economy when measured by its share in employment in total industry, production, goods exports, and value added creation. Years 2016 and 2017 saw record levels, where ca. 11% of the total output, 28% of goods exports, 13% of employees in the industry, and over 17% of value added were attributable to the MV production. In 2020, 90.6% of final products and 76.1% of automotive suppliers' production were exported. The EU (top eight export markets absorbing 65.5% in 2020), and especially Germany (with nearly 33% share in 2020), represent key destinations for automotive exports (Sdružení automobilového průmyslu, 2022c). Hence the EU policy toward cuts in greenhouse gas emissions and the 'Fit for 55' initiative (European Commission, 2021a) represent a challenge for the transformation of the Czech automotive production from the mainly ICE-oriented (internal combustion engine) toward the EV-oriented one. From 2035 on, new vehicles will be subject to the zero-emission limit. Therefore, the ICE-powered or hybrid vehicles will be destined exclusively for the exports to non-EU member states, where mostly non-zero average MFN rates are applied on imports of the transport equipment (Statista, 2021, p. 22).

In addition, Czechia shows a considerably high and increasing intensity of specialization in the automotive industry when measured by the number of MV manufactured per thousand inhabitants, which is the second-largest number in the world (Sdružení automobilového průmyslu, 2022c).

We can state that the Czech economy is exposed to external shocks affecting the automotive sector's performance and competitiveness. Hence the economic downturn or supply chain disruptions of any kind affecting the sector's output (out of which 91.2% was exported in 2021; (Sdružení automobilového průmyslu, 2022b)), which automotive producers face, can notably affect both internal and external economic stabilities of the Czech economy. Mareš and Janíčko (2022) assert the both-side relation between the proxies of automotive sector performance (namely retail sales, average monthly salaries, employment, and new PC registrations) and the selected macroeconomic indicators (among other things GDP in absolute terms, unemployment rate, and total industrial production) over 2000 – 2017. In addition, they state that any shock faced by the Czech automotive industry is reflected in the macroeconomic performance of Czechia within at most two-quarters time, and *vice versa*.

Table 3.2 Share of NACE 29 in selected macroeconomic indicators (2010-2021)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total production (GDP production approach)	**7.6%**	**8.1%**	**8.1%**	**8.5%**	**9.6%**	**10.3%**	**11.1%**	**11.1%**	**10.7%**	**10.4%**	**9.4%**	**-**
Merchandise exports	**19.8%**	**20.1%**	**20.3%**	**21.1%**	**22.8%**	**26.0%**	**28.0%**	**28.2%**	**27.2%**	**27.6%**	**26.3%**	**24.4%**
Employment in industry	**11.1%**	**11.4%**	**11.2%**	**11.1%**	**11.4%**	**11.9%**	**12.3%**	**12.7%**	**13.0%**	**13.0%**	**-**	**-**
Units of MV produced per 1000 inhabitants	**102.2**	**113.5**	**110.8**	**107.0**	**109.7**	**118.5**	**126.6**	**133.4**	**126.2**	**133.7**	**106.0**	**-**
Value added of total industry	**13.4%**	**13.2%**	**13.0%**	**13.7%**	**15.4%**	**16.2%**	**17.8%**	**17.4%**	**16.2%**	**16.6%**	**-**	**-**

Source: own calculations based on data from Czech Statistical Office (n.d.)

Moreover, Pavlínek (2019) calculated that the index of foreign control in the Czech automotive industry was worth 91.4 in 2015, which was the third-largest figure in the EU. The index mentioned above is calculated as the average of the shares of foreign-controlled firms in the following indicators: production value, value added at factor cost, gross investment in tangible goods, the number of persons employed, and turnover or gross premiums written in the manufacture of motor vehicles, trailers, and semi-trailers.

The sizeable role of the automotive sector in the Czech economy, together with the dominance of the foreign-controlled firms in the sector's overall economic performance, can raise issues as to the actual implementation and success of governmental policies targeted at upgrading, innovations, and higher value capture of Czech automotive sector. Indeed, the fundamental strategic business decisions are made by foreign-owned headquarters.

The previous subchapters demonstrate the importance of the automotive sector in the Czech economy. This sector has been hit by the COVID-19 pandemic and the following consequences on both supply and demand sides. To estimate the impact on the industry, we analyzed the changes in companies' turnover growth using the Orbis (2022) database. We counted the average turnover of companies with the turnover exceeding 5,000 mils. EUR over the periods 2012-2014 and 2017-2019. The average turnover growth in automotive companies (NACE 29) between 2012-2014 and 2017-2019 amounted to 57%, whereas the average decline between 2019-2020 reached 13%; see Table 3.3.

Table 3.3 Car manufacturers in Czechia

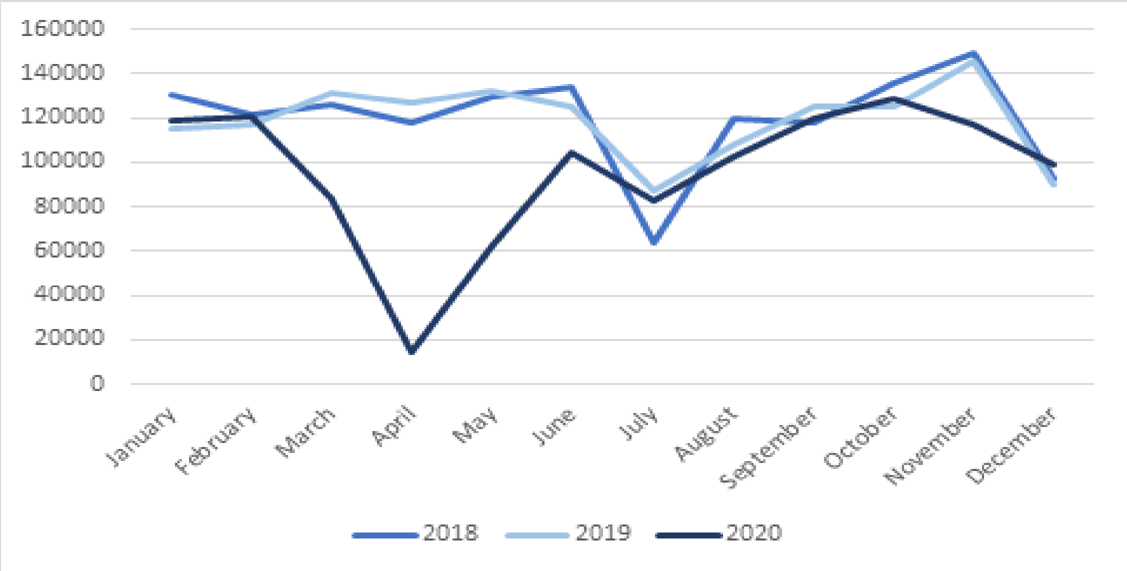
Manufacturer	Indicator	2018	2019	2020
Škoda Auto	Operating revenue (th EUR)	16,536,771	18,387,264	16,643,822
	Number of employees	33 696	33 881	35 437
	Added value (th EUR)	3,364,967	3,933,784	n.a.
	Share of added value on production	20.3%	21.4%	
Hyundai Motor Manufacturing	Operating revenue (th EUR)	5,203,940	5,023,056	4,508,631
	Number of employees	2 552	2 580	2 800
	Added value (th EUR)	408,867	556,774	520,201
	Share of added value on production	7.9%	11.1%	11.5%
Toyota Motor Manufacturing Czech Republic	Operating revenue (th EUR)	1,482,383	1,528,405	1,230,643
	Number of employees	2 185	2 188	2 500
	Added value (th EUR)	n.a.	n.a.	n.a.
	Share of added value on production	n.a.	n.a.	n.a.

Source: own elaboration based on Orbis (2022) database

The drop in production was the most significant in April 2020, when the car manufacturers were forced to cease production for several weeks. The stoppage of production of OEMs impacted the whole value chain; see Figure 3.1.

The lower number of produced cars and light commercial vehicles (LCVs) in 2020 is seen in the drop in turnover of the leading OEMs. The value added of Škoda Auto a.s. and Hyundai Motor Manufacturing Czech s.r.o. has been growing over the last years. The highest value added is produced by the Škoda Auto a.s.

Figure 3.1 Production of cars and light commercial vehicles and the development in Czechia



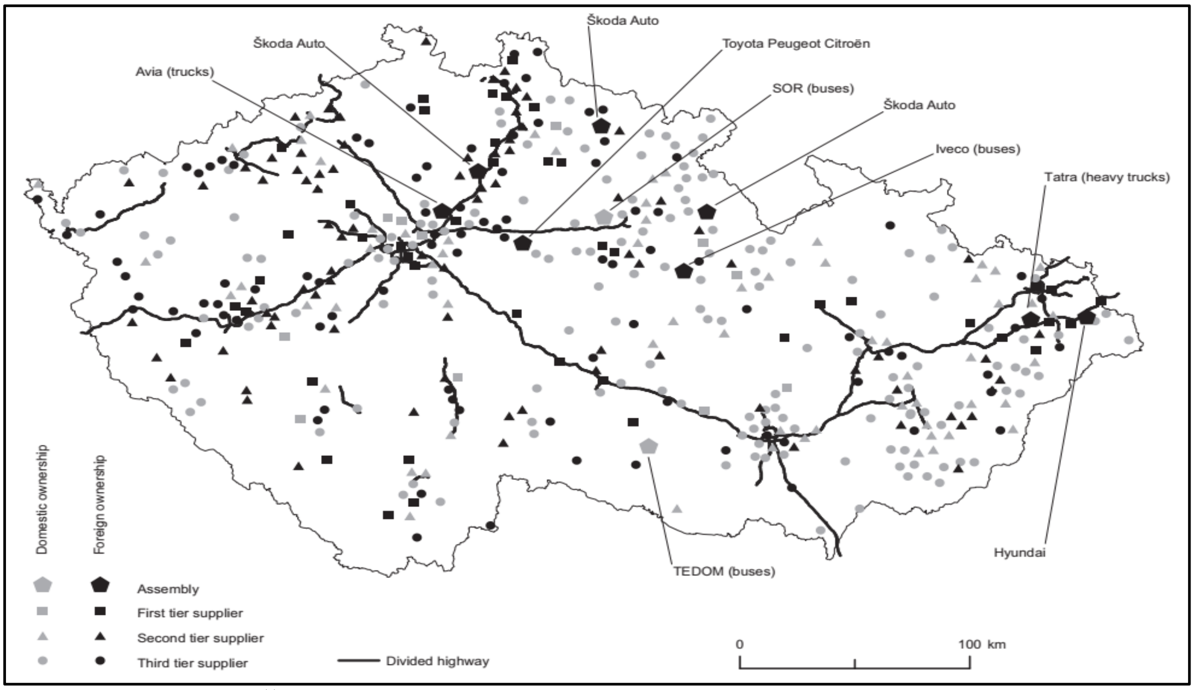
Source: own elaboration based on Sdružení automobilového průmyslu (2022d)

The lower number of produced cars and light commercial vehicles (LCVs) in 2020 is seen in the drop in turnover of the leading OEMs. The value added of Škoda Auto a.s. and Hyundai Motor Manufacturing Czech s.r.o. has been growing over the last years. The highest value added is produced by the Škoda Auto a.s.

3.1.3 Position within GVCs

Figure 3.2 demonstrates the spatial distribution of motor vehicle producers and their suppliers in 2009, while their positions within the value chain are differentiated. The NACE division 29 'Manufacture of motor vehicles, trailers and semi-trailers' is divided into the following groups (Eurostat, 2008) - 291 'Manufacture of motor vehicles', 292 'Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers', and 293 'Manufacture of parts and accessories for motor vehicles'. The former group is represented by the producers of final products and chassis and engines. The latter two groups refer to the suppliers of various parts and accessories for vehicles yet exclude the producers of, e.g., tyres, batteries for vehicles, and rubber products. Hence, the industries related to automobile production represent a more comprehensive range of activities than just those embodied in NACE 291 and 292. Figure 3.3 details the geography of OEMs and assembly factories of final producers.

Figure 3.2 Final producers, Tier 1, 2, and 3 suppliers in the automotive sector in 2009



Source: Pavlínek & Žížalová (2016), p. 337

NACE 293 represented the most influential group in terms of the number of undertakings and employees, yet less critical in VA creation and personal costs, Table 3.4. Unlike it, group 291 is characterized by a relatively low number of entities involved and a lower share in total employment within the NACE division 29, yet creating nearly a half of its value added. From 2008-to 2018, the number of business entities within NACE 29 slightly exceeded one thousand, with the peak equal to 1.292 units in 2010 (Ministry of Industry and Trade, 2019, p. 175).

A closer look at the domestic VA embodied in the production and exports (Table 3.5) reveals that the share in gross exports decreased over the period by more than five percentage points to 42.6%, which is far less than both EU27 and OECD averages (84.8% and 90.7% respectively). Likewise, the domestic VA in exports of final products as a share of total gross exports shrank by four percentage points to 24.3% (the same indicator equals 54.9% and 60.1% at the EU and OECD averages, respectively). The VA represented only 20.6% of the production and saw a downward trend over the investigated period, as opposed to 30.5% and 27.8% on the EU and OECD averages, respectively; (OECD, 2021b). Czechia is primarily involved in assembly operations connected with the lower value added part of the so-called 'smile' curve, higher cost reduction pressures, and price competition (Shih, 1996).

Figure 3.3 Final producers and original equipment manufacturers (OEM) as of 2019

Source: CzechInvest (2019)

Table 3.4 Disaggregation of NACE 29 division in 2018 (%)

NACE group	Personal costs	VA	Sales	Equity	Assets	No. of employees	No. of enterprises
291 Manufacture of motor vehicles	32.7	48.1	47.0	52.2	45.9	23.7	7.6
292 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1.4	1.0	0.7	0.9	0.9	1.8	14.8
293 Manufacture of parts and accessories for motor vehicles	65.8	50.8	52.3	46.9	53.2	74.5	77.7

Source: Ministry of Industry and Trade (2019), p. 173

In general, the capabilities of Czechia in innovations, Industry 4.0, and involvement in high VA activities have been widely discussed (Bič & Vlčková, 2020). Aridi and Querejazu (2019) point to the risk of the middle-income trap. Pavlínek (2019) also indicates that Czechia acts as an integrated periphery with a lower wage level than in the traditional automotive producing regions, showing a high degree of foreign control and ownership, while its involvement in the high value added activities within GVCs is minimal.

Table 3.5 Position of the Czech automotive sector in GVCs (in %)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Domestic VA share of gross exports	47.9	46.4	44.1	44.1	43.3	42.9	42.9	42.9	42.6
Domestic VA embodied in foreign exports as share of gross exports	4.0	4.3	4.2	4.8	5.0	5.5	5.4	5.2	5.1
Domestic VA in exports of final products as a share of total gross exports	28.4	27.2	25.9	25.3	24.6	23.8	24.0	24.3	24.3
Domestic VA in exports of intermediate products as a share of total gross exports	19.5	19.2	18.2	18.8	18.7	19.1	18.8	18.6	18.3
Industry domestic VA contribution to gross exports	9.6	9.7	8.7	9.3	10.0	10.7	11.2	11.3	10.9
Domestic services VA share of gross exports	12.3	11.8	11.0	11.7	10.8	10.8	10.4	10.6	11.3
Domestic VA share of gross imports	1.3	1.3	1.3	1.5	1.5	1.6	1.6	1.5	1.4
Share of domestic VA embodied in foreign final demand	82.6	84.7	87.0	87.9	88.8	88.0	88.6	88.6	88.7
VA as a % of production	23.2	22.3	21.8	21.1	21.8	21.3	21.7	21.5	20.6

Source: own elaboration based on data from (OECD, 2021b)

3.2 Hungary

3.2.1 Main features of the automotive sector

The automotive industry plays a central role in the Hungarian economy through employment, added value, and integration into global value chains and exports. According to the latest figures by the Ministry for Innovation and Technology (ITM, 2021), the automotive industry in Hungary accounts for 25 percent of value added and 5 percent of GDP in 2020. The number of firms involved in manufacturing is 491, employing 98,583 people (see Table 1).[18] The share of direct automotive employment in total manufacturing accounts for 12.9%, which is the fifth-highest figure in the EU after Slovakia, Romania, Sweden, and Czechia. Automotive companies are export-led, meaning that they sell the vast majority of their production on external markets. Therefore, the sector also has a significant share in foreign trade, with automotive products accounting for 21 percent of the Hungarian exports (ITM, 2021). The most important foreign trade partner is the European Union, with Germany playing a significant role.

The performance of the export-led industry was directly affected by temporary closures and declining demand due to COVID-19. Due to the pandemic, supply chain outages caused factory closures and production difficulties in Hungary. In 2020, the number of assembled cars fell by 18.4 percent compared to the previous year (see Table 3.6), which is favourable compared to

[18] According to the data of ITM (2021), 740 companies are operating in Hungary along the automotive value chain, and approximately 175,000 jobs are related to the sector. However, we do not know the data methodology, therefore, these data are not comparable with the official Hungarian data published in international statistics (e.g., in the ACEA - European Automobile Manufacturers Association).

the EU27. However, supply chain disruptions due to COVID-19 have been a long-standing problem. Thus, the year 2021 did not bring the expected boom in production, which fell by a further 3 percent year on year. Factories in Hungary have been forced to reduce or stop production several times (autonavigator.hu, 2021) due to a shortage of raw materials (mainly semiconductors).

Table 3.6 Main indicators of the Hungarian automotive industry

Manufacture of motor vehicles, trailers, and semi-trailers (NACE Division 29)

	2010	**2015**	**2018**	**2019**	**2020**	**2021**
Enterprises (number)	485	494	497	505	491	n.a.
Production value (million euro)	13 214	25 007	26 498	29 126	26 074	n.a.
Persons employed (number)	65 153	88 555	101 908	103 737	98 583	n.a.
Road vehicle assembly (number)	211 461	495 370	430 988	498 158	406 497	394 302

Source: Eurostat 2022, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E) and oica.net (2022)

There are four car manufacturing OEMs in Hungary. In addition, there are other automotive OEMs in the commercial vehicle industry (mainly in the bus and towed commercial vehicle production). Car assembly (final assembly of the Opel Astra) and production of engines in Opel Szentgotthárd (in western Hungary next to the Austrian border) commenced in 1992. Since 2021 the Hungarian subsidiary has been a part of the multinational company Stellantis (after the merger of FCA-PSA). Currently, the production focuses on the engine for hybrid cars. However, with the switch to electric car production, the factory's future will become questionable.

The Japanese Suzuki launched a car assembly in Esztergom (30 kilometres north of Budapest) in 1992. The Hungarian factory is the Japanese company's first and only European production unit. The plant only carries out assembly activities. At the same time, the significance of the plant lies in the fact that the share of suppliers of domestically owned companies is relatively high compared to other OEMs in Hungary (Mészáros, 2009). The share of parts suppliers from Hungary (Japanese, local and non-Japanese) is 30 percent (Csonka et al., 2021).

German Audi’s internal combustion engine production started in Győr (Western Hungary) in 1993. Initially, it was only an engine manufacturer but later developed into the Audi Group's central powertrain supplier, currently the world's largest engine manufacturer, with a capacity of 2 million a year. In 1998, the assembly of the vehicle began. The number of models produced and the number of products has gradually increased. As part of the technological change, electric motor production began at Audi Hungaria in late 2018. In parallel with the increase in electromobility, the assembly of electric motors accounts for an increasing share of total motor production (see Table 3.7).

The latest OEM investment is the Daimler in Kecskemét (in central Hungary, 85 kilometres from Budapest), where the assembly of cars started in 2012. The establishment of the factory was justified by the fact that the Mercedes is increasing the number of compact car models from two to five, producing around 190,000 units a year. Today, the Kecsmét factory is the largest assembly plant in Hungary regarding the units of cars assembled (see Table 3.7). In October 2021, the factory started assembling its first battery-electric model.

Hungary's fifth car plant will be built in Debrecen in the eastern part of the country. The production was initially scheduled to start in 2022, but COVID-19 has delayed the investment. According to current plans, construction will start in 2022, with the plant starting production in 2025, two years later than planned (hvg.hu, 2021). The factory, which will have a capacity of 150,000 vehicles, will assemble only electric cars.

Hungary's position in commercial vehicle production is marginal compared to the pre-1990 period. Among the Hungarian serial manufacturers, Rába (axles) and Kravtex-Kühne (bus production) should be mentioned. Major manufacturers are all foreign companies such as Schwarzmüller (towed commercial vehicles) or Chinese BYD, which manufactures electric buses and bus chassis. In bus production, only BYD can export. In contrast, domestic manufacturer, such as Kravtex-Kühne (Credobus), depends on the domestic market, where government purchases account for a large share of the revenue. The other indigenous company Chinese-Hungarian joint venture Electrobus Europe (assembly of electric buses), has not yet shown any results.

3.2.2 Challenges for Hungarian firms

The transition to electromobility will not avoid the Central European car industry either, we can only observe a difference in the global and regional strategies of each company. An example of this is Suzuki, which also manufactures in Hungary and plans to switch to electric propulsion at its plant later than its European competitors (autosajto.hu, 2021). In contrast, European manufacturers, especially Volkswagen, have announced ambitious electromobility plans. The switch to electric propulsion is also required by European environmental regulations.

Table 3.7 OEM's production in Hungary

Units		2015	2016	2017	2018	2019	2020	2021
Audi	Cars	159,842	122,975	105,491	100,000	164,817	155,157	171,015
	IC engines	2,022,520	1,926,638	1,965,165	1,954,301	1,968,742	1,661,599	1,620,767
	EV motor	0	0	0	9,453	90,367	87,343	
Mercedes-Benz	Cars	180,000	190,000	190,000	190,000	190,000	160,000	n.a.
Opel	ICE	511,000	630,000	486,000	313,000	350,000	n.a.	n.a.
Suzuki	Cars	185,000	211,266	170,000	175,000	177,718	112,475	n.a.

Source: authors' compilation based on companies' financial reports

Similar to other European semi-periphery economies (Central and Southern European countries), the automotive industry in Hungary is assembly-oriented (Lung 2007, Barta, 2012). This also means that lower value added manufacturing functions predominate in the function-based hierarchy of the global value chain (Pavlínek, 2019). The automotive value chains in Hungary show persistently low backward linkages, mainly provided by manufacturing-type added value, with a low R&D contribution (Gáspár et al., 2020). This is also supported by the fact that the domestic added value is one of the lowest in European comparison (Vakhal & Czakó, 2020). The lag is even more pronounced when examining domestic small and medium-sized enterprises, where local content remained relatively low (Pavlínek et al., 2017).

R&D&I activity by OEMs operating in Hungary is not significant. Most of them focus on assembly, except Audi Hungaria, which has built up significant research and development capacity and higher education relations in Hungary. The Hungarian subsidiary has built up significant capacities within the group over the past two decades for certain R&D activities (tribology-related ones) and, as a result, enjoys global exclusivity in certain areas of activity (Sass & Szalavetz, 2014). Other automotive companies also have linkages with the Hungarian educational system, but these are limited to vocational training in dual-system and training for production engineers. Due to the transfer of competence with the outsourcing of automotive production activities, the development activity is concentrated mainly at Tier 1 suppliers.

As a result of foreign investments, leading European (Aptiv, Autoliv, Bosch, Continental, Delphi, Schaeffler, Lear, ZF, Valeo) and overseas suppliers (Flex, Hanon, Nemak, Magna International, Visteon) are also present in Hungary. However, a few indigenous companies have successfully integrated into global value chains. Some former automotive suppliers, such as Rába Mór Kft. or Videoton Holding, have successfully adapted to the new situation after 1990 and are still operating. Others, such as Ajkai Elektronikai Kft., Fémalk Zrt., HAJDU Autotechnika Zrt. or Pemü Zrt., are new entrants in the automotive industry. Part of the supplier network is related to domestic assembly, but the majority of production is exported.

Significant research and development activities have taken place at suppliers in recent decades. Outstanding R&D&I in automotive electronics (Bosch, Siemens, Continental Automotive) has been given new impetus by electromobility and autonomous driving. In the field of autonomous drive software development, there are R&D centres in the universities as well as at the OEMs and suppliers. Knorr-Bremse, Continental Automotive, Robert Bosch in Budapest, AVL AUTÓKUT in Budapest, and Zalaegerszeg have innovations in autonomous driving. Autonomous drive hardware development is most often related to software development. Solutions related to self-driving technologies also play a significant role in developing, e.g., a 'smart' electro-mechanical steering servo at Thyssenkrupp's Budapest R & R&D centre. Electronics and electric motor parts for hybrid cars are manufactured at Continental's Budapest or Thyssenkrupp's Pécs sites. Two Hungarian-based / affiliated companies show that innovation can successfully integrate into the global value chain. One is the navigation system developer NNG which is now a global player in built-in information technology systems (in-car technologies). The other is Aimotive, which develops self-driving systems based on artificial intelligence, the so-called vision-first technology.

3.2.3 Focus on battery plants

After 2016, there has been a noticeable change in investment, with significant improvements in electromobility and the development and production of new automotive solutions. In addition to the production (Audi) and assembly of the main units of electric vehicles, large amounts were invested into vehicle battery production. Since 2016, a total of 5.29 billion euros and nearly 14,000 jobs have been created due to capital investments in the vehicle battery industry (ITM, 2021). SK Innovation's Gigafactory in Iváncsa is among the largest greenfield projects and will produce about half a million EVs a year (HIPA, 2021). It received the highest state aid in Hungary ever (K-Monitor, 2020). By 2025, after Germany and Poland, Hungary could be the third-largest battery producer in the EU (Transport & Environment, 2021).

Investments in the vehicle battery production represent a new trend. While car assembly companies came mainly from Europe, the leading investors in the production of battery cells for electric vehicles in Hungary are the leading Asian (South Korean, Japanese, and Chinese) companies. The largest investors are the South Korean companies. Samsung SDI started assembling the battery in the former monitor manufacturing plant in Göd near Budapest in 2017. It then continuously expanded production in the following years. SK Innovations will build its next plant in Iváncsa (34 kilometres from Budapest) after its battery production plant in Komárom (74 kilometres from Budapest), which was established in 2018. In addition, the Japanese GS Yuasa and South Korean Inzi Controls have established plants in Hungary. In parallel with the start of battery production, Tier 2 and Tier 3 suppliers also appeared. In the case of suppliers, there are mainly South Korean companies (Dongwha, Doosan, Lotte Aluminium, Sangsin EDP, SungEel Hitech), complemented by Japanese (Mektec, Toray), and Chinese (Semcorp, Shenzhen Kedali Industry) affiliates. In response to the active support policies of Asian manufacturers, and in particular the dominant countries (China, South Korea, Japan), the European Union and industry associations are mobilizing significant funds (Energy Materials Industrial Research Initiative, 2020) for the development of battery value chain (from the related R&D to manufacturing and recycling). In the recent period, the Hungarian government has also provided significant support to the newly established battery manufacturers and further expansion of the existing ones. Thus, if the state aid is included (support for jobs creation, infrastructure support), the estimated investment can be worth up to ten times the actual investment at times (Váczi, 2019). For some investments related to battery production, the amount of state aid is much higher. The government contributed nearly 25 percent to the investment in Samsung's SDI plant in Göd (Tamásné Szabó & D. Kovács, 2022). Overall, the state contribution to battery manufacturing accounted for 10 percent of investment by the end of 2021.

According to Bloomberg (2021), Hungary will be ahead of Poland and Czechia in 2021. The ranking is based on a complex indicator and measures performance in five areas. Compared to Central European countries, Hungary has a remarkable capacity in battery cell production, but the demand for batteries is lagging behind. In Czechia, the demand for Li-ion batteries is higher due to the significant production of commercial vehicles (mainly buses). As a result, Czech electric vehicle production is much better developed vertically, resulting in a higher position in the global value chain instead of export-led production. In contrast, Hungarian battery cell production is export-led.

In the Hungarian automotive industry, along with global processes, there has been a change in trends, with investments pointing in the direction of electromobility. Significant investments are being made in the assembly of battery electric vehicles and the production of the essential units (electric motor, vehicle battery). However, in addition to the proximity of markets, export-led production is mainly based on a favourable regulatory environment and low labour costs. In the current structure of investments, increasing domestic value added does not seem realistic in the medium term.

3.2.4 Experiences of interviews

In March and April 2021, a series of interviews were conducted with stakeholders in the Hungarian automotive industry. They involved the automotive companies in domestic and foreign ownership, representatives of industry associations and the Government Office of a NUTS3 region strongly specialized in automotive manufacturing, and the Hungarian Metalworkers' Federation president. The latter constitutes the trade union representing the interests of workers in the automotive, electronics, metal, and machinery industries).

We summarise the comments of four key informants who have shared their ideas and suggestions regarding the necessary policy instruments aimed at promoting local automotive actors' upgrading and the high-road integration of the Hungarian automotive industry in the European and global automotive value chains. Since most of our interviewees opted for anonymity, the names of their organisations will not be disclosed.

The first set of questions was targeted at the interviewees' views on the radical transformation of the automotive industry. More specifically, we asked whether they considered the impact of digitalisation and electrification as threats or opportunities for upgrading. Next, we inquired about companies' upgrading trajectories and the enablers of and barriers to their upgrading. We tried to gain insights into the specifics of interviewees' upgrading, with respect to all upgrading dimensions, set out in the theory of global value chains (Fernandez-Stark and Gereffi, 2019; Humphrey and Schmitz, 2002). These questions set the context for asking our informants to evaluate the Hungarian industrial policy, specifically the automotive industry-related policy instruments and initiatives, and make recommendations regarding the best ways of fostering the upgrading of local automotive actors. The latter questions were elaborated upon only by four informants, as detailed below.

Our results indicate a consensus among respondents that the government considers the automotive industry of particular importance for the Hungarian economic performance. Automotive companies are the recipients of the lion's share of public subsidies.[19] All interviewees referenced Hungary's excessive exposure to the automotive industry and its dependence on the strategic decisions of German automotive companies (cf. Braun et al., 2020).

The interviewees considered Hungary's specialisation in automotive manufacturing excessively high. Yet surprisingly, they saw the radical turn of the automotive industry towards electric vehicles as a distant threat. All interviewees pointed out that the automotive industry is undergoing expansion in terms of both, the production capacities and employment. Neither digital and robotic technologies nor the shift of consumers' demand toward electric vehicles has entailed massive downsizing.[20] According to the interviewees, the current expansion of automotive production is fuelled by the upswing of demand for some conventional and electric vehicles and massive investment inflows in the battery industry. One interviewee underscored the importance of organic development at Hungarian manufacturing subsidiaries. He claimed that a decade-long continuous process upgrading, openness to learning and absorbing new technologies, and proactive participation in the ongoing competition across subsidiaries for higher-value assignments (functional upgrading) had shaped the parent companies' commitment to consolidate production activities in their Hungarian subsidiaries. The flipside of the coin is organic development at domestic-owned automotive suppliers, doing their best to meet automotive consumers' ever-rising requirements in terms of cost-efficiency and production quality and investing in advanced manufacturing technology. These non-abating efforts enabled the highest-flying domestic suppliers to co-evolve with their automotive customers.

[19] This view is substantiated by data. According to Vasvári et al. (2019), over the period between 2004 and 2018, automotive companies have received more than 60% of the so-called 'VIP cash subsidies' based on individual government decisions.

[20] The case of Wescast manufacturing automotive exhaust systems and turbocharger housings was mentioned among the exceptions (exhaust systems epitomise the losers of the transition to electric vehicles). Another exception was the recently (April, 2021) announced closure of one of Johnson Control's manufacturing plants in Hungary, where the reported reason was restructuring involving the relocation of automotive component production from the Hungarian plant to other facilities of the company that feature a much higher automation rate.

Our informants asserted that large-scale investments of foreign (mainly Korean) investors in the establishment of battery manufacturing facilities would indeed contribute to creating new jobs, which is indispensable for mitigating the adverse impacts of job losses – expected in the medium term. These job losses will not necessarily be induced by the automotive industry's shifting to electric vehicles, but rather by the robotic automation of particular manufacturing and, more importantly, logistics activities.

Jobs comprising low-skill, highly repetitive activities are expected to be eliminated by advanced manufacturing technologies. Although the first phase of this process is already over, there is still no meaningful growth in technological unemployment. Automation has been decided and implemented in response to increasingly pressing labour shortages that have already jeopardised production. In this vein, the operators whose work has become redundant by the installed robotic solutions have started to perform other activities within the given firms and were not laid off. Notwithstanding, future investments in further automation may already cause technological unemployment. According to our interviewees, however painful, these developments are necessary for upgrading the quality of work at the existing automotive manufacturing plants. Automation and digitalisation are indispensable for improving the competitiveness of the local subsidiaries as well.[21]

Relatedly, our informants have pointed to one of the most serious mistakes of the Hungarian industrial policy: *the misalignment among the individual policy components*. Some components of the Hungarian industrial policy try to foster the upgrading of incumbent automotive actors and enable a high-road integration of the industry into global value chains. Policy instruments supporting firms' digitalisation and the implementation of advanced manufacturing solutions can, indeed, contribute to upgrading. The direct impact of these investments is process upgrading: the upgrading of resource efficiency and operational excellence. Indirect impacts may also be meaningful: increased digital maturity usually entails functional upgrading.

In a similar vein, science, technology, and innovation policy programmes promoting the location of R&D-intensive activities to the premises of manufacturing companies, or subsidising the hiring of researchers and the procurement of high-value testing equipment, and/or fostering industry-university collaborations can also increase parent companies' commitment to delegate high-value assignments to local subsidiaries (functional upgrading).

By contrast, the policy instruments stimulating FDI attraction and retention are characterised by a race-to-the-bottom behaviour. These instruments still exemplify dependent market economy-type policy that tries to accommodate the needs of global investors by keeping labour costs low and labour market

[21] The case of Johnson Electric, described in footnote 2, was mentioned again as an example of the risks of local subsidiaries not following the overall trends of increasing automation.

flexible,[22] and by abstaining from imposing and enforcing strict environmental regulations.[23]

The main problem with this race-to-the-bottom behaviour is that it effectively hinders the achievement of the other efforts: those of upgrading. Suppose automotive investors are encouraged to capitalize on the low-cost features of the Hungarian location. In that case, they are not motivated to upgrade their local activities and invest in collocating research, design, and other quality activities to local production sites.

Another policy component that is not aligned with the ones envisaging and promoting a high-road development is the education policy. If the upgrading of vocational and higher education is neglected, this can effectively nullify the efforts to channel the industry's evolution towards a high-road trajectory. The reason is simple: automotive companies trying to upgrade and increase the skill intensity and value added of local activities have to face a lack of qualified workforce at all levels. Automotive companies find it increasingly hard to hire skilled employees: IT specialists and engineers, technicians with domain-specific and programming skills, and operators with at least medium technical competencies. Interviewees underscored that the performance of the Hungarian education system keeps deteriorating.

Over and above repeating the usual messages about investing in and improving vocational and higher education, our interviewees have called for policy consistency, that is, for a more coherent policy design across policy instruments envisaging FDI attraction, retention, and stimulation of incumbent actors' upgrading.

Developing the vocational and general education system was considered the primary and critical condition of upgrading and keeping up with the requirements posed by technological progress in the automotive industry. The interviewees have also emphasised that the government's race-to-the-bottom behaviour exacerbated the problem of qualified labour shortage.

One interviewee mentioned that massive funds allocated by the European Union Structural Funds for the greening of the transport sector and for supporting R&D and technological development had increased the capacity of the state to steer the development of the industry. With non-negligible funding available to support functional upgrading, the government's bargaining power is non-negligible either. Consequently, the race-to-the-bottom public policy behavior vis-a-vis Asian battery industry investors is by no means justified. The state should leverage its bargaining power and encourage investors to establish research centres specialised in electric vehicle battery research and engage in innovation collaboration with local universities. This kind of proactive

[22] The Hungarian so-called 'Slave Law' deregulating overtime work was mentioned in this respect and the lenience of the government towards specific companies, owned by Asian investors who recurrently repress labour unions and ignore employees' rights to decent working conditions (cf. Artner, 2020).

[23] The cases of battery manufacturing facilities have been mentioned in this respect.

stimulation of a high-road development should be prevalent not only in the battery manufacturing industry but also in the government-industry relations across the automotive industry.

3.3 Poland

This subchapter focuses on the Polish automotive sector, especially on the transnational corporations and domestic firms which manufacture motor vehicles and automotive intermediaries. Additionally, the subchapter contains statistics concerning total automotive production in Poland.

3.3.1 Transnational corporations and domestic companies in the Polish automotive industry

From 2015 to 2020, the automotive industry (manufacture of motor vehicles, trailers, and semi-trailers24) produced goods representing approximately 1.60–1.75% of Poland's GDP (Eurostat database, 2022). As far as employment is concerned, 1.55–1.95% of all employees belonged to the automotive industry in 2015–2020 (Eurostat database, 2022). In addition, the share of automotive industry products in the total exports of Polish goods and services in 2015–2020 was around 7–8% (UNCTADstat, 2022). The fundamental factor shaping the functioning of the automotive industry in Poland is foreign direct investments. From 2015 to 2020, the value of the FDI inward stock in the Polish automotive industry accounted for about 5–6% of Poland's total FDI inward stock (NBP database, 2022). The first year of the pandemic (2020) did not bring any substantial change in all mentioned shares.

There are production plants of many leading transnational corporations in the automotive industry in Poland. Concerning the most recognizable brands in the global automotive sector, the list of plants operating in Poland includes:

Fiat Chrysler Automobiles – the factory in Tychy manufactures Fiat 500, Abarth 500, and Lancia Ypsilon; the factory in Bielsko-Biała produces engines and Teksid Iron Poland factory manufactures iron castings in Skoczów (Fiat Chrysler Automobiles, 2022).

Opel – car factory in Gliwice and factory of engines in Tychy (Opel Manufacturing Poland, 2022) (in 2021, the owner of Opel – Groupe Peugeot Société Anonyme merged with Fiat Chrysler Automobiles, and Stellantis was created (Stellantis, 2022)).

Volkswagen (VW) – production plants of VW Caddy (Poznań), VW Transporter (Poznań) and VW Crafter (Białężyce near Września); foundry manufacturing cylinder heads (Poznań) and special vehicle body plant in Swarzędz (Volkswagen Poznań, 2022).

[24] According to the Statistical Classification of Economic Activities in the European Community, Rev. 2 (NACE Rev. 2).

MAN – assembly of trucks from the TGS and TGX series in Niepołomice; factory of MAN city buses and tourist NEOPLAN in Starachowice (MAN Polska, 2022) (Volkswagen and MAN are owned by Porsche and Piëch Familie (Orbis database, 2022)).

Volvo – production plant of Volvo buses in Wrocław (Volvo Buses Polska, 2022).

Toyota – production of engines, transmission, and transaxles in Wałbrzych and manufacturing of engines in Jelcz-Laskowice (Toyota Manufacturing PL, 2022).

Mercedes-Benz – factory of engines and batteries for electric cars located in Jawor (Mercedes-Benz Manufacturing Poland, 2022).

Scania – production of city buses Scania City Wide and bus chassis in a factory in Słupsk (Scania Production Słupsk S.A., 2022) (Scania is also owned by Porsche and Piëch Familie (Orbis database, 2022)).

In addition, three factories are located in Poland (Mielec, Gliwice, Gniezno) belonging to Kirchoff Automotive, in which metal structures and metal/aluminium combinations for body and chassis are manufactured (Kirchoff Automotive, 2022). Moreover, Valeo has four production plants in Poland: the engine systems production plant in Skawina, the wiper systems production plant also in Skawina, the lighting systems production plant in Chrzanów, and the plant for the production and starters, air dampers and valves, exhaust gas recirculation and innovative electric generators for hybrid vehicles, as well as the regeneration of alternators, starters, dual mass flywheels and compressors for car air-conditioning in Czechowice-Dziedzice (Valeo, 2022). Automotive parts are also produced at five plants owned by Lear Corporation (Tychy JIT&Foams – headrests, armrests, bolsters, plating, and foam of car seats; Tychy Structures – car seat constructions, Jarosław Trim – car seat covers; Legnica Structures – steel constructions, guides and mechanisms of car seats; Bieruń Guilford – laminated materials and Mielec E-Systems – electric wire harnesses for passenger cars) (Lear Corporation, 2022). Additionally, ZF concern produces safety seat belts and airbags (plant in Częstochowa), steering and control systems (plants in Bielsko-Biała and Czechowice-Dziedzice), braking systems (plants in Gliwice and Wrocław) (ZF, 2022). At the end of the review of the most important, though not all, FDI in Poland, it is worth mentioning Brembo, which has three production plants in Poland. Brake systems and brake discs are produced in Częstochowa and Dąbrowa Górnicza, respectively, while steel housings (to mount on brake discs) are manufactured in Niepołomice (Brembo, 2022). Nexteer – a Chinese state-owned company – whose subsidiaries are located in Tychy and Gliwice is also worth mentioning. Nexteer produces electric power steering, steering columns, driveline, ADAS&automated driving, and hydraulic power steering (Nexteer, 2022).

The values of the FDI outward stock and FDI outflows from the Polish automotive industry are much lower (ca. twenty times lower) than the value of the

FDI inward stock and FDI inflows into the Polish automotive industry (NBP database, 2022). An example of a Polish company from the automotive industry that invested abroad is Grupa Boryszew. It produces various components for the automotive industry, such as air-conditioning hoses, electric power steering systems, active suspension systems, and plastic, galvanized, and chrome-plated components. Grupa Boryszew possesses 35 plants and 6 R&D centres located in Europe (Poland, Germany, France, Italy, Spain, Ukraine, Russia), Asia (China, India), and in both Americas (the United States, Mexico, Brazil) (Grupa Boryszew, 2022).

The Polish companies from the automotive industry listed below are worth mentioning as well: Solaris Bus&Coach (Solaris, 2022) (bus manufacturer; since 2018, the owner of Solaris is a Spanish company – Construcciones y Auxiliar de Ferrocarriles (Orbis database, 2022)), Jelcz (PGZ Jelcz, 2022) (currently the production of heavy-loaded trucks, until 2008 also buses; Jelcz is a state-owned company), Autosan (Autosan, 2022) (production of buses; Autosan is a state-owned company), Wielton (Wielton, 2022) (production of semitrailers, trailers, and body), Mega (Mega, 2022) (production of semitrailers and axles for semi-trailers and trailers; since 2017 the owner of Mega is French company – Benalu (Orbis database, 2022)), AMZ (AMZ, 2022) (production of special vehicle bodies), EMTECH (EMTECH, 2022) (production of semitrailers and trailers) and Inter Cars (Inter Cars, 2022) (production of a wide spectrum of automotive components).

3.3.2 Automotive production in Poland

In the Orbis database, there are 1,999 companies in the automotive sector (manufacture of motor vehicles, trailers, and semi-trailers) located in Poland. The information about the ultimate global owner is available for 1,071 companies. In the case of 272 companies (about 25%), the ultimate global owner comes from abroad. However, in the top 10 (out of 1,999) companies with the highest current operating turnover (revenue), nine companies are foreign branches of transnational corporations (Orbis database, 2022). Additionally, over the period 2008–2014, the share of the production of foreign branches of transnational corporations in total production was about 87–92% (more current data are not available) (Eurostat database, 2017). According to the presented statistics, transnational corporations play the leading role in the Polish automotive sector, and domestic firms are small and medium enterprises.

Table 3.8 Production of selected goods in the Polish automotive sector during 2010–2020 (number of units)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Engines	1 675 963	1 930 331	1 589 794	1 622 335	1 534 657	1 391 379	1 335 729	1 321 799	1 249 010	1 304 617	1 583 186
Passenger cars	785 005	740 548	539 671	475 119	472 567	534 685	554 712	514 514	451 545	434 666	278 788
Buses	4 566	5 059	4 012	4 205	5 027	5 051	5 293	5 310	5 987	7 358	6 037
Trucks	76 122	86 236	99 772	104 589	109 243	112 006	110 995	158 224	187 740	194 819	155 893
Road tractors	3 776	5 829	4 271	6 484	6 634	8 933	11 005	11 549	14 401	12 983	9 261
Other motor vehicles	1 807	2 122	3 718	7 576	6 131	7 974	7 245	8 940	10 582	10 228	8 142
Road containers	38 546	44 513	38 357	40 461	40 707	38 186	56 501	60 423	62 164	64 524	64 298
Trailers and semitrailers	19 763	29 870	36 484	35 835	41 781	36 207	37 650	56 933	34 263	70 084	63 581

Source: own deliberation based on *Statistics Poland* (2022)

Table 3.8 presents the production of selected goods (number of units) in the Polish automotive sector. It is worth noticing that a significant decline in the production of passenger cars, buses, trucks, and road tractors in 2020 compared to 2019 was probably caused by the pandemic. However, the number of engines produced in 2020 was higher than in 2019, and the number of containers, trailers, and semitrailers fell slightly.

Comparable but less disaggregated statistics concerning the value of production in the Polish automotive sector are available only for the years 2018–2020 (see Table 3.9). Firstly, about 60% of total production accounted for the manufacturing of intermediaries. Interestingly, the analogical proportions in the case of Polish exports are different as about 45% of total exports accounted for manufacturing exports during the years 2018–2020. It suggests that a pretty significant part of produced intermediaries (together with foreign intermediaries as backward participation of the Polish automotive sector in global value chains has been fluctuating around 45 – 49%) is transformed into final goods in the Polish automotive sector (OECD, 2021b). Secondly, the decline in 2020 vs. 2019 caused probably by the pandemic was stronger for intermediaries (about 17%) than for final goods (about 9%). This confirms the Forrester (bullwhip) effect.

Table 3.9 The value of the production in the Polish automotive sector during 2018–2020 (billions of PLN)

	2018	2019	2020
Final goods: passenger cars, buses, trucks, road tractors, and other motor vehicles	53	55	50
Intermediaries: engines, road containers, trailers, semitrailers	85	86	71

Source: own deliberation based on *Statistics Poland* (2022)

3.4 Slovakia

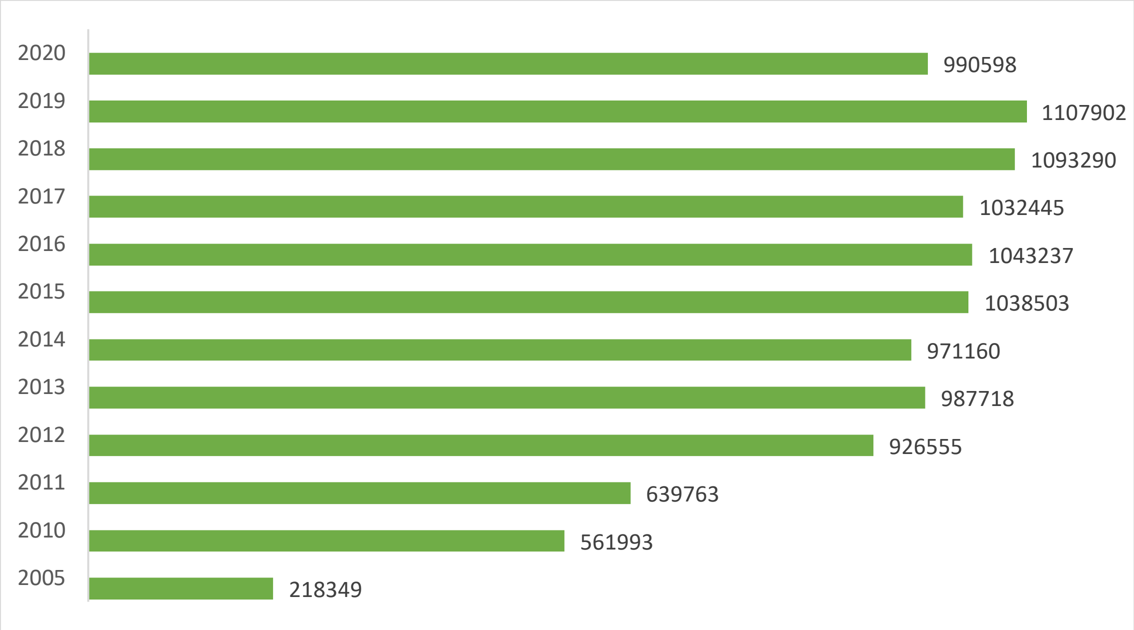
Historically, the development and expansion of the Slovak automotive industry date back to the 90s of the last century, while the crucial moment was the start of operation of the German car manufacturer Volkswagen AG in Bratislava. Due to the arrival of this carmaker, a supply network from abroad began to form rapidly, which resulted in another influx of connected FDIs to Slovakia. In 2003 - 2005, we received another wave of investments in the automotive industry, in the form of the arrival of two other large PSA Peugeot Citroën cars near Trnava and KIA Motors in Žilina. A significant investment determining the dominance of the automotive industry in Slovakia and the profile of the Slovak economy and exports itself was the establishment of Jaguar Land Rover in 2015 and the launch of production in 2018. One of the strengths of the automotive industry in Slovakia is large supply chains and a diversified global value chain at the V-4 level. The significant impact of the automotive industry on the Slovak economy is noticeable, either directly through the four mentioned manufacturers or indirectly through supply networks.

3.4.1 The importance of the automotive industry for the Slovak economy

The Slovak economy is in the top ten most open economies globally and shows an extreme dependence on exports. The automotive industry (HS 87 product group) share in Slovak exports is approximately 34.6% (ITC, 2022), representing a 2.3% share in global vehicle exports. The dominance of this sector has caused the integration of the Slovak industry into global value chains in the automotive industry, but with less significant integration of its subcontracting capacities in the creation of added value of exported vehicles. The accession of Slovakia to the EU in 2004 and the entry into the monetary union in 2009 (i.e., adoption of the single European currency, accelerated the arrival of new investors in this sector.

With the growing year-on-year GDP and the volume of exports and imports, car production in Slovakia is also growing. The total production of cars is shown in Figure 3.4 between 2010 and 2020. To highlight the growth dynamics of the automotive industry in Slovakia, the graph also shows the year 2005, when car production did not reach even 40% of production in 2010. From 2010 to 2020, we can observe a growing trend in car production, except for 2017, when production fell by more than 10,000 cars. In percentage terms, this decrease is at the level of 1%, and therefore it is not a significant deviation from the growing trend. The second natural slowdown was recorded in 2020 due to the global pandemic COVID-19, which disrupted global value chains in the automotive industry (ports, shortages in semiconductors, and several times more expensive transportation from Asian ports).

Figure 3.4 Car production and its development in Slovakia

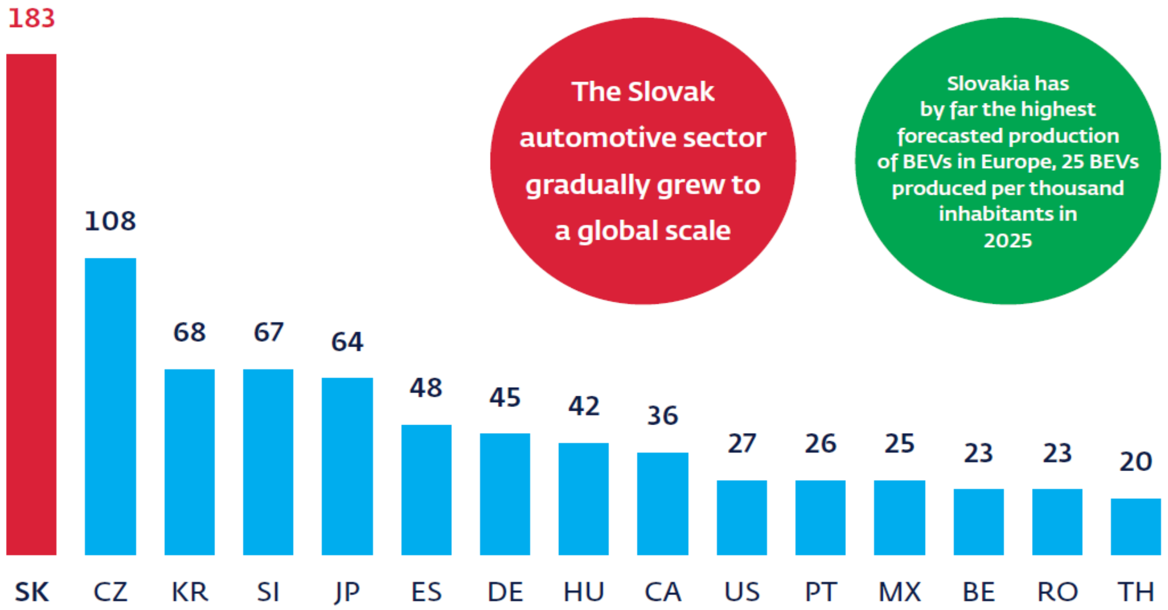


* Production in 2020 was hit by disruptions in global value chains caused by the COVID-19 pandemic

Source: processed by authors based on data from the Slovak Investment and Trade Development Agency – SARIO (2022)

The decline in car production in Slovakia in 2020 and the predictions for 2021 are influenced by the global problem of coronavirus SARS-CoV-2, which will most likely result in an economic crisis (associated with rising prices) affecting all sectors of the economy, industry without exception. The automotive industry in Slovakia is a dynamically developing sector, the contribution of which is currently significant for the Slovak economy, especially for the export competitiveness of Slovakia. The dominant position of the automotive industry in Slovakia can be observed in Figure 3.5, which shows the production of cars per 1,000 inhabitants in comparison with countries such as South Korea, Germany, Belgium, V-4 countries, and others. Slovakia ranks first in this comparison (in 2019, it was even 202 cars per 1,000 Slovak citizens), while there is a difference of almost 80 cars per 1,000 inhabitants between Slovakia and the second Czechia. Poland ranks last with 11.6. These findings document the strategic importance of the automotive industry in the Slovak economy (Baláž et al., 2020; Zábojník et al., 2020). According to SARIO data (2022a), the production of passenger cars represents up to 48% of the industrial production of Slovakia.

Figure 3.5 Car production in selected countries per 1,000 inhabitants



Source: based on data from SARIO (2022a)

The vast majority of car production in Slovakia is divided among the four most significant car manufacturers in Slovakia - Volkswagen Slovakia, a.s., Kia Motors Slovakia, s.r.o. and PCA Slovakia, s.r.o. In each year of the period under review, Volkswagen Slovakia, a.s. is based in Bratislava, with the most cars producing 426,313 units in 2013. After 2015, the carmaker recorded a decline in production in two consecutive years, by 2.20% between 2015 and 2016 and 6.92% between 2016 and 2017. However, it was also related to the transformation of the product portfolio of the Bratislava plant, which gradually began to produce premium models with a higher rate of added value. Subsequently, VW Slovakia, a.s. increased production again to 408,208 cars produced in 2018, so that production will fall to 309,348 vehicles in 2020 due to the COVID-19 pandemic (SARIO, 2022a).

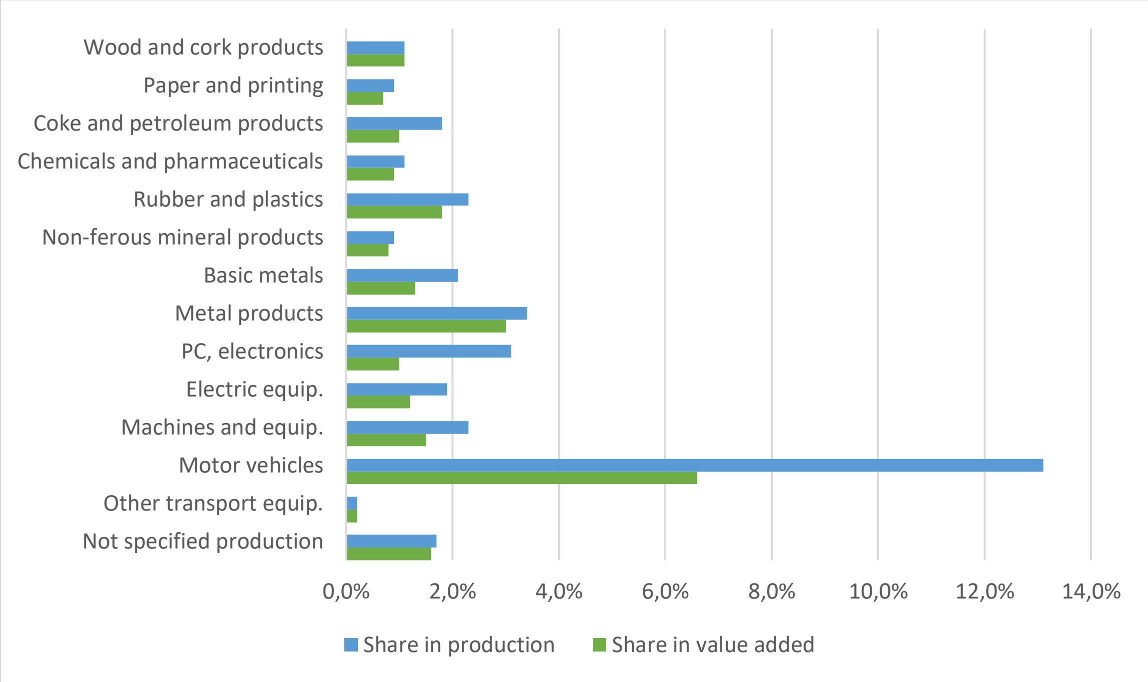
Until 2018, Kia Motors Slovakia, s.r.o. occupied the second place in car production in Slovakia based in Žilina, but did not follow the growing trend of its production between 2012 and 2016, and after two years of slight decline, when production fell by 1.91% between 2016 and 2018, PCA Slovakia, s.r.o. surpassed it in the number of cars produced. The pandemic also affected this carmaker when Kia's production volume fell in 2020 to 268,200 units.

The automotive manufacturer PCA Slovakia, s.r.o. (Stellantis Slovakia) based near the city of Trnava was the only one of the three to maintain stable continuous production growth, while between 2012 and 2018, it increased car production by 64.05%. The average annual increase in production in the period under review was 8.76%. The pandemic period reduced production volume, and in 2020 the value stabilized at 338,050 cars produced in Trnava. The production of Jaguar Land Rover Slovakia, the last carmaker and the youngest investment, and OEM in the Slovak market, began to raise Slovak export numbers more significantly in 2018, three years after establishing the greenfield. In 2020, production was around 150,000 vehicles per year, with a product portfolio of Land Rover Discovery, Land Rover Defender 90, Land Rover Defender 110, and Land Rover Defender 130 (SARIO, 2022a).

3.4.2 Global value chains and value added in the Slovak automotive industry

The production of motor vehicles as an industry contributes the largest share of the total production in Slovakia. Other industries with a significant share in total production are metal products, computers, electronics, or rubber and plastic products. These are the industries associated with the automotive industry. Many of the manufacturers in these industries are among the subcontractors of the largest automobiles. The share of individual industries in the total production and value added created in Slovakia is shown in Figure 3.6.

Figure 3.6 The share of individual industries in the total production and value added created in Slovakia



Source: based on data from Preťo (2019)

The share of value added in the motor vehicle industry in total value added is relatively low compared to the production volume of this sector. The motor vehicle industry accounts for approximately 13.1% of the total value of Slovakia's gross production but only 6.6% of the total value added. However, the sector still accounts for the largest share of total value added in absolute terms. Slovakia's gross exports contain almost half (44.8%) of foreign value added, which it imports into the country, with industrial production, including the automotive industry, having the largest share of the sector. Industrial production accounts for more than three quarters (76.2%) of the total exported value added of Slovakia.

In the case of Slovakia, the share of foreign value added in the gross exports of industry reaches one of the highest values in the world. It is due to several factors, especially the size of the Slovak economy, the cluster of automotive industries affecting neighbouring countries, the use of OEM economy of scale in the region, but also, to a large extent, the lack of adaptability and innovative capacity of Slovak subcontractors (Zábojník et al., 2019). Slovakia has a share of foreign value added in the gross exports of the industrial production sector worth 52.4%. Its share in the gross exports of the whole economy equals 44.8% (OECD, 2016), which is the second-highest share after Luxembourg, which speaks of the dependence and interconnectedness of the Slovak economy with other countries.

The highest share of foreign value added among individual industries is in the computer and electronics sector, with 62% of foreign value added. The second-highest share is held by the transport equipment industry, which is the automotive industry, where the foreign value added accounts for 59%; according to TiVA data, it even reached the value of 60% in 2016 (OECD, 2016). The fact that these sectors create more than half of the value added and occupy a high share in the overall economy represents the sign of the strong backward participation of GVCs.

Industrial production in Slovakia focuses mainly on the final stages of industrial production, where the share of domestic value added is limited. The inputs needed for production are primarily imported from abroad. The Slovak economy does not have the opportunity to ensure the production of all necessary inputs required for such a complex industry as the automotive industry concerning the dynamics of change and massive innovations of their utility parameters in the pre-pandemic and pandemic period. Despite the lower share of domestic value added in this sector, the automotive industry generates a higher value added per employee than the average in the economy.

Comparing value added per employee in the automotive industry in Slovakia, Czechia, and Germany does not sound positive for the Slovak economy. In 2016, the value added per employee was 41 thousand EUR, while in Germany up to 123.7 thousand EUR. The production value per 1 employee in the automotive industry in Slovakia reaches 80% of the value produced in Germany. However, the added value of a Slovak employee is only 11% compared to the value in Germany at 28%.

Table 3.10 Value added of the largest car manufacturers in Slovakia

Name of the company	in mil. €	2016	2017	2018
Volkswagen Slovakia, a.s.	Production	7 586.6	7 549.1	10 380.0
	Intermediate consumption	6 739.4	6 615.2	9 201.6
	Added Value	846.9	933.8	1 178.4
	Share of added value on production	11.2%	12.4%	11.4%
Kia Motors Slovakia, s.r.o.	Production	5 566.2	5 184.7	5 185.6
	Intermediate consumption	4 782.2	4 369.5	4 643.3
	Added Value	784.0	815.2	542.4
	Share of added value on production	14.1%	15.7%	10.5%
PCA Slovakia, s.r.o. (Stellantis)	Production	2 464.8	2 664.5	2 752.8
	Intermediate consumption	2 349.2	2 510.2	2 616.1
	Added Value	115.6	154.3	136.7
	Share of added value on production	4.7%	5.8%	5.0%

Source: own elaboration

Table 3.10 shows the value added of the three most significant cars operating in our territory and the share of value added in the value of total production in monetary terms. Kia Motors Slovakia, s.r.o. has the largest share of added value, when in 2017, it exceeded the share of added value by 15%. The lowest share is held by PCA Slovakia s.r.o., which equalled ca. 5% of the share of value added in the observed period.

3.4.3 Automotive industry supply network of Slovakia and its specifics

As OEMs certify and contract premium suppliers and sufficiently innovative suppliers able to meet the dynamically changing consumer requirements at the level of the OEM headquarters in the home country, the current supply structure of the automotive industry consists of a lower number of suppliers compared to the supply structure in the past. Many individual suppliers who traded directly with the final car manufacturer have transformed into a small number of system suppliers. These suppliers supply the manufacturer with a full range of stocks, working with their subcontracting structure.

Further expected development of the supply structure in the automotive industry leads to the creation of supply networks that represent the transition between the current supply structure to the structure consisting of the supplier network. This change will bring new types of suppliers, such as component specialists, automotive technology specialists, and automotive systems. In the future, automotive suppliers are expected to be able to take on several roles as the final carmaker. Another expected characteristic feature of the new supply structure will be the creation of innovation centres, solid partnerships, and deepening cooperation between suppliers and final car manufacturers.

3.4.4 Supplier structure integration

The so-called modular production characterizes the current automotive industry in Slovakia. The final manufacturer cooperates with suppliers of complete systems or modules. Part of this strategy is that suppliers of larger functional units (modules) are involved in the production process from the initial stage of module development. It is a supplier integration model that requires high expertise and specialization of the supplier. At the same time, however, it is a guarantee of quality. Another strategy used in the automotive industry is to assemble different models using the same platform. This strategy is an effective way for a car manufacturer to reduce costs, production complexity, or the need for various components. (Hughes et al., 1998)

There are apparent growing demands on the supply structure in the subcontracting network within the automotive industry in Slovakia, mainly Tier 1 suppliers. These suppliers produce complete modules, while indeed, they are responsible for the required quality. It is not uncommon for suppliers to operate in another country or continent than the producer of the final product. Outsourcing the assembly of individual units allows the manufacturer to reduce costs. It allows him to take advantage of the comparative advantages of supplier countries, which is reflected in the final price.

From the point of view of Tier 1 suppliers, this situation means higher requirements for their design and development capabilities. On the other hand, suppliers can achieve a higher level of added value and thus move higher across the value chain. Table 3.11 provides an overview of the largest suppliers to the automotive industry operating in Slovakia in terms of sales in 2018. The share of exports in total sales is also shown, while it is possible to observe some companies' intensive or even total export orientation. Table 3.10 also shows the added value, namely the volume of exports realized by the given enterprises until 2018.

Table 3.11 The largest suppliers in the Slovak automotive sector

COMPANY NAME	COUNTRY	LOCATION	SALES REVENUE	EMPLOYEES	Share of export on revenues*	Added Value in %
			2020 (kEUR)	2020	2020	2020
Mobis Slovakia	South Korea	Gbeľany	1 226 147	2 035	13.3%	N.A.
Continental Matador Rubber	Germany	Púchov	902 195	3 171	80.7%	38.2%
SAS Automotive	Germany (France)	Bratislava	835 589	558	0.2%	3.8%
Faurecia Automotive Slovakia	France	Bratislava, Hlohovec, Košice, Lozorno, Trnava, Žilina	834 663	2 616	19.2%	N.A.
Continental Matador Truck Tires	Germany	Púchov	514 422	1 568	83.2%	31.9%
Schaeffler Kysuce	Germany	Kysucké Nové Mesto	509 153	4 425	100,0%	67.6%
ZF Slovakia	Germany	Trnava, Levice, Komárno, Šahy, Detva	446 545	3 284	97.4% / N.A.	N.A. / N.A.
Hanon Systems Slovakia	South Korea	Ilava	391 235	847	60.2%	N.A.
Schaeffler Skalica	Germany	Skalica	389 694	4 159	N.A.	N.A.
Yura Corporation Slovakia	South Korea	Lednické Rovne, Hnúšťa, Hlohovec, Topoľčany, Prievidza, Rimavská Sobota	346 472	1 572	50.3%	N.A.
Lear Corporation Seating Slovakia	USA	Prešov, Voderady	311 459	1 659	63.3%	13.5%
Adient Slovakia	USA	Bratislava, Trenčín, Žilina, Lučenec, Martin	299 700	2578	65.2%	21.4% / N.A.
Plastic Omnium Auto Inergy Slovakia	France	Prešov	278 626	271	N.A.	N.A.
Panasonic Industrial Devices Slovakia	Japan	Trstená	268 803	1 897	98.8%	N.A.
Bekaert Hlohovec*	Belgium	Hlohovec	260 579	2 319	90.9%	N.A.
Continental Automotive Systems Slovakia	Germany	Zvolen	259 345	1 121	100,0%	N.A.
HELLA Slovakia Lighting*	Germany (France)	Kočovce	250 424	2 018	N.A.	N.A.
ZKW Slovakia	Austria (South Korea)	Krušovce	226 262	2 258	99%	N.A.
Visteon Electronics Slovakia	USA	Námestovo	221 400	588	100,0%	10.8%
Brose Prievidza	Germany	Prievidza, Lozorno	210 522	1 111		N.A.
Sungwoo Hitech Slovakia	South Korea	Žilina	196 565	427	3.0%	7.7%
HBPO Slovakia	Germany	Lozorno	194 709	209	3.9%	13.8%
LEONI Slovakia	Germany (USA)	Trenčín,	181 971	2 259	N.A.	N.A.

		Trenčianská Teplá			N.A.	N.A.
Marelli Kechnec Slovakia	Italy	Kechnec	174 749	588	100,0%	N.A.
Vertiv Slovakia	USA	Nové Mesto n. Váhom	173 427	1 126	N.A.	N.A.
Matador Automotive Vráble	Slovakia/Portugal	Vráble	172 130	1 334	N.A.	N.A.
Yanfeng International Automotive	China/USA	Bratislava, Námestovo	171 175	1 285	N.A.	N.A.
Technology*					N.A.	N.A.
Magna PT	Germany	Kechnec	164 300	719	N.A.	N.A.
Golde Lozorno	Spain	Lozorno	145 118	751	N.A.	N.A.
Hyundai Steel Slovakia	South Korea	Gbeľany	136 856	62	N.A.	N.A.
Boge Elastmetall Slovakia	China	Trnava	125 374	789	N.A.	N.A.
Hyundai Transys Slovakia	South Korea	Žilina	125 136	304	N.A.	N.A.
Iljin Slovakia	South Korea	Pravenec	123 280	255	N.A.	N.A.
Grupo Antolin Bratislava	Spain	Bratislava	122 539	412	N.A.	N.A.

Source: SARIO (2022a) based on data from Finstat (2022); Note: * Data for 2019

The automotive industry is experiencing sharp changes in production conditions. The ACES transformation model is decisive: the massive "A" - autonomous vehicle elements, "C" - connectivity and the growing share of vehicle electronics, the expected "E" - electromobility and the impact on manufacturers' product portfolio and the "S" - shared mobility services, where we anticipate a gradual change in the business model and a decline in the priority of vehicle ownership. These trends in the advancing Industry 4.0 require an unprecedentedly high input of commercially usable innovative R&D outputs. European, but especially Slovak carmakers, currently outsource a large part of electronics and sophisticated components mainly from Asian suppliers (PRC, Japan, South Korea). For this reason, the value of gross exports of Slovak car producers is high. However, the real value added on car exports (contributing to GDP and living standards in Slovakia) is at one of the lowest levels in the world: only 40%. Car production in Slovakia or other relevant production brings lower added value per capita than in those EU countries where this sector carries out its own research and development (Zábojník et al., 2019).

The activation of innovation policy is necessary for the qualitative progress of automobiles and the engineering industry and their shift in Slovakia in the value chain towards higher added value. Its output should be greater involvement of domestic subcontractors in activities, such as research, development, design, sales of cars, and process optimization. An important factor that is likely to increase the need for high-tech solutions for subcontractors is the advent of electromobility in the product portfolio of virtually every carmaker. However, it is assumed that the value added in this segment in Slovakia will grow, as the four most prominent car manufacturers in Slovakia produce up to 23 electric cars (BEV). This parameter also gives a particular assumption of the subcontracting network in Slovakia for greater involvement and growth of domestic added value in the volume of vehicle exports to the EU and outside the EU.

4 Recent changes in GVCs in the automotive sector in V-4 countries – case studies

4.1 Czechia

4.1.1 Increasing the value by upgrading within GVCs

Technological changes pose continuous challenges to the firms[25]. “The challenge to management is to create the strategies and structures, resources and capabilities, and to use the new technologies efficiently, to encourage this cross-disciplinary, cross-sectoral, and cross-technology synergy” (Dogson et al., 2008, p. 307). By upgrading, firms develop their products, increase efficiency in their operations or proliferate into new industries by using their skills while developing new capabilities.

There are four different forms of upgrading:

(a) process upgrading by reorganization of activities or implementation of new technologies,

(b) product upgrading by the increase in the value of the product,

(c) functional upgrading by gaining new roles in the value chain,

(d) inter-sectoral upgrading by entering new production activities (Humphrey & Schmitz, 2002).

The key to upgrading is innovation. In the V-4 automotive industries, the situation within GVCs is more favourable for process and product innovations (Antal et al., 2015). The important aspect is the collaboration in creating innovations along the value chain, especially between the OEM and TIER 1 suppliers. In the said industry, the research emphasizes the role of buyers (Humphrey & Schmitz, 2002). Companies involved take different approaches to the innovation strategy. Companies that update based on the specifics provided by their customers apply a passive innovation strategy. Innovating suppliers can adopt reactive, active, or proactive innovation strategies, the latter being the most demanding in terms of resources and innovation capabilities (Dodgson et al., 2008). The conditions favourable for upgrading include a stable business and political environment, knowledge, skills, and education (Antal et al., 2015).

In our case studies, we present the stories of two global companies operating, among others, in Czechia and other V-4 countries. They have proven competent in performing innovations, for they have successfully met the challenge of the electromobility trend that substantially altered the competitive environment in the sector.

[25] The co-author to this subchapter is Petr Procházka from Dept. of International Business, Faculty of International Relations, Prague University of Economics and Business.

4.1.2 Electromobility in Europe – step by step

If we neglect the very first attempts to construct an electric vehicle (EV) that date back to the 19th century (Deal, 2010), the world's first mass-produced hybrid passenger vehicle was the Toyota Prius, launched in Japan in 1997 (Toyota, 2021) and worldwide in 2000 (Department of Energy, 2014). Yet Tesla company pushed the process of EV proliferation forward in 2006 by announcing the plans to produce a luxury electric sports car. Tesla received a loan from the US Department of Energy for its production worth nearly USD 500 million in 2010. The subsequent Tesla headway and success made the other carmakers join the 'race'. They speeded up their efforts to develop their own electric cars (Department of Energy, 2014).

After several efforts with hybrid (plug-in hybrid vehicles; from now on referred to as PHEV) or fully electric vehicles (battery electric vehicles; BEV) produced in tiny series in the 1990s or early 2000s, the European carmakers were somewhat slower in starting mass production. For instance, Volkswagen debuted with e-Golf not earlier than in 2013 (Volkswagen UK, 2021), while Renault in 2012 (Renault Group, 2021) and BMW in 2013 with the BMWi sub-brand (BMW group, 2012). The gradual increase in EV stock is demonstrated in Tab. 4.1. A significant momentum that multiplied the EV stock was given in 2008 when Tesla Roadster (first generation) was launched. In April 2010, the regular production of the said model commenced (Tesla, 2021).

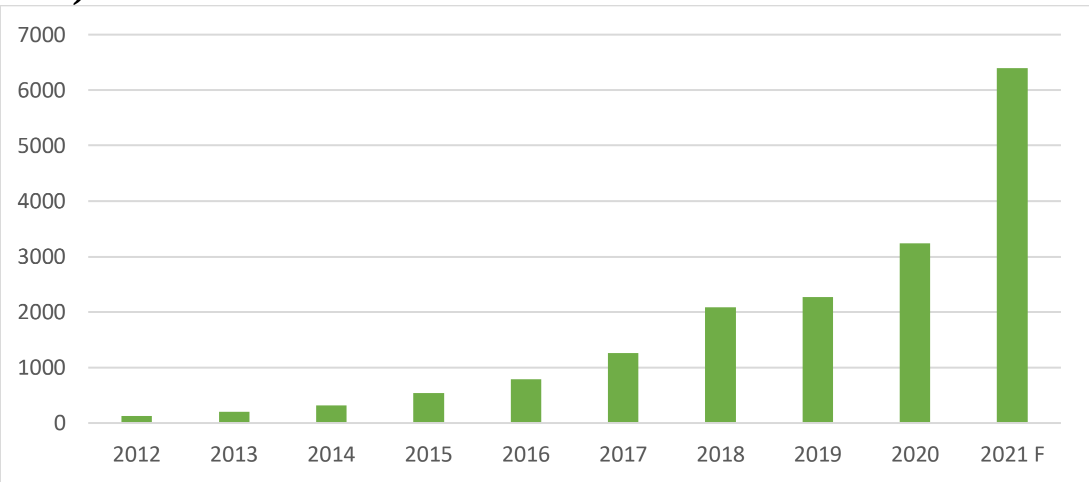
Table 4.1 Electric car stock (BEV and PHEV) by country over 2005-2019 (in thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Australia							0.0	0.3	0.6	1.9	3.7	5.1	7.3	10.9	20.1
Canada							0.5	2.5	5.7	10.7	17.7	29.3	45.9	90.1	141.1
China					0.5	1.9	7.0	16.9	32.2	85.3	292.7	628.7	1207.7	2288.8	3349.1
Finland							0.1	0.2	0.5	0.9	1.6	3.3	7.2	15.5	29.4
France	0.0	0.0	0.0	0.0	0.1	0.3	3.0	9.3	18.9	31.5	54.5	84.0	118.8	165.5	226.8
Germany	0.0	0.0	0.0	0.1	0.1	0.2	1.9	5.3	12.2	24.9	48.1	72.7	109.6	177.1	258.8
India				0.4	0.5	0.9	1.3	2.8	2.9	3.4	4.4	4.8	7.0	9.1	11.2
Japan					1.1	3.5	16.1	40.6	69.5	101.7	126.4	151.2	205.3	255.1	294.0
Korea						0.1	0.3	0.8	1.4	2.7	6.0	11.0	25.7	60.6	92.4
Netherlands				0.0	0.1	0.3	1.1	6.3	28.7	43.8	87.5	112.0	119.3	146.7	214.8
N Zealand						0.0	0.0	0.1	0.1	0.4	0.9	2.4	5.9	11.4	17.7
Norway			0.0	1.7	1.8	2.7	3.9	8.4	15.7	35.4	69.2	114.1	176.3	249.0	328.6
Portugal						0.7	0.9	1.0	1.1	1.3	2.5	4.3	8.7	17.0	29.7
Sweden						0.0	0.2	1.1	2.7	7.3	15.9	29.3	49.7	78.6	97.0
Thailand		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.4	9.0	19.4
UK	0.2	0.5	1.0	1.2	1.4	1.7	2.9	5.6	9.3	24.1	48.5	86.4	133.7	184.0	259.2
U.S.	1.1	1.1	1.1	2.6	2.6	3.8	21.5	74.7	171.4	290.2	404.1	563.7	762.1	1123.4	1450.0
others	0.6	0.6	0.6	0.6	0.7	0.9	3.6	7.7	13.4	27.0	51.6	85.5	146.2	220.1	328.5
Total	1.9	2.24	2.70	6.60	8.89	17.03	64.32	183.64	386.32	692.63	1235.73	1988.18	3136.78	5111.92	7167.83

Source: own calculations from IEA (2020), p. 247

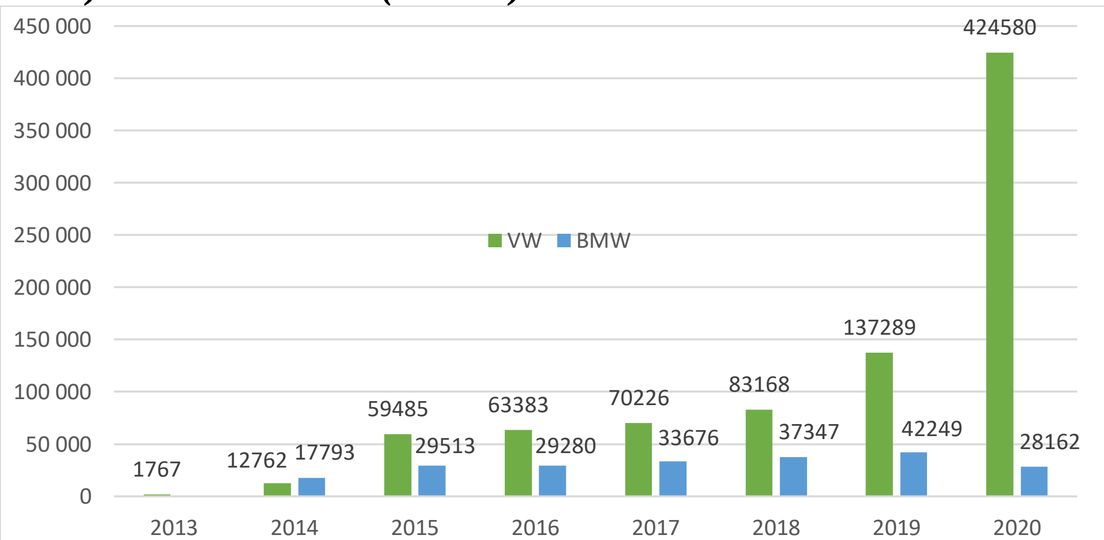
The EV sales gradually rose from 2012 to 2021, with the highest year-on-year hike in 2021 (according to forecasts); Fig. 4.1. As for Volkswagen only, the most significant year-on-year rises can be seen in 2013/2014, 2014/2015, and 2019/2020; Fig. 4.2. The market share of BMW is much lower in comparison.

Figure 4.1 Global EV sales (PHEV and BEV) over 2012-2021 (thousands of units)



Source: own elaboration from EV-Volumes.com (2021a).

Figure 4.2 EV worldwide sales of Volkswagen Group and BMW group (i series) over 2013 – 2020 (in units)



Source: own elaboration from EV-Volumes.com (2021b); BMW (2021).

Indeed, the EU legislation and EU member states' tax incentives gave additional impetus to the process that Tesla started. The 'sustainable tomorrow' initiatives and related EU and national legislation constitute stepping stones for European carmakers when projecting their respective R&D efforts and investments into EV production. They create and expand the future market potential and demand. We can highlight the role of emissions limits for passenger cars and tax incentives for electric vehicles in these terms.

4.1.3 The regulatory framework

The Directive 2006/32/EC of the European Parliament and of the Council on energy end-use efficiency and energy services stipulated in the preamble: "The motor fuel and transport sectors have an important role to play regarding energy efficiency and energy savings." And in Annexe III, the Indicative list of eligible energy efficiency improvement measures involved "motors and drives (e.g., increase in the use of electronic controls, variable speed drives, integrated application programming, frequency conversion, the electrical motor with high efficiency)"; (Directive 2006/32/EC). The aforesaid Directive was replaced by the Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, which is still in effect in its consolidated version of January 2021.

Directive 2009/33/EC of the European Parliament and of the Council of April 23, 2009, on the promotion of clean and energy-efficient road transport vehicles, is still in effect in its consolidated version of August 2019 (Directive 2009/33/EC). It gives legally binding minimum targets for shares of clean and energy-efficient road transport vehicles in total numbers of purchased, leased, or rented road vehicles in public procurements; (Directive 2009). In other words, it pushes public sector bodies to respect the mandatory shares of clean and energy-efficient road transport vehicles when expanding the public road transport fleet hard forward.

Another major impetus to electromobility was given in 2019 by Regulation 2019/631 of the European Parliament and of the Council setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles. It sets emission targets for vehicles registered in the EU for the first time that have not previously been registered outside the EU (Regulation 2019/631). The main target is to live up to achieving net-zero greenhouse gas emissions by 2050. Contemporarily, the European Green Deal, a set of policy initiatives of the European Commission aimed at making the EU climate neutral in 2050, represents a hot topic of political, ecological, economic, and social debates. Suppose the proposed measures are adopted by the European Parliament and EU member states and become legally binding. The average CO_2 emissions of every new passenger car have to be decreased by 55 % by 2030 and 100 % by 2035 (in comparison to 2021 levels); (European Commission, 2021a). That would mean that any new passenger car with a combustion engine could not be registered in the EU from 2035 onwards. Indeed, if this political decision is transposed into binding legislation, even hybrid cars would be prohibited, leaving entire space for fully electric vehicles and hydrogen cars. Yet, given comparatively much higher prices of EVs and a still limited density of the network of charging stations (The Automotive Disruption Radar by Roland Berger, 2021), the total number of cars sold is very likely to shrink, making independent car transport less affordable. In addition, imports from abroad (i.e., from countries less ambitious on climate) will likely not help affordability. They are planned to be subject to the particular import barriers countervailing the lesser environmental protection rules in the country of production, resulting in a lower price. The so-called 'Carbon Border Adjustment Mechanism' is meant to obstruct (in fact, increase the allegedly dumped price) imports of products manufactured under lesser carbon-emissions-responsible conditions (European Commission, 2021b).

Table 4.1 Snapshot of EV-related tax benefits and purchase incentives in V-4 in 2021

	Tax benefits			Purchase incentives
	Acquisition	Ownership	Company cars	
Czechia	Exemption from registration charges, vignettes and toll fees	none	yes	none
Poland	Yes, but capped by 2,000 cubic centimetres in engine displacement volume	none	none	none
Slovakia	Max. charge of €33 for BEV, depreciation of 2 years for BEV and PHEV	yes	none	none
Hungary	yes	yes	yes	Grant of €7,350 or €1,500 in case of gross price of up to €32,000 or between €32,000 and €44,000, respectively

Source: ACEA (2021b)

To date, carmakers are under growing pressure regarding CO_2 emissions limits. In 2021, the emission limit per average car was 95 g per km. If the carmaker does not respect the limits, it is subject to penalties for every vehicle sold. Indeed, the high share of EVs in total sales of the given carmaker can countervail cars' emissions with a combustion engine. Hence the average emission per car is decreased. To conclude, the carmakers with a high percentage of EVs in total car sales are better off (iDNES.cz, 2019). EU member states give additional momenta to the EV market expansion through purchase or tax incentives for EV owners in the form of exemption from ownership taxes of various kinds and road taxes. In 2011, the provisions involved personal income tax reductions, corporate income tax bonuses, cash incentives for purchasing EVs, exemptions from fuel consumption tax, vehicles tax, registration tax, road tax, or company car tax (ACEA, 2011). As of 2021, except for Estonia, which does not provide any stimulus, each EU member state provides either tax benefits or/and purchase incentives related to EVs. The purchase incentives are available in 17 member states in the form of cash grants, bonuses, or cashback, whose amounts vary according to the type of EV purchased. BEVs are mostly preferred and eligible for the higher bonus. Yet the incentive is typically available only for less expensive vehicles, i.e., the eligible list price is capped. The cap ranges from €44,000 in Hungary to €62,500 in Portugal. The tax benefits can be related to the acquisition or/and ownership of private or/and company cars; (ACEA, 2021b). Tab. 4.2 details the situation in V-4 countries.

4.1.4 Product innovation under challenging circumstances

In Czechia, companies have proved a considerable strength in challenging times and adaptability to the changing market conditions. There are many textbooks to teach about competitiveness, but the reality is far more challenging than stated in the lines of a textbook. In many cases, strategic decisions are adopted without knowing the future. Many unknowns are always there that experienced managers do bear in their minds.

We are presenting a case study of a successful company and a leader in their segment that has proven all the necessary skills and capabilities to remain competitive in the changing environment. DURA Automotive is a member of the family of 31 affiliates in 13 countries. The global automotive supplier produces lightweight systems, mechatronic systems, advanced exterior technologies, and technologies for car safety with a strong emphasis on their design, engineering, and development. The multinational employs 6700 employees worldwide and has four production plants in Czechia (DURA Automotive, 2020). These production facilities deliver to VW Group operations and Ford Motor Company operations. Other vital customers of DURA Automotive are, e.g., Suzuki, Jaguar Land Rover, and the Group PSA (DURA Automotive CZ, 2019, 2020, 2021).

The production plant in Strakonice, a town located in the south of the Czech Republic, announced in 2018 the launch of a new product, a battery tray for electric vehicles. The piece of precision has been developed jointly with the Daimler company and needed to complement all weight and safety requirements and integrate with other systems, especially electronics (DURA Automotive CZ, 2019).

After an introduction phase of the new product, the serial production started in the second half of 2020. The company has successfully launched the production in a fully automated working environment employing robots and integrated electronic systems (sensors) to comply with the highest Industry 4.0 standards achieving precision and high efficiency.

Besides product innovation, the company continues to innovate its processes in procurement and IT systems. An effort in achieving and demonstrating the management system's highest standards has been rewarded by obtaining the ISO 14001, ISO 50001 certification, and IATF 16949 certifications. IATF 16949 is the International Standard for Automotive Management Systems based on the ISO 9001 certification and considers the specifics of the automotive sector. ISO 14001 and ISO 50001 norms help manage environmental aspects and optimize energy use to reduce waste, energy consumption, increase efficiency, and introduce sustainable practices. Certifications are subject to regular audits and meet the standards of modern production plants (DURA Automotive CZ, 2019, 2020, 2021).

In this case, we see the continuous effort made to remain competitive in terms of products, efficiency, and corporate social responsibility. The company has developed a new product and announced its launch in 2018. The introduction of the production of the new product was accompanied by investment and expectations. The COVID-19 pandemics, supply constraints, and the development of the demand for EVs in the years to come were unknown.

4.1.5 Targeting investments to increase the value added and competitiveness globally

Valeo is a French world-leading producer celebrating its 100th anniversary of operations in 2023. The global company operates in 33 countries. The company's tremendous growth needs to be mentioned, but we will focus mainly on the product innovations. The company has an established presence in the central European countries and contributes to the added value growth by investing in innovations in this region.

The long path to becoming a global automotive supplier has some critical milestones. The company invested in R&D and registered its patents from the very beginning. The story started with expansion in regions of France. The further international expansion dates back to the 1960s and targeted European countries, establishing new sites in Italy and Spain. Besides developing its premises and research centres, the company grows thanks to acquisitions and take-overs. The company expanded outside Europe in 1980, opening operations in the United States; other countries followed - Mexico 1982, Tunisia 1984, Brazil 1985, Japan 1985, South Korea and Turkey 1988, and India 1997 (Valeo_Our Story, 2022). In 1994 the company entered China, which is now its most important foreign market. The most recent focus of the company is the fast-growing Asian markets (Valeo Case Study by Jacques Aschenbroich, 2020).

During its growth, the multinational did not just extend its international presence but also the scope of activities from clutches and friction materials to heating and air-conditioning systems. The company became a significant supplier of lighting and wiping systems. The long-term strategy encompasses electrical components (spark plugs, alternators, and starters), ignition systems, lighting and wiping systems, security systems, and autonomous and intelligent systems. Consequently, 30% of engineers in R&D are in software (Valeo Case Study by Jacques Aschenbroich, 2020). The global strategy is to develop business in visibility, thermal, powertrain, and comfort & driving assistance systems (Valeo_Our Activities, 2022). The investments in innovations were partly achieved not only by own investment in R&D but also by further acquisitions, partnerships, joint ventures, and investment in start-ups.

Valeo has been present in Central European countries since 1995 when they entered Czechia and Poland. In Czechia, the first operation was in Rakovník, a small town 45 km west of the capital Prague. In 1995, Valeo acquired a major share in the company from Siemens and, in the following year, became the only owner of the plant. The size of the plant has grown over the years, and so has the number of employees steadily increasing. The peak turnover was achieved in 2017. The other production plants are situated in Žebrák, Humpolec, and Podbořany. The newest projects in Czechia are the extension of the R&D centre in Prague, the test track in Milovice, and the extension of the Žebrák production plant with the production of battery coolers for electric vehicles (Valeo in the Czech Republic, 2022).

The company announced the investment into the new production plant for battery cooling modules in Žebrák in 2018 and launched the production at the end of 2019. The battery cooling systems were designed by Valeo and keep the battery at the optimal temperature to ensure its optimal performance and longevity. These cooling systems are designed to be adapted to any electric vehicle – a hybrid, plug-in hybrid, and fully electric. The capacity of the new production plant is over 1.2 million battery cooling modules annually (Valeo_Žebrák, 2022).

The newly developed product combined technological and market opportunities. Companies research and design products which are new either to their portfolio or to the market. Companies can benefit from their prior resources, e.g., prior R&D, sales and procurement network, and production sites. There is a potential to achieve synergies, but at the same time, there is the challenge of not losing efficiency. The risks to be considered include market risks (related to the development of the demand), competitive risks (behaviour of competitors), technological risks (potential technological issues), organizational risks (does the new product require any organizational changes), operational risks (production of the product), and financial risks (considerable investments and uncertain payoffs) (Dodgson et al., 2008). When developing a new product portfolio to serve the growing electromobility market, the company can benefit from the respective expertise it gained.

The case study *Increasing the value by upgrading within GVCs* from Czechia draws a picture of the changing environment and companies' efforts to keep their leading positions in the market. We focused our attention on electromobility, but new technologies are parallelly developing and being tested. Financing and bearing the risk for new product development had become even more difficult in the period after the COVID-19 pandemic when companies were facing the turnover drops, costs increased, and the cash flow management was challenged. Not to lag behind, the national and international cooperation with research centers at universities and other institutions can be further strengthened and joint projects developed. Future research should lead to the use of clean energy sources that would enable the sustainable mobility.

The role of any of the value chain members is not simple. In the case study, we accentuated the role of buyers, because they have to make the "do or buy" decisions. The cases from the past brought evidence that excessive outsourcing leads to supply chain problems and loss of expertise. On the other hand, the producers (such as OEMs) can relieve themselves of, e.g., the operations management or innovations management and share the connected risks with their supply chain partners (Tang et al., 2009). At the same time, besides opportunities outsourcing might create for suppliers, cross-sectoral innovations can place a heavy burden on suppliers. The questions related to innovations, outsourcing, collaboration, and supply chain management with implications for the automotive sector remain unanswered.

4.2 Hungary

4.2.1 Upgrading by domestic-owned automotive companies: The role of business development and quality certificates – the case of Tom-Ferr Plc.

Research on global value chains, discussing upgrading[26] on the example of middle-income, dependent market economies suggests that upgrading is predominantly process upgrading. It is the outcome of local manufacturing subsidiaries' implementing new production technologies and absorbing and mastering production processes, which enables them to increase productivity and operational excellence. Subsidiaries that can demonstrate their production capabilities are gradually delegated higher-level assignments by parent companies, for instance, design, testing, and specific R&D tasks, whereby they also undergo functional upgrading and increase the local value added of their activities. Gradual upgrading ensures a good position to these subsidiaries in the ongoing inter-subsidiary competition for new, future-oriented products.[27] If they are chosen by the headquarters as the manufacturing site, where the new products are produced, this decision entails product upgrading for the subsidiary.

By contrast, domestic-owned companies follow an utterly different upgrading trajectory. In their case, business development and innovation are the key drivers of upgrading: it is new business opportunities that entail product and process upgrading – and sometimes chain upgrading as well.

This latter trajectory is exemplified by the development of Tom-Ferr Plc., a family-owned Tier 2 automotive supplier. Tom-Ferr, founded in 1994, is specialised in the manufacturing and wholesale of seamless and welded precision steel tubes and other steel products.

[26] The concept of upgrading concerns the ways countries, regions and firms increase the value added of their activities to improve their positions within global value chains (Fernandez-Stark and Gereffi, 2019; Gereffi, 1999). Humphrey and Schmitz (2002) identified four types of upgrading at the firm level. These include product upgrading (moving to higher-value products); process upgrading (improving the efficiency of the production process by introducing process innovations); functional upgrading (moving to or diversifying the activity mix with activities the value added content of which is higher than previously); and chain upgrading (moving to new industries and/or entry in new value chains).

[27] For example, a local manufacturing subsidiary specialised in manufacturing steering wheel components reported (to the author of this case study) that as a result of a decade long efforts to demonstrate its production capabilities and technological capabilities, the subsidiary could co-evolve with the parent company regarding the ongoing advances in steering technology. Starting with the manufacture of mechanical and hydraulic solutions, later, it managed to obtain responsibility for manufacturing electrically-assisted solutions.

Over the 1990s and the 2000s, due to the foreign direct investment-driven massive expansion of the automotive industry in Hungary, Tom-Ferr had more and more automotive customers. From the point of view of safety, high-strength precision steel tubes are key components in a vehicle, since they account for crash absorption, acting as passive safety devices. Apart from their structural role in vehicles, acting as shock absorbers and accounting for stability (e.g., cross car beams), these tubes are used in a variety of other automotive parts, such as airbags, seats, and wiper systems.

Although Tom-Ferr's wholesale business was characterised by stable growth, which was partly due to the limited number of competitors, there were signs of changing demand patterns, prompting the owner to invest in upgrading and expanding the activity mix to suit future trends. Automotive customers recurrently signalled their demand for *processed* steel tubes, requesting, for example, tube end machining. Responding to customers' requirements Tom-Ferr has gradually diversified its processing services, including cutting, cold forming, bending, milling, welding, and CNC machining.

Obviously, the diversification of the manufacturing services required investments in advanced production technology, such as CNC-controlled precision cutting and pipe bending machines, and a fully automated machining centre. Altogether, process upgrading at Tom-Ferr was going on continuously, aligned with the rapid technological progress the industry itself has been undergoing. Examples of this co-evolutionary process include Tom-Ferr's investment in laser processing equipment, welding robots, and the purchasing of a new measuring equipment enabling 3D measurement[28] of its products. Most recently, this co-evolutionary process is epitomised by a fully automated new production plant equipped with advanced industry 4.0 solutions (with cyber-physical systems capturing and automatically processing data on practically all production process parameters) that ensure full process transparency and operational excellence.

This process development was indispensable for introducing a range of new products manufactured according to customers' specifications. The increasing weight of automotive components within Tom-Ferr's product mix prompted an organisational change: in 2008, a new (automotive) division was created.

Since return on investment in advanced technological solutions is ensured only if demand for the company's products is stable or rather expanding, Tom-Ferr's marketing and sales department redoubled efforts to expand the customer base. As a Tier2 supplier it can acquire large OEM customers (including Suzuki, Volkswagen, or Daimler) through Tier 1 suppliers, such as Toyo Seats or Kirchhoff (in 2018, Tom-Ferr was chosen the global supplier of the year by Kirchhoff).

[28] The measured valued can be compared to the 3D model of the component and deviations are identified automatically.

As of 2015, Tom-Ferr initiated a marketing offensive to acquire new customers in established western European markets and diversify its stable domestic and south-east European customer base. This latter is served mainly by Tom-Ferr's marketing and sales subsidiary in Serbia, established in 2005. In the framework of the marketing offensive, Tom-Ferr improved its website, prepared professional marketing materials, diversified its marketing channels, including various social media platforms, and most importantly, started to regularly participate in international automotive trade fairs and B2B exhibitions.

One of the critical conditions for acquiring customers in the automotive industry is possessing the necessary quality certificates. The most recent quality standard published by the International Automotive Task Force is IATF 16949. It includes several technical specifications regarding operations, quality management, and related processes. Accordingly, automotive companies have to possess proven and thoroughly documented processes that ensure operational perfection and guarantee the traceability of any error. Every step of the manufacturing operations has to be precisely defined and documented in this vein. For instance, companies have to be able to present the documentation of their production planning and capacity planning methods, their approach to maintenance management, their product testing and part approval processes, and they have to provide documentation of how the root causes of errors are analysed and identified. The newest version of IATF 16949 also includes prescriptions concerning the companies' supply chain management and risk management processes. One of the most important new requirements is that each tier controls its own suppliers: be able to audit them and propose adjustments for the improvement of suppliers' processes.

Accordingly, apart from providing all the necessary documentation on how it can guarantee that customers' complaints are effectively addressed, Tom-Ferr needs to be able to demonstrate how it manages its own complaints and risks, if, for instance, its own suppliers deliver defective items or if their deliveries are delayed. For this sake, it has to formally evaluate internal and external risks, and elaborate a risk mitigation strategy, make relevant organisational changes, devise new key performance indicators, and upgrade the training of the staff.

Evidently, these actions required a *cross-functional approach*, which has generated positive changes in organisational culture. The manager interviewed underscored that Tom-Ferr's becoming an IATF 16949:2016 certified supplier has definitely added to the professionalism of the company's processes.

The far from an exhaustive list of requirements of an IATF 16949 certificate suggests that complying with the new quality standards, i.e., with all the technical, organisational, and process-related specifications, is nowadays *the key driver of automotive companies' functional upgrading*.

Tom-Ferr's efforts to obtain the new IATF quality certificate have given rise two further notable developments. The first one is the implementation of an enterprise resource planning system – necessary for enhancing control over all processes and business functions. It goes without saying that ERP implementation, itself, requires and drives learning and results in upgrading across all business functions.

An even more important development was Tom-Ferr's opening of a steel tube manufacturing plant in 2019, motivated by the aim of securing supplies. The decision of Tom-Ferr's owners to increase the vertical integration of production by taking on upstream activities is a strategic move that can be referred to as *chain upgrading*.

Altogether, Tom-Ferr's case demonstrates that the drivers of the upgrading of domestic-owned companies are different from those of global companies' local manufacturing subsidiaries. Moreover, their upgrading trajectory is often longer and more diversified than that of captive subsidiaries.

4.2.2 Gearwheel Factory

Fogaskerékgyár Ltd. (Gearwheel Factory) is a typical domestic-owned company, established nearly 30 years ago, in 1992. It is owned by three Hungarian private persons and has 60 employees (2019). Its turnover was EUR 2.5 million in 2019. Export accounted for nearly 10% of sales. Since the main profile of the firm is designing, manufacturing and repairing drive gears and manufacturing drive-technical elements, sales are project-based,[29] that is, the company does not manufacture in long production runs. Consequently, the company abstains from participating in the pure cost-based competition:[30] its value proposition rather concerns quality and is based on decades-long knowledge accumulation in design, engineering, and repair-related issues.

The company has two manufacturing plants in Tata and another in Budapest, in Csepel (both are established industrial regions). Additionally, it has an engineering office in Budapest.

The customers and business partners of Fogaskerékgyár are very heterogeneous. As the manager interviewed put it, *"we are suppliers of almost the whole Hungarian industry"*.[31] Consequently, automotive supplies account for a minor share of total sales, even if the industry is considered broadly, including

[29] The fact that the company specialises in individual and specially designed products accounts for the volatility of sales and export ratios. In 2018, for example, export accounted for 30% of sales.

[30] The manager interviewed recounted a story to substantiate this claim. A global automotive supplier with three manufacturing plants in Hungary, specialised in assembling axles and drives, inverters, sealing products etc., contacted them requesting a quote for specific gearwheels. It turned out that the potential customer was very rigid concerning the prices it was willing to pay. As the manager interviewed said, it was not a Chinese but rather a Vietnamese price level they had in mind. The company interviewed did not sign the contract. Although competition in this field is quite intense in Hungary, the global company has been unable to find a supplier since it recently opened a fourth manufacturing plant in Hungary, specialised in manufacturing drive system components (e.g., drive gears) for internal use.

[31] Gear drives are important components of the production equipment in practically all industries. Accordingly, Fogaskerékgyár supplies mill and furnace drives for the cement industry, extruder drives for the plastic industry, mill drives for the paper industry, crane drive gears, conveyor drives, agricultural drive gears, and so forth.

heavy duty vehicles manufacturing firms, such as Rába, public transport companies, such as the one serving the transport of Budapest (Fogaskerékgyár delivers components to funiculars and undertakes repair and retrofit work for the company), and the Hungarian Railway Company.

By contrast, except for some services provision,[32] Fogaskerékgyár's supplies to automotive OEMs are *indirect*, since the company has not obtained the quality certificate necessary for direct automotive supplies. (Although Fogaskerékgyár obtained an ISO 9001 quality assurance system in 2003 and it and regularly renews it since then, this is not sufficient for being entitled to supply automotive OEMs directly.) Accordingly, it happens from time to time that a certified supplier of an OEM is entrusted by the OEM to design an auxiliary equipment performing certain tasks at a production line, and the certified supplier would then prepare the design and outsource the manufacturing of the given special-purpose machine to Fogaskerékgyár.

Upgrading for the company refers mainly to new technology implementation, enabling, for example, precision CNC machining, 3D printing, and/or particular measurement and testing. Since purchasing new kinds of special machinery requires massive investment, the company regularly submits applications for public subsidies aimed at promoting SMEs' technological upgrading.

One of the most recent automotive-specific programmes Fogaskerékgyár managed to participate in, is the so-called Complex Innovation Programme for creating jobs in the Pons Danubii region. This programme is a cross-border one, funded by INTERREG. The Pons Danubii region includes the twin cities in Slovakia and Hungary: Komárom and Komárno, as well as additional neighbouring cities, such as Tata, Oroszlány, Kolárovo, Hurbanovo and Kisbér. This region hosts a surprisingly large number of car manufacturing and automotive component manufacturing plants. According to a complementary interview carried out with the head of the employment office of the government office of Komárom–Esztergom County, there are more than sixty notable automotive companies in the Hungarian part of this cross-border region.

The INTERREG programme aimed to promote the upgrading of the automotive sector in this region and enable automotive stakeholders to respond to the paradigm changes this industry is facing in innovative ways, e.g., by developing new products and providing improved training to the workforce. Altogether, the programme envisages the creation of high value added jobs in this automotive region.

The role of Fogaskerékgyár in this programme is to host an 'innovation laboratory', that is, a shared development centre for regional SMEs. The company received subsidies to purchase a 3D printer, equipment for advanced material

[32] Examples include the modification or reconditioning of machine tools for OEMs, e.g., to make them suit the production tasks related to new products manufacture.

analysis, and a CNC machining centre – to be used for the design, preparation and testing of prototypes.

As the manager interviewed explained, if an SME has a new product idea, it can rapidly turn this idea – shown initially only on paper – into a fully-fledged product, or rather, a prototype. Product design is helped by a CAD design programme (also purchased in the framework of this project), allowing for testing and modifying the concept, and fixing any emerging problems virtually. Next, the innovator SME can move on, to CAM (computer-aided manufacturing) by feeding the relevant software programme into the CNC machine or the 3D printer.

This prototype development and testing is too expensive to be affordable for individual SMEs. This INTERREG project started only recently, consequently, there are no entrepreneurial success stories yet. Fogaskerékgyár was willing to host this laboratory in the hope of getting access to these services easily. It was also hoping that it can find new collaboration partners among the participating entrepreneurial SMEs. At the same time, the company also hosts a dual education workshop equipped with virtual technology for trainees. The INTERREG programme also funded this latter workshop.

Although government support programmes subsidising the implementation of advanced manufacturing technology, and the aforementioned INTERREG programme provide non-negligible support for upgrading, these programmes tie up a lot of Fogaskerékgyár's resources. Consequently, in order to avoid the well-known trap of an excessively rapid expansion of assets, the management of the company decided to 'slow down' and focus on better absorbing and mastering the new technological solutions before initiating further expansionary projects.

Nevertheless, the company has several further strategic objectives, each of which involves upgrading. The first one is implementing an enterprise resource planning system to calculate costs and expenses better – also in terms of working hours and machinery capacity. Furthermore, an ERP system is expected to improve capacity planning and enable greater transparency of the state of affairs.

Another medium-term objective is to complement the company's current manufacturing and engineering services portfolio with products characterised by larger batch sizes. According to the manager interviewed, this will require changes in the production equipment, organisation and modification of the corporate culture. *"Large-scale manufacturing is completely different from what we have been doing so far. It requires a different managerial approach and different ways of working, not only in production but also in support functions. Consequently, we will organise this activity into a separate division."*

This latter strategic step will be interesting to investigate utilising longitudinal research. Suppose this strategy turns out to be successful. In that case, the case could demonstrate that upgrading is possible not only by shifting from relatively low value added, scale economy-based mass production to fully customised and high value added activities but also the other way round, by diversifying towards larger batch sizes.

4.2.3 Effects of COVID-19 – Continental Automotive Hungary

The disruption of supply chains causes a large-scale problem. Shortage of semiconductors (from Asia) is the main issue, but the transportation of plastic parts is also a challenge. Most products include several components, so if a delivery does not arrive, the given production line will stop or be suspended. There is a product, for example, that consists of three thousand parts, so the supplier system is quite fragile. This has serious financial consequences because the deliveries usually come in the Just-In-Time (JIT) system only a day before, so if no parts are arriving, the workers have to stop. Still, they are getting paid the same way.

Despite the problems of supply chain disruptions, finding another supplier is not a short-term issue. Most supplier contracts are 10-15 years long and include joint product development. The company looks for an alternative supplier only if there is a long-term supply difficulty, otherwise suppliers have no alternative. If multiple manufacturers can provide specific components, the company relies on various sources of supply anyway.

The supply and demand shock caused a downturn at Continental Automotive Hungary between February and August 2020. Subsequently, orders from OEMs gradually increased to previous levels. The company’s goal was to avoid layoffs and retain its workers thanks to emergency state government assistance. In 2020 and 2021, Continental received the so-called state aid for employment in reduced working time for maintaining jobs for both blue-collar (assembly line workers) and white-collar (R&D) employees. The Hungarian subsidiary does not take loans. Through the company's network of contacts / suppliers, the interviewee found that large companies reacted better than SMEs to the situation of large companies, both in terms of specific measures and financial solutions.

The company has introduced standard virus protection measures to reduce the number of contacts and locate infected workers. For office workers, the home-office was preferred. A decision-making group was set up under the direction of the parent company to develop and coordinate COVID protection strategies. Anti-COVID measures only transformed the work environment, not affecting production and not reducing work efficiency. Measurable quantitative and qualitative indicators did not deteriorate. There is no public data about the infected employees or whether there were any interruptions due to the illness of the workers.

The pandemic did not change the JIT system, because the supply chain is designed for continuous production. There is a strictly scheduled production, where the suppliers have no capacity to produce more or to produce for storing. There are initiatives in the industry, mainly by OEMs, towards suppliers to increase their storage capacity, but this also raises severe financial issues as it requires significant financial resources from suppliers.

At the same time, COVID did not cause any price increase for the products or the parts supplied, i.e., there is no detectable change on an annual basis. In the case of emergency delivery, however, this may arise. The main reason for price stability is that there is strong pressure in the system against price increases.

The pandemic has accelerated quite a few processes and new factors emerged in terms of production. Reducing dependence on markets and workers had begun long before the pandemic, so the effort is not new. At the same time, automation, the long-term reorganization of the supplier market, home office, the spread of the virtual environment and digitalization accelerated because of the virus. There is also the diversification of the supplier market and the emphasis on locality, but in addition to the advantages, localization has a number of disadvantages that need to be considered.

Employee needs have also changed, which seems to appreciate the work-life balance. The issue of physical and mental health has become much more important, and the flexible work system of the home office has also come to the fore.

Based on the interview with Head of HR and Head of Plant Industrial Engineering, of the Continental Automotive Hungary May 14, 2021

4.2.4 Schwarzmüller Vehicle Construction and Trading Ltd

The Germany-based Schwarzmüller group founded its first “eastern” trading company in Hungary in 1989. This was followed in 1993 by the construction of a manufacturing plant in Dunaharaszti. Since then, as a result of several stages of development, the company has become a vehicle factory covering the entire production process and a strategic producer of its group. Currently, the Hungarian factory is the largest in the group (there is also one production plant in Czechia and another in Germany). Here, flatbed semi-trailers are mainly produced for long-distance freight transport.

The company has more than 600 employees, almost 400 of them in the production unit (assembly). The company has piece production (i.e., not a mass production), with significant consumption of raw materials and labour-intensive input. As a result, the most significant costs and expenses are material ones. The materials are mostly sourced from EU countries (Austria, Germany, Czechia) and to a lesser extent from Hungarian suppliers. The company’s procurement system is centralized, the parent company provides the raw materials, parts and components needed for production through long-term contracts.

In 2020, due to increasing market competition, economic difficulties and due to the COVID-19 pandemic, the company’s sales volume decreased compared to previous years. According to the financial report for 2020, revenue was 9.4%

lower than in 2019. In 2020, the sales revenue of the productive activity accounted for 96%of the total revenue. The company produces largely for export, with export sales accounting for nearly 70 percent. The main markets are Austria, Germany and Poland.

During the pandemic, the company's most serious problem was the shortage of raw materials (steel), supply chains came to a standstill, which significantly jeopardized the production. Procurement was centralized; therefore, the Hungarian subsidiary did not have the opportunity to look for alternative sources of procurement. In the case of steel products, demand is dominated by China and the US, therefore supplies to other countries are pushed into the background. To prevent supply chain disruptions, the company does not have the ability to stockpile / accumulate. This would require a storage capacity that is not available to the company.

Workers who fell out due to COVID-19 disease accounted for 10%of the total workforce. The company has introduced standard virus protection measures, for office workers, the home-office was preferred. Anti-virus measures (social distance, sanitation) slowed down the assembly and caused an efficiency problem for the company.

The interviewee thought, that the COVID does not cause profound long-term changes in the operating environment of companies, either in the supply chain or in the way they work. At the same time, the (negative) impact of the crisis on domestic SMEs will only be felt in the longer term. Domestic companies differ in liquidity (cash) from companies owned by foreign investors with substantial capital.

Due to the company's unique production, which is a labour-intensive process, the introduction of robots for mass production is limited. Still, the company tries to automate every work process that is possible. The first automatic welding robot was introduced in 2019. The pandemic amplifies this automation process.

The company resolved the decline in production due to COVID-19 partly through layoffs and compulsory leave. The number of redundancies was determined on the basis of performance. The Hungarian subsidiary did not take loans and public job retention assistance during the pandemic period.

As a result of the COVID, there is a significant price increase in this sector. Steel prices have been rising by more than 50 percent in the past year, and shipping costs for containers from China have more than quadrupled. Not only the price of raw materials but also of products has been rising. Due to the increase in demand in the freight transport sector, there are encouraging forecasts for both revenues and the workforce in the coming period.

Based on the interview with a HR department employee of the "Schwarzmüller Járműgyártó és Kereskedelmi Kft" 14 July, 2021

4.2.5 Private Hungarian owned automotive Tier 1 company

The Joint Stock Company was established in 1989 by some former engineers of a ceased state-owned company specializing in the manufacture of aluminium castings. The company first transformed into a limited liability company and later changed to a closed joint stock company.

The company is owned by Hungarian private individuals, employs about 1000 people and has three production plants. The headquarter is in Budapest. To serve the growing customer needs, the enterprise had to increase its production capacity; therefore, in 2014, it opened its first greenfield investment near Budapest. A few years ago, a third production plant was set up in eastern Hungary. The main product of the firm is engine brackets for automotive companies. A number of new activities have expanded the company's range of activities since its founding. Currently the company has three main activities: aluminium die casting, machining and assembly. Besides these, there are supporting activities such as mould design and mould production, innovation and predevelopment, and testing. The company supplies automotive OEMs and first/second tier suppliers. The main partners are BMW and Volkswagen.

The crisis and the long-standing stagnation of the car industry hit the company hard, with net revenues 27%lower in 2020 than the previous year. Exports account for 93%of revenues, with Germany and Austria being the company's main markets. In 2020, there were no changes in the main markets and partners.

COVID-19 has not caused any disruptions in the company's supply chain, and the current shortage of raw materials is not a problem, as orders are also down. The epidemic and the significant increase in raw material prices have also affected the price of their products. A substantial part of the product prices is the raw material, which can be claimed from their contracted customers within a few months. The shortage of semiconductors has caused production losses for customers, which also affects the company.

There was a 10%loss of employees due to sickness. The company has introduced standard virus protection measures (masking, disinfection, testing, isolation), an inoculation point has been set up, and a 3–4-day home-office work period has been introduced for white-collar workers. The company did not take any loans, and in 2020 it applied for a state subsidy and a wage supplement for R&D staff.

The company has made minor changes to manage the supply chain. The enterprise has been "multi-supplier" in its strategic sourcing, sourcing from multiple suppliers in parallel. Therefore, they have not seen the need to seek alternative sources of supply and partners. Due to the increase in raw material prices, they have built up more extensive aluminium and have also brought forward their orders for steel for tooling.

The 2021 orders represented only 60-70% of their capacity. Nevertheless, they had no plans to reduce workforce because in case of order volume increase, the company would not be able to hire workers on time or with the required quality. Because the current situation mainly affects the car industry, but not other sectors, their workers, especially in Budapest, could easily find employment elsewhere and are unlikely to return.

The intensity of cooperation with partners increased as a result of the epidemic. There is constant consultation with suppliers on expected deliveries and price changes. Their customers are also trying to keep the company informed of expected changes. In the case of production, they have built up a large stock of finished products in preparation for the sudden call-off of large quantities by customers.

The Case Study was made based on the interview with the Head of Finance and Accounting on October 29, 2021

4.2.6 Bus manufacturer: expanding the product mix and upgrading

Facing compressed and declining margins, the owner of a Hungarian bus manufacturer decided to venture into the electric city bus business.

This company, once one of the largest bus manufacturers in the world, is currently medium-sized and in domestic-ownership. In 2019, the number of employees was 124, and turnover amounted to EUR 8.7 million (100 % domestic sales).

The owner's decision to diversify the product mix and develop electric buses was motivated by a perceived strong 'tailwind', promising a rapid improvement of business performance in a growing market.[33] It is no surprise that there have been multiple foreign direct investment (FDI) transactions in the V-4 countries over the past couple of years, by investors establishing plants specialised in the manufacturing of electric buses and components. Examples include BYD in Hungary[34] and MAN in Poland[35]. Domestic-owned manufacturers have also entered the electric bus business (e.g., SOR Libchavy in Czechia and Solaris in Poland (Solaris has been acquired by the Spanish company CAF), since the market for electric buses is characterised by considerably higher profit margins than the market for diesel buses.

To overcome its technical deficit in electric powertrains, the case company created a joint venture with a Chinese electric bus manufacturer, and developed

[33] On one hand, strict European emission standards and the EU's Clean Vehicle Directive drive the growth of the market (according to the Clean Vehicle Directive, a minimum of 22.5% of all new buses ordered in 2021 across Europe will have to be zero-emission ones). On the other hand, generous government subsidies promote the adoption of electric buses. In 2019, 112 electric buses were manufactured in Hungary (https://autopro.hu/gyartok/negyedevel-nohet-iden-a-magyarorszagon-gyartott-elektromos-buszok-szama/370561)

[34] https://www.automotiveworld.com/news-releases/byd-opens-hungary-electric-bus-factory-targeting-400-year-capacity/

[35] https://www.electrive.com/2021/03/29/man-to-begin-articulated-e-bus-production-in-poland/

the prototype of an all-electric bus. Although the new bus was based on a Chinese licence, this undertaking required considerable capability accumulation, since it had to be redesigned to obtain the necessary approval of the prototype. In order to achieve 50% local content, several components had to be replaced by European ones, the integration of which required additional development work.

Digital technologies have had an important role in the product development process, especially simulation software, digital documentation and document sharing solutions, and digital solutions enabling concurrent engineering.

Building on the synergy effect stemming from the complementary capabilities of the Chinese and the Hungarian partners in the joint venture, the development and the certification of the prototype took less than two years for the joint venture. However, irrespective of the significant production capacity at the Hungarian location and a marked growth of the local market for electric buses, the case company still has to struggle with commercial hurdles.[36]

Although the company was aware of the fact that developing electric buses is a high-risk undertaking even in a high-growth[37] market, since there are already several established players, and competition is rapidly increasing,[38] the owner had high hopes in the recently launched Green Bus Programme of the Hungarian government. This programme envisages the replacement of the municipal diesel bus fleet by electric buses in all Hungarian cities with a population of above 25,000. The government earmarked subsidies of EUR 100 million (over a period of ten years) to support this objective. Consequently, a series of pilot demonstration projects started in various Hungarian cities – projects that precede the launching of public procurement tenders.[39]

Apart from the performance of the prototypes tested during these pilot demonstration projects, bus companies and municipalities will have to weigh a range of other considerations. One issue is the purchase price of electric buses, which is 150% of a conventional diesel bus. The total cost of ownership is influenced, among others, by the number of subsidies, maintenance costs (compared to those of diesel buses), the range the electric bus can deliver on a single charge, and by the availability and price of chargers.

[36] A quick review of the business press reporting about recent purchases of electric buses by Hungarian cities and transport operators indicates that these stakeholders have opted for foreign manufacturers, such as MAN, Mercedes, and Solaris, or BYD (the Chinese company with a manufacturing plant in Hungary) and not for the buses of the case company.

[37] Notable in this respect is the fact that the market for electric buses is highly concentrated. By 2019, there were over half a million electric buses in use around the world. However, 98% of them were located in China, and only 4,500 in Europe (Amstrong, M. (2021). China Charges Ahead With Electric Bus Rollout. https://www.statista.com/chart/24462/electric-bus-stocks-by-global-region). Poland is the largest market within the V-4, with 430 registered electric buses in 2020 (https://www.statista.com/statistics/1081362/poland-number-of-registered-electric-vans-and-trucks/).

[38] According to Statista (Electrification of public transport report, 2019), in 2019, the number of electric bus manufacturers was 26 in the world.

[39] The case company participates in one of the Green Bus pilot demonstration projects, to test its newly developed electric bus in a large Hungarian city.

Buses are expected to be charged overnight at the depot or at the terminal station. However, since the range battery electric buses (BEBs) can deliver is lower than the distance these buses have commute a day, BEBs need to be recharged during the daytime. Furthermore, few bus companies have the necessary charging capacity at their depots, which is the most-difficult-to-overcome barrier for bus companies and municipalities in Hungary. The main problem is grid capacity: creating the necessary technical conditions for charging several buses simultaneously may take several years and involve prohibitive costs.

Therefore, if electric bus companies want to sell their products at the Hungarian market (in this respect, the situation is similar also in other countries), they have to diversify into developing and installing chargers for their buses. For example, when BYD delivered ten e-buses to public transport operator Tüke Busz in Pécs (a city in southern Hungary), it also took on the responsibility for designing and installing a charging infrastructure for these buses.[40]

Having recognised this imperative, the surveyed company decided to engage in developing a smart charging solution to be able to compete with a 'full package' solution. Development of a high-power DC fast-charging station involving e-bus batteries that can store and discharge energy started in 2020. This solution can also integrate alternative energy resources, e.g., solar power. Battery storage adds flexibility to the system by enabling it to avoid the prohibitive costs of peak hours charging.

The prototype of the charging solution is expected to be completed and certified by the end of 2021. Although the company has contracted German and Chinese R&D services providers for this project, the lion's share of the work is performed internally. For this sake, the company increased its headcount of software developers and engineers by more than twenty high-skilled employees.

According to the project manager interviewed, although charging stations are rightly considered tangible products, the dominant part of the related development is software development, including charging management, monitoring and control, and load balancing.

The software intensity of electric bus and charging station development conveys significant upgrading opportunities for the company in question. Software represents higher value added than manufacturing mature products.

In summary, the diversification of the company's product mix and the shift to electric bus production have not only enhanced its resilience in a rapidly transforming industry but have also entailed various upgrading opportunities. The case illustrates how *product upgrading* elicited *chain upgrading* (in terms of chargers) and *functional upgrading*. New, high-value activities include the

[40] https://www.automotiveworld.com/news-releases/byd-completes-ebus-fleet-delivery-to-pecs-in-hungary; In a similar vein, when Solaris delivered five electric buses to the Polish city of Opole, it also delivered and installed charging equipment, e.g., three plug-in charging stations for the depot. https://www.electrive.com/2021/03/29/opole-oders-5-solaris-e-buses-charging-equipment/. A similar full-package business transaction was recently reported in Paks (Hungary) where Solaris delivered ten electric buses along with charging infrastructure. https://hvg.hu/gazdasag/20191121_paks_elektromos_busz_beszerzes

management of the joint venture and the new product related open innovation activities; the monitoring of the global market for identifying component providers and technology providers; and the expansion of in-house software development activities. The manager interviewed also made reference to *process upgrading,* involving the automation of specific manufacturing processes and the procurement of welding robots. Last but not least, notable is the upgrading of the product development process, achieved through integrating smart digital solutions that can augment engineers' work.

4.3 Poland

4.3.1 Can Chinese intermediaries be replaced by the components produced in Poland and other Visegrad countries?

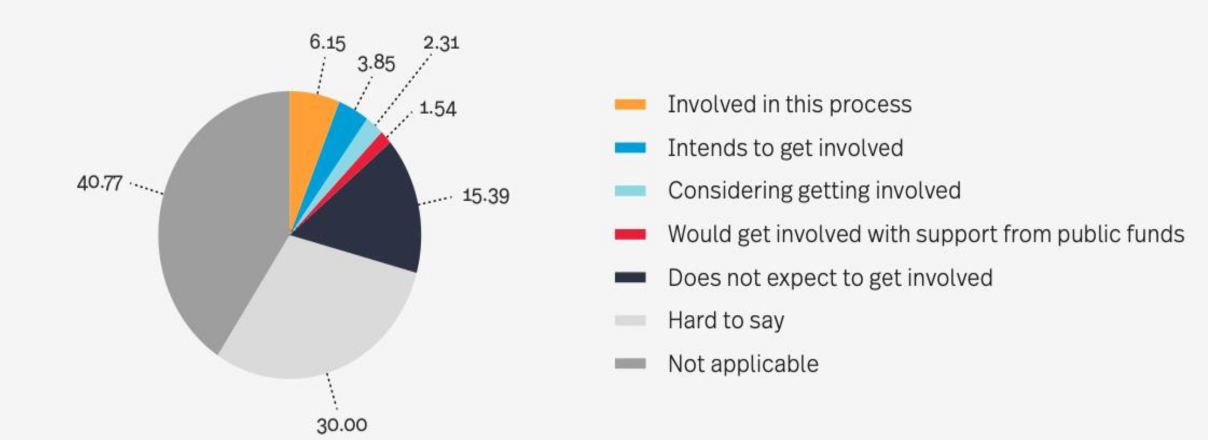
The outbreak of the COVID-19 pandemic has triggered an intensive debate about its impact on businesses and international production networks, such as the automotive sector, which constitutes one of the leading supply chains in Europe, especially in the central region. Supply shocks caused by labour unavailability, lack of natural resources, and difficulties in transport organization have strongly affected manufacturers in the automotive sector in Europe. It also strongly influenced Polish manufacturers. Nevertheless, these results are not only seen in reduction of outcomes due to the lockdowns and lack of resources or disorganized transportation links. Polish producers may also be affected by an impact of the pandemic on Asian economies in terms of international trade and division of labour. To secure smooth supplies in strategic sectors, the authorities of many countries considered that the concentration of production in one place (for instance, in China) is too hazardous (Leonard, 2020). Therefore, the enterprises were attentive to reorganizations in their supply chains. As a result, the new GVCs were expected to be established away from China - primarily in Japan, the US, and the European Union. Poland was supposed to be one of the countries to gain from reconstruction of the global value chains (*Czy pandemia koronawirusa zrewolucjonizuje globalne łańcuchy dostaw i handel międzynarodowy?*, 2021). Despite these expectations and the announced tendency to shift supply sources out of distant Asian locations to sites much closer to factories in Europe, the effects of the pandemic on Polish automotive manufacturers are not yet as apparent as may be expected.

According to Polish Economic Institute (PEI), in May 2020, Poland could gain up to $8.3 billion each year as global value chains shift away from China. Moreover, Poland would be the biggest beneficiary of this change in Europe. The benefits would result from more significant domestic production of intermediate goods once outsourced abroad and – together with other Eastern European countries – taking over the production for the entire EU. The PIE report lists some other CEE countries which may benefit from shifts in GVCs. Czechia has a gain of $4.9 billion in Hungary and Romania, which gains respectively $2.7 billion and $2.6 billion.

Due to the pandemic, the redesign of automotive production organizations took place worldwide (Wilczek, 2020). Similar conclusions may be drawn from a blog entry made around the same time by an economist at Poland's largest bank PKO BP (Czaplicki, 2020).

In July 2021, the optimism about Poland's growing role in the GVCs waned a year later. Some 6% of the Polish enterprises surveyed by the PEI admitted that they were participating in the supply chain shift from China. In comparison, 15% of the respondents did not expect to be involved in the relocation of production from China and almost 41% perceived that issue did not apply to them – see figure 4.3.

Figure 4.3 Polish companies' attitude to the relocation of supply chains from China by international corporations (%), July 2021



Source: Ambroziak et al. (2021), p. 38

The PEI survey indicates that the COVID-19 pandemic has not changed GVCs forever. It may have just disrupted formerly established cooperation links. Even though many companies announced their plans to shift production from China, there were few such rearrangements. There was also no mass relocation of production to Poland or other CEE countries.

The recognition if a change of GVCs is possible and which countries may take the position and role of China in previous cooperative networks depends on multiple factors. Firstly, economic factors affect the profitability of business endeavours undertaken in China or emerging economies. On the other hand – these are geopolitical factors.

Industrial manufacturing in China has been attracting a massive inflow of foreign direct investment (FDI) for years. The FDI was in China because of lower labour costs than in investors' home countries, the availability of natural resources, especially raw materials, and the size of the domestic market. Geopolitical motivations also explain China's critical role in global value chains, especially in the manufacturing sector. The way China was treated in the

European and the U.S. strategies in the past decades is illustrated by the "Dell hypothesis" concept. According to that approach: "No two countries that are both parts of a major global supply chain, like Dell's, will ever fight a war against each other as long as they are both parts of the same global supply chain". This concept has been generalized by Thomas L. Friedman to "McDonald's theory of international relations". No country in which McDonald's operates will ever attack the (other) country in which McDonald's is located. It is based on the conviction that participation in the global value chain is an expression of the integration of the domestic economy with the global economy and of cultural openness, which determines the economic unprofitability of war.

The western countries also hoped that thanks to gradually expanding cooperation with Chinese corporations, "western values" would be spread in China. Both the period before the pandemic and, even more, during the pandemic revealed that this plan did not work correctly. First of all, China has become more authoritarian. Chinese strategic plans (e.g., the Belt and Road Initiative) have complicated its market, with Chinese companies in many sectors overtaking production so far limited to European or American companies. Secondly, the behaviour of China during the pandemic revealed that the country is not a reliable global player (Leonard, 2020).

We may conclude that now the geopolitical determinants should not influence companies' decisions about substituting China with other partners within GVCs. Moreover, the lesson from the ongoing war of the Russian Federation against Ukraine is that even if there are some economic benefits in individual cases (as in the case of Russia – purchasing "cheaper" gas and oil), the total costs of maintaining close trade and production relations with some countries should be judged in much broader perspective (for example, infringement of intellectual property rights in China significantly increases total transaction costs). As the research of the World Bank indicates, countries that are deeper integrated into GVCs, have quicker recovery after a crisis (Brenton et al., 2022). Deepening integration within GVCs is a reasonable strategy for many states seeking the drivers of development themselves. Despite some concerns raised in the literature that strong integration within a GVC increases exposure to risk (Baldwin & Freeman, 2021), other empirical studies provide the opposite evidence (Brenton et al., 2022; Borin et al., 2022).

If appropriate economic policies are introduced (Drelich-Skulska et al., 2021) (including the growth of awareness of interlinkages both within a domestic economy and externally), Poland might benefit from the reorganization of GVCs globally. Poland's active participation in global value chains in electromobility has established the country as being a prominent producer and exporter of electric buses and the largest exporter of lithium-ion (Li-ion) batteries in the European Union (Ambroziak, 2021). Poland's unique central European location has supreme access to major European networks in automotive production networks. There are over 60 li-ion battery-related manufacturing plants. After Germany and

Italy, it locates Poland as the third producer in Europe. The country had supplied 40% of the total production in Europe in 2019.

Except for the batteries, there are numerous domestic and world-leading upstream and downstream suppliers for the automotive sector (more details see chapter 3.3).

4.3.2 What does the statistical data tell us about changes in GVC during a pandemic? – some insights on misleading assumptions

Since Germany is one of the biggest exporters (and participants in global value chains) and the significant economic partner of the V-4 countries, we analyse the origin of value added in German exports before (2015–2019) and during the first year of the pandemic (2020). Unfortunately, the statistics concerning the year 2021, have not been available yet. We treat this case as a good lesson on avoiding making too hasty conclusions.

In 2020 the share of foreign value added in German exports (of all goods and services) was lower than a year before – 28.15% vs. 32.63% (see Table 4.3). The reason for such a difference is most likely the COVID-19 pandemic. As soon as lockdowns were announced and limited international trading relations, the domestic intermediaries straightway replaced the foreign components. However, the share of foreign value added in 2020 was higher than shares in 2015 and 2016, so the decrease was noticeable but not as spectacular as expected. If the share of foreign value added in 2020 were 5% or 10%, the solid negative shock caused by the pandemic would be the most probable explanation. Thus, they can be other reasons for an unimpressive decrease in 2020. We suppose that some newly established German companies have started offering components. There might also be a case that formerly existing companies had developed their activities before the pandemic and, in 2020, have been able to supply necessary output to their domestic partners. As a result, some German companies reduced the imports of the components.

Table 4.2 The foreign value added in German exports (of all goods and services) during 2015–2020, top countries in 2020

Value added sourcing country	2015	2016	2017	2018	2019	2020
People's Republic of China	1.94%	1.84%	2.16%	2.57%	2.53%	2.41%
United States	2.47%	2.32%	2.53%	3.06%	2.82%	2.33%
France	2.18%	2.10%	2.58%	2.66%	2.22%	2.09%
Netherlands	1.23%	1.14%	1.68%	1.94%	1.94%	1.80%
Switzerland	1.03%	0.93%	1.00%	1.05%	1.57%	1.56%
United Kingdom	1.72%	1.52%	1.61%	1.95%	1.92%	1.50%
Austria	0.94%	0.90%	1.01%	1.34%	1.32%	1.31%
Italy	1.40%	1.31%	1.50%	1.82%	1.57%	1.25%
Poland	1.16%	1.11%	1.29%	1.47%	1.22%	1.14%
Belgium	0.77%	0.63%	0.74%	0.80%	0.92%	0.88%
Spain	0.81%	0.78%	0.88%	1.06%	0.91%	0.72%
Czechia	0.81%	0.77%	0.87%	0.94%	0.85%	0.71%
Sweden	0.51%	0.46%	0.59%	0.70%	0.62%	0.54%
Hungary	0.47%	0.41%	0.49%	0.60%	0.57%	0.51%
Russia	0.70%	0.55%	0.81%	0.78%	0.58%	0.51%
Denmark	0.40%	0.36%	0.44%	0.47%	0.51%	0.47%
Republic of Korea	0.45%	0.43%	0.49%	0.54%	0.52%	0.45%
Turkey	0.50%	0.48%	0.64%	0.54%	0.37%	0.38%
Japan	0.42%	0.40%	0.44%	0.43%	0.42%	0.34%
Romania	0.24%	0.22%	0.26%	0.30%	0.34%	0.32%
Slovakia	0.29%	0.29%	0.33%	0.34%	0.32%	0.30%
Mexico	0.23%	0.26%	0.34%	0.37%	0.40%	0.28%
Canada	0.29%	0.27%	0.29%	0.30%	0.32%	0.26%
India	0.23%	0.27%	0.31%	0.41%	0.31%	0.23%
Luxembourg	0.15%	0.13%	0.15%	0.13%	0.23%	0.22%
Taipei, China	0.17%	0.16%	0.19%	0.21%	0.22%	0.21%
Finland	0.23%	0.22%	0.24%	0.29%	0.04%	0.20%
Ireland	0.15%	0.16%	0.20%	0.23%	0.23%	0.20%
Australia	0.19%	0.17%	0.20%	0.20%	0.22%	0.19%
Brazil	0.24%	0.18%	0.22%	0.22%	0.24%	0.19%
Norway	0.26%	0.23%	0.22%	0.22%	0.23%	0.19%
Portugal	0.17%	0.16%	0.18%	0.23%	0.22%	0.19%
Greece	0.12%	0.09%	0.12%	0.13%	0.14%	0.12%
Singapore	0.10%	0.12%	0.16%	0.20%	0.15%	0.11%
Thailand	0.06%	0.07%	0.08%	0.08%	0.14%	0.11%
Malaysia	0.08%	0.08%	0.12%	0.12%	0.12%	0.09%
Slovenia	0.07%	0.07%	0.09%	0.11%	0.11%	0.09%
Bulgaria	0.07%	0.06%	0.08%	0.09%	0.08%	0.07%
Croatia	0.05%	0.05%	0.06%	0.07%	0.08%	0.07%
Lithuania	0.06%	0.02%	0.04%	0.06%	0.08%	0.07%
Viet Nam	0.03%	0.04%	0.06%	0.08%	0.08%	0.07%
Indonesia	0.07%	0.05%	0.07%	0.09%	0.08%	0.06%
Estonia	0.04%	0.04%	0.04%	0.05%	0.03%	0.03%
Hong Kong, China	0.05%	0.05%	0.06%	0.05%	0.04%	0.03%
Kazakhstan	0.02%	0.03%	0.03%	0.03%	0.04%	0.03%

Latvia	0.02%	0.02%	0.03%	0.03%	0.04%	0.03%
Philippines	0.05%	0.05%	0.05%	0.08%	0.04%	0.03%
Bangladesh	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Cyprus	0.01%	0.02%	0.02%	0.02%	0.01%	0.02%
Malta	0.01%	0.01%	0.01%	0.01%	0.02%	0.02%
Pakistan	0.02%	0.03%	0.03%	0.03%	0.02%	0.01%
Sri Lanka	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Rest of the World	3.65%	4.18%	4.23%	3.37%	4.58%	3.15%
Total	27.38%	26.25%	30.32%	32.91%	32.63%	28.15%

Source: own calculations based on *Asian Development Bank MRIO* (2022)

In 2020 the share of Chinese value added in German exports was slightly lower than in 2019 – 2.41% vs. 2.53% (see Table 4.3). Also, the foreign value added from the V-4 countries was narrowly lower in 2020 than in 2019 (2.66% compared to 2.96%). Thus, the numbers have not confirmed the story of replacing Chinese components with the intermediaries coming from Central Europe. For example, if in 2020 the share of Chinese components was 1.50% and the share of the intermediaries was 4%, the explanation based on the pandemic and the replacing the risky Chinese supplies with the safe supplies from Central Europe would be very probably. Does it mean that there are no changes in global value chains caused by the pandemic? The answer is no, and it does not. Changes in production and supplies need time, so it this possible that noticeably changes in the origin of foreign components in German exports will be visible in the year 2021. Moreover, it is worth noticing that the share of the V-4 countries is higher than the share of China, which can be a good sign for the role of the V-4 countries in German value creation. However, we must remember that in 2022 we have another solid external shock caused by the war in Ukraine, which is much more dangerous for the V-4 economies than for the Chinese economy.

Table 4.4 presents similar data as Table 4.3, but it refers to German exports of the transport equipment. The possible explanations for the changes in 2020 compared to 2019 are pretty much comparable like before - the decrease in the share of foreign value added is noticeable while not spectacular. Thus, it can result from a pandemic, but not necessary. The decrease in the share of Chinese foreign value added (from 5.87% to 3.54%) is accompanied by the decline in the share of value added from the V-4 countries (from 3.29% to 3.13%). The decrease in the case of Chinese foreign value added is much more substantial than in the case of value added coming from the V-4 countries, which makes the pandemic slightly more probable explanation. However, still, we cannot say that Chinese components were crowded out by the intermediaries coming from the V-4 countries.

Table 4.3 The foreign value added in German exports of transport equipment during 2015–2020, top countries in 2020

Value added sourcing country	2015	2016	2017	2018	2019	2020
People's Republic of China	3.25%	3.00%	3.40%	3.43%	5.87%	3.54%
United States	5.03%	4.70%	4.83%	4.09%	5.85%	3.30%
United Kingdom	2.84%	2.80%	2.67%	3.68%	3.30%	2.85%
France	2.69%	2.45%	2.96%	2.98%	3.39%	2.64%
Italy	1.18%	1.10%	1.20%	1.51%	1.41%	1.26%
Netherlands	0.72%	0.65%	0.93%	1.21%	1.16%	1.18%
Poland	0.96%	0.88%	1.00%	1.15%	1.24%	1.12%
Austria	0.61%	0.53%	0.61%	0.95%	0.88%	0.98%
Spain	1.23%	1.13%	1.23%	1.32%	1.53%	0.97%
Republic of Korea	0.71%	0.61%	0.73%	1.00%	0.88%	0.88%
Russia	1.12%	1.24%	1.46%	0.94%	1.39%	0.88%
Switzerland	0.68%	0.68%	0.69%	0.94%	0.75%	0.86%
Czechia	0.69%	0.65%	0.76%	0.97%	0.92%	0.83%
Sweden	0.60%	0.65%	0.68%	0.84%	1.06%	0.74%
Hungary	0.46%	0.46%	0.51%	0.68%	0.69%	0.65%
Belgium	0.61%	0.58%	0.62%	0.67%	0.68%	0.56%
Slovakia	0.34%	0.32%	0.41%	0.49%	0.44%	0.53%
Japan	0.66%	0.64%	0.65%	0.55%	0.62%	0.44%
Denmark	0.21%	0.21%	0.26%	0.42%	0.34%	0.39%
Norway	0.41%	0.37%	0.33%	0.37%	0.31%	0.37%
Canada	0.54%	0.51%	0.52%	0.44%	0.54%	0.36%
Mexico	0.37%	0.27%	0.44%	0.49%	0.48%	0.35%
Turkey	0.61%	0.55%	0.72%	0.31%	0.52%	0.33%
Taipei, China	0.20%	0.20%	0.20%	0.32%	0.23%	0.32%
Portugal	0.28%	0.26%	0.29%	0.35%	0.35%	0.31%
India	0.41%	0.28%	0.42%	0.41%	0.55%	0.28%
Romania	0.13%	0.13%	0.14%	0.25%	0.16%	0.25%
Australia	0.29%	0.29%	0.31%	0.34%	0.30%	0.24%
Finland	0.24%	0.22%	0.23%	0.00%	0.28%	0.24%
Brazil	0.17%	0.21%	0.18%	0.24%	0.20%	0.17%
Ireland	0.21%	0.14%	0.19%	0.20%	0.33%	0.16%
Malaysia	0.15%	0.10%	0.18%	0.18%	0.17%	0.15%
Greece	0.06%	0.08%	0.07%	0.13%	0.08%	0.13%
Luxembourg	0.10%	0.10%	0.09%	0.10%	0.10%	0.09%
Thailand	0.06%	0.05%	0.06%	0.11%	0.07%	0.09%
Singapore	0.03%	0.02%	0.04%	0.10%	0.06%	0.08%
Slovenia	0.06%	0.06%	0.07%	0.09%	0.09%	0.08%
Lithuania	0.02%	0.03%	0.03%	0.08%	0.05%	0.06%
Bulgaria	0.04%	0.04%	0.05%	0.06%	0.05%	0.05%
Croatia	0.04%	0.04%	0.04%	0.07%	0.05%	0.05%
Indonesia	0.03%	0.04%	0.04%	0.06%	0.06%	0.05%
Philippines	0.01%	0.01%	0.01%	0.05%	0.01%	0.04%
Estonia	0.03%	0.03%	0.04%	0.04%	0.05%	0.03%
Hong Kong, China	0.06%	0.05%	0.06%	0.04%	0.05%	0.03%
Kazakhstan	0.01%	0.01%	0.01%	0.03%	0.01%	0.03%

Latvia	0.02%	0.02%	0.02%	0.03%	0.02%	0.03%
Bangladesh	0.05%	0.03%	0.05%	0.03%	0.03%	0.02%
Cyprus	0.02%	0.02%	0.02%	0.01%	0.02%	0.01%
Malta	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%
Sri Lanka	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Viet Nam	0.03%	0.02%	0.03%	0.01%	0.03%	0.01%
Rest of the World	4.32%	3.83%	3.22%	6.10%	2.81%	4.24%
Total	33.61%	31.28%	33.71%	38.90%	40.49%	33.26%

Source: own calculations based on *Asian Development Bank MRIO* (2022)

The position of Poland has recently not changed much on both lists, although its share in German value added declined in 2020 compared to 2019. Only a few countries increased their share during this time. In terms of value added in total exports, these were Turkey, Finland and Cyprus. On the other hand, in the case of production in the automotive industry, their share in the creation of added value increased, among others, in Netherlands, Austria, Switzerland, and Slovakia. The position of Poland is quite significant and stable. However, Poland overtook Spain and Russia on the list of countries creating added value in the German export of transportation equipment production.

Based on statistical data, these conclusions are uncommitted to the business organization's changes expected since the pandemic's outbreak. Therefore, a final assessment of the impact of the pandemic and the shift in supply chains should be awaited, at least until more recent data are available. However, Russia’s aggression on Ukraine and disruptions in global economy may make it impossible to separate the effect of pandemic and war on shifts in GVCs.

4.4 Slovakia

4.4.1 Upgrading Slovak value added via Industry 4.0 and innovations

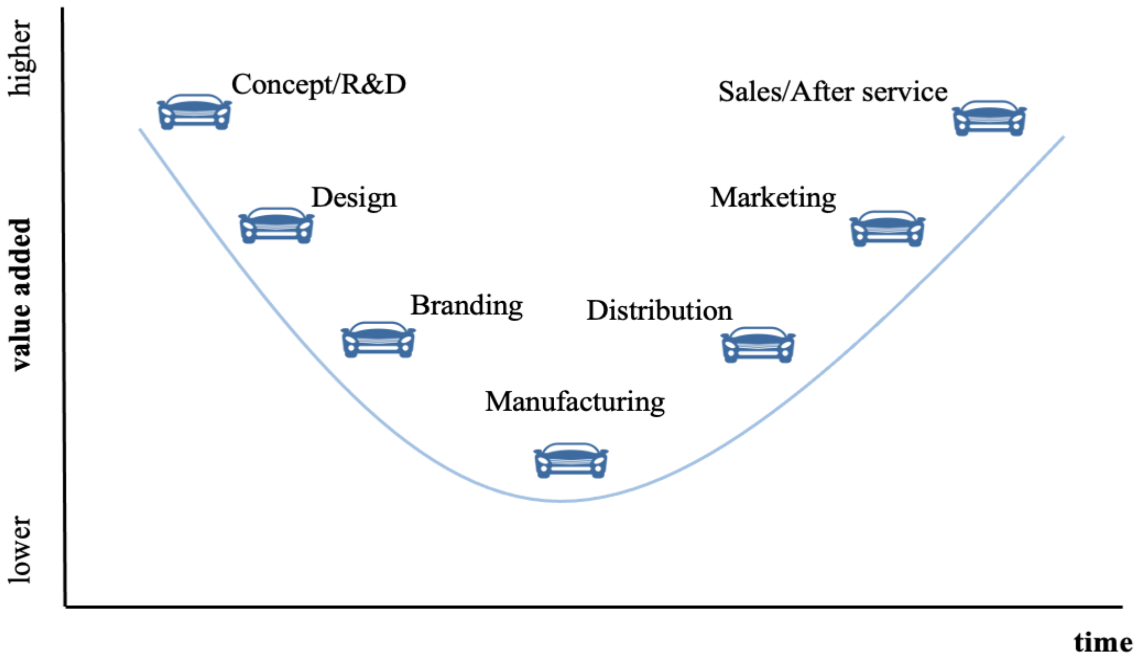
We are witnessing a time of change, crises, and constant unrest. We are witnessing a dynamically changing world of the economy, environmental policy, power influences, inflation, and, last but not least, watching the massive development of technological innovations. The struggle for competitiveness and market share is conditioned by the continuous improvement of technology, automation, and digitization of production, cost reduction, or more innovative marketing.

The growing importance of the fourth-generation industry (Industry 4.0) as a key for any company that has the vision to become innovative and prosperous is striking. Such a demanding process of integration of the Industry 4.0 concept is closely related to the issue of global value chains and multinational companies, which in the Slovak Republic are primarily engaged in the automotive industry. From various analyses, we can already confirm the dependence of the Slovak Republic on the automotive industry and its lower added value in car production. Through the application of high-tech operations and current trends in this industry, Slovakia can become visible and bring the long-awaited proactive character of the innovative country.

4.4.2 Trends and opportunities for value added growth in the automotive industry

Porter's (1998) conclusions about the acquired competitive advantage can answer the question of increasing the added value of the automotive industry. For example, in Japan, it can be a quality supply of labour that is considered a source of innovation. A level change in the value chain in favour of creating higher added value can be achieved in four ways - by shifting strategies in global value chains (Assche & Gangnes, 2011; Gehl Sampath & Vallejo, 2018): process upgrading (evolutionary changes and higher process efficiency), product upgrading (changes in the product portfolio to increase the value added), functional upgrading (application of activities with a higher rate of added value: research and development, sales/service, design, and marketing) and interchain upgrading (changes in the production base of companies that will allow entry into new global markets).

Figure 4.4 GVC in terms of value added (individual processes)



Source: own elaboration based on Zábojník et al. (2020)

Intelligent processing

Information technology has already simplified human-to-human (P2P) communication, later human-machine communication, and can now help with machine-to-machine (M2M) communication. Development of this type can pave the way for continuous, higher automation through many communication channels and digital control systems.

Design and question of raw materials

With the onset of the fourth industrial revolution, the issue of product design is directly linked, which contributes a firm effect on the personalization and individual needs of customers. Computer-Aided Design (CAD) technology is a system that uses virtual and augmented reality and simulation in design.

Interoperability and standardization

It is necessary to register these two concepts as another critical factor in increasing competitiveness and growth in the digital economy. They can streamline cooperation between elements of the digital environment, enabling better levels of communication and transparency in global supply networks.

Creativity

Creativity is a very important and current concept in the field of digitization and innovative technologies. This is a process where the design becomes more important than the technology itself, the production process or the final product (MESR, 2021).

Smart research

Research and development in ICT, cybernetics, and artificial intelligence is the primary reflection of intelligent manufacturing, which will enable a sharp increase in value added. Research and development in the conditions of the Slovak Republic must be subject to changes that will ensure its higher expertise, critical research capacities and, last but not least, sufficient funding (SARIO, 2022b). It is important and almost necessary to "network" application and research centres with the possibility of using the already existing research and development infrastructure of the Slovak Republic.

Intelligent energetics

This includes the need for a new concept that will be needed to engage in smart technologies on both sides (production and consumption). The essence of the concept is to create a so-called smart grid in the Slovak Republic as a key technical solution for developing the electricity system (MESR, 2021).

Transcendence of new trends into other industries

Technologies trigger innovation and productivity in business, industry, and many other sectors. For the end-user, this will mean operational efficiency and lower costs. The most advanced intelligent transport systems, telematics, and multimodal integration will support cities in terms of increasing mobility, reducing emissions, and personalizing the user experience. Transport systems in the sense of Industry 4.0 represent the basis for the proper functioning of the "smart city" concept, which supports the overall integration of technology and communication.

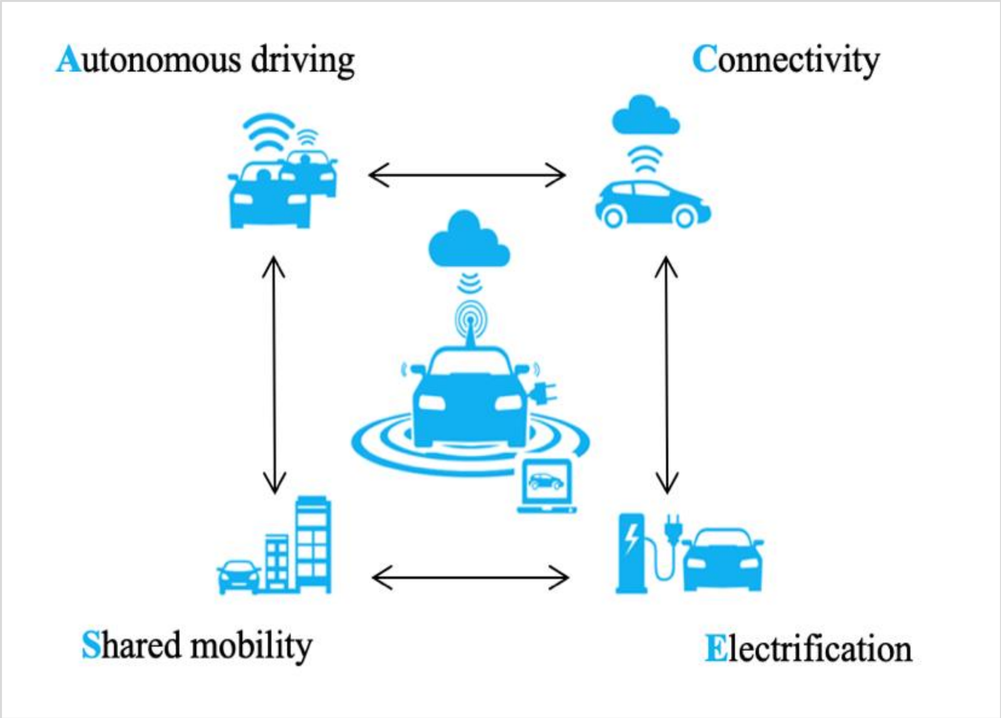
4.4.3 Current trends in the automotive industry

Recent years have been marked by an excellent increase in electromobility trends and megatrends, which is mainly associated with the fourth industrial revolution in the automotive industry. As a general rule, there is an increase in value added, comfort and safety, which results from electrical engineering and connectivity (IBM, 2008).
These trends naturally affect the production parameter by their demands, and therefore it is of priority to monitor the adaptability of automobiles through the adoption of innovative elements in vehicle production. The next section presents key trends that evoke the need for innovative solutions (Zábojník et al., 2019).

„ACES“ model

As a result of already known data on the automotive industry, it is justified to claim that the AP will remain in the territory of the Slovak Republic at least in the medium term and its key role for our economy. Current trends in the automotive industry are described by most experts as the transition and transformation to the so-called ACES model (from English A - driving autonomy, C - vehicle connectivity, E - electromobility, S - shared mobility services) (McKinsey, 2018). According to research and study by the author of the ACES model, up to 80% of trucks will be "online," by 2030. This is primarily an increase in traffic safety. The number of potential customers who would like an electric car has increased by almost half.

Figure 4.5 ACES Model



Source: own elaboration from McKinsey (2018).

E-mobility

The vision of building electromobility in public and individual passenger transport is a long-term character. However, more significant support for this trend has been reaching since 2010, mainly from national governments, local governments, and various organizations due to slowing global climate change and missing investment opportunities.

Innovative ability and sustainability of competitiveness in automotive industry

The starting point for the highest competitiveness in the automotive industry, using previous analyses, belongs to Germany. A wide range of innovations in the sector can be seen as the reason for this sustainability and economic progress. According to the Centre for European Economic Research (ZEW, 2019), the German automotive industry achieved the highest number of innovations in its production (50.57%).

Quality workforce

One of the positive aspects of Industry 4.0 is the value creation effects resulting from increased efficiency and new business models. However, technological changes can have positive and negative effects on employment (Roblek et al., 2016). Advances in technology and flexible development depend on innovation intent and corporate policy, education, and quality work skills. Job restructuring will be a challenge, as some more minor demanding occupations will quickly disappear (Kane et al., 2015).

Digitization

Increasingly connected vehicles will change business strategies, from product sales to offering customer experience-focused value (Hoffmann, 2019). Digitization will significantly improve the value chain by increasing efficiency, reducing costs, and creating more collaboration and innovation. It will evolve from business-to-business approaches through its dealerships to a business-to-consumer model, with new ways of interacting with customers and partnering with suppliers interacting through data.

Impulses of „R&D“

In order to determine the right policy and the right tools, an analysis of the current state of the environment and follow-up capabilities is necessary for the right response to stimuli. It is an initiative to create tools that would be used to condition the Automotive Industry's investment in R&D (Zábojník et al., 2019). We characterize three levels of R&D:

1. **Self-implementation of R&D** (internal activity) – Companies have R&D activities declared as part of their own business.
2. **Specialization R&D** (external service) – When the company dominates the existing infrastructure, it is possible to specialize in completely innovative activities (practice).
3. **Public R&D sector** – Public investment and activities within schools. They still do not have the desired effect, on the contrary, they are risky investments.

Innovative subcontracting chains in automotive industry

The production of the automotive industry is a sophisticated system based on quality supplier-customer relationships within the existing value chain. Automobile production includes suppliers across various industries, economic divisions, and sections. The traditional supply chain structure is grouped by levels (Slušná & Balog, 2015):

TIER 1: First-stage suppliers who deliver directly to assembly plants. They need design and innovation capacity.

TIER 2: Second-tier suppliers. These companies often work on assembly plants or global mega-suppliers' designs.

TIER 3: Third-party suppliers supply primary products. They have only basic engineering skills and experience.

4.4.4 Chasing up the value added during the pandemic era. PSA Group Slovakia

Historical context[41]

In January 2003, the Government of the Slovak Republic accepted the investment plan of the French automobile concern PSA Group (at that time the second-largest automobile producer in Europe) to build a new production plant in the Slovak Republic. According to PSA Group's strategic expansionist

[41] The co-author of this subchapter is Ing. Marek Nagy, Faculty of Operation and Economics of Transport and Communications, University of Žilina, Slovakia.

considerations, it was most advantageous to build a factory near new core markets closer to the centres of Central and Eastern Europe (as a fast-growing region with huge sales potential). In six Central European countries (Czech Republic, Croatia, Hungary, Poland, Slovakia, and Slovenia), the French manufacturer had a 12.7 percent market share, compared to 5% in 1998.

At the time of the investment, the investors and experts analysed and presented the circumstances leading to the decision to build a new production plant within CEE in Trnava, Slovakia gathered in table 4.5.

Table 4.4 Criteria for deciding on a new PSA Group site in CEE

Localization criteria officially published by the investor:	**Other factors** of the investor's decision-making - according to analysts:
• position in central Europe • building land with an area of 190 hectares, which is easily accessible by rail, highway, and navigable river • the possibility of creating a supply park near the plant • the industrial tradition of the region, and available workforce with a good level of education • proximity to important markets in which the PSA Group is expanding rapidly	• political stability • reform and integration-oriented government • government activity and involvement in the project • established and potential subcontracting base • quick access to the airport • proximity to Vienna, where the children of French managers can study in their mother tongue schools • plans of the Slovak school system to open French schools in Trnava as well • openness of universities in Trnava and Bratislava for cooperation with the investor • the potential to efficiently install and use the technical equipment of the plant • the potential to increase the added value of own car manufacturer

Source: *Materials Passed by the Government of SR* (2003)

The Government of the Slovak Republic naturally agreed with this investment plan and provided several investment incentives. The rationale for supporting this project was primarily the benefit for public finances (taxes, levies, reduction of social expenditures), the growth of the volume of industrial production in the Slovak Republic, and the increase in overall economic growth (*Materials Passed by the Government of SR*, 2003). After the start of the operation, the volume of production was estimated at 100 billion SKK per year (approximately €3.32 billion). The value added realized by the new investor was estimated for 2006 by government advisers at the level of 10 billion SKK (approximately €332 million) represented up to 1% of Slovak GDP at that time. Thanks to this investment and the creation of value added within the new plant, Slovak GDP would grow by 1% in the future. The government's ambition was to increase the share of domestic suppliers to increase added value in exported cars. Another positive impact was employment growth (and a decrease in high unemployment at the time) and a positive impact of investment for the trade balance (export growth and a promising decline in imports due to greater involvement of Slovak suppliers).

Contemporary development

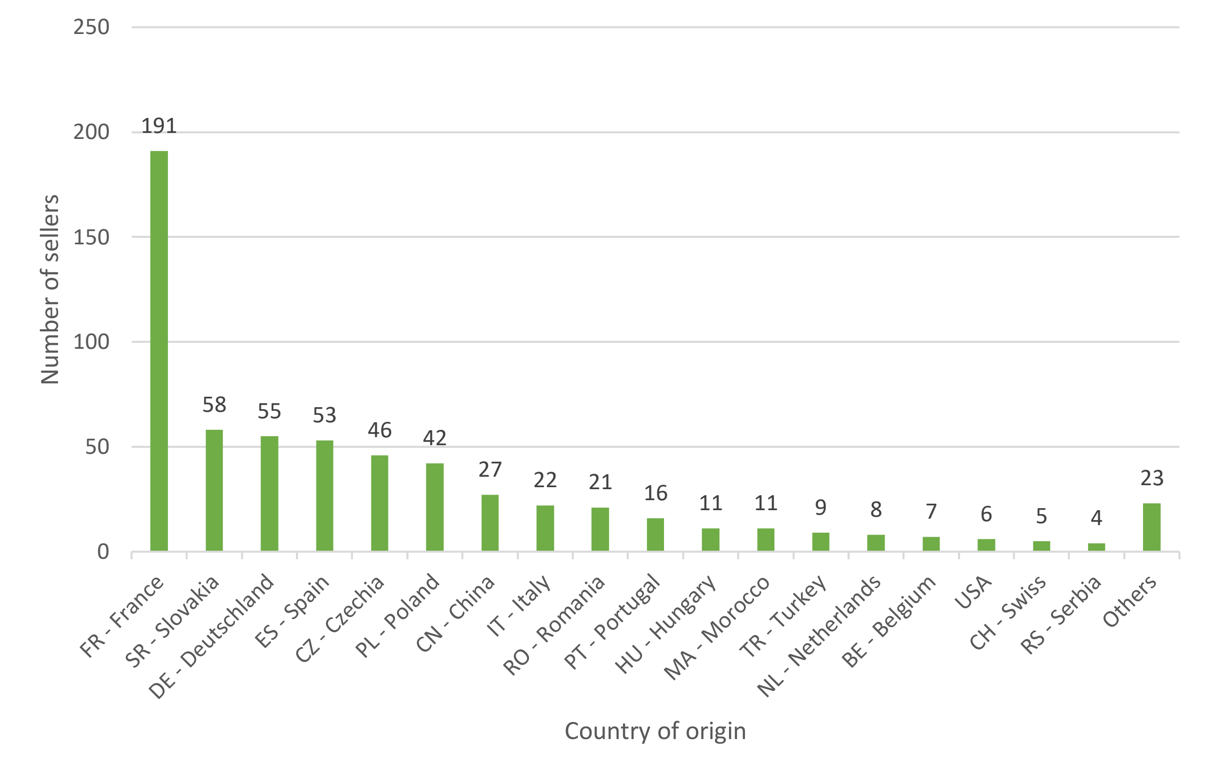
The carmaker based in Trnava is a leader in producing small vehicles in the B-mainstream segment. It currently produces the extremely popular Citroën C3 and Peugeot 208 models. In July 2020, the carmaker had already produced 3.5 million vehicles. Serial production at the carmaker plant began in 2006, and its products are aimed at satisfied customers on almost every continent (PSA, 2021). At a production cadence of 62 vehicles / h, it produces approximately 1,395 vehicles per day (PSA, 2021). The Trnava carmaker directly generates almost

4,400 jobs. In addition, it employs almost 20,000 people through its subcontractors located in Slovakia. In 2019, the carmaker in Trnava ranked 4th among the largest non-financial companies in Slovakia. It also has a dominant position in the foreign trade of the Slovak Republic. In 2019, it became the third-largest exporter within Slovakia. It currently ranks fourth. In 2020, it produced 338,050 vehicles. In the seventh consecutive year of year-on-year growth, production at the Trnava production centre increased by 5.1% compared to the previous year, 2019. Of the total number of vehicles produced, 33,334 were electric, with the e-208 monogram. Last year, the "battery-factory" completed 35,922 battery packs. The establishment in Slovakia of the parent company made and still makes sense; the production is situated in the middle of the automotive cluster within the V-4 region. The cumulative value of the Group's foreign direct investment in Slovakia has already exceeded € 1.2 billion (PSA, 2021).

Basic Fundaments of PSA Group Slovakia

The main objective of this case study is to analyse PSA's attitude toward the Fourth Industrial Revolution, innovation, electromobility during and after the COVID-19 pandemic and use particular examples from production management to identify how this trend significantly affects and helps more efficient and error-free production, which in turn generates also increased value added in car exports and at the same time point out sufficient resp. insufficient state support in the parameters of the business environment. The right business environment and conditions for innovation activity can be seen as a major incentive for Slovak suppliers to participate more in subcontracting for PSA Group and thus increase the rate of the value added generated in the Slovak Republic (and thus maximize the positive effects of FDIs for the host economy). To characterize and answer these questions, the case study identifies the primary areas where it is possible to define the innovation potential of this company, also based on the supply structure to identify potential gaps and analyse the attitude to environmental policy (since decarbonization policy has seriously impacted the European industries).

Figure 4.6 PSA Group SVK supply structure by supplier's home country

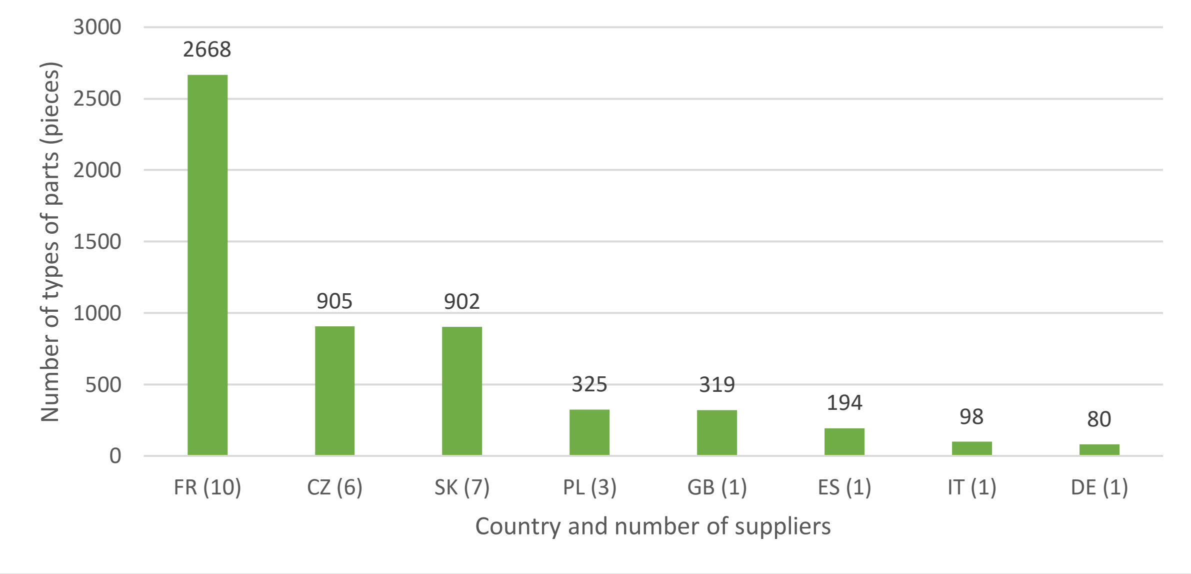


Source: own elaboration

Figure 4.6 represents all suppliers based on the country of origin (categories - specific and joint suppliers) in 2020. The figure represents the international supply chain, the number of suppliers has increased to 615 compared to other years, and in the international context, their structure is more fragmented. The first, most robust suppliers are suppliers from France with 191 companies (approximately 31%); this country, therefore, represents a particular supplier leader, which the registered office of the parent company could be assumed. The second is the Slovak Republic with 58 suppliers (approx. 9.43%), and the third place is represented by Germany (55 - approx. 9%).

In the analysis of previous years, it can be identified that in each year the number of suppliers was dominated by France. It also directly creates the highest value added, as it is a French carmaker, which is dominant on the so-called “smile curve”. The smile curve comprises following the most demanding value chain activities (the highest value added): the original idea, know-how, and car design come from here. The influence of suppliers from the Slovak Republic is less significant: it represents the second place in terms of the number of suppliers.

Figure 4.7 Suppliers of PSA Group SVK by part types in pieces (2019)



Source: own elaboration

Looking at PSA Group's suppliers by type of parts (Fig. 4.7), France is the first to import about 2,700 types of parts to the carmaker (10 companies - 2,668 types of parts). Import from the Czech Republic follows; PSA Group Slovakia imported 905 types of parts from six Czech companies. The third place belongs to the Slovak Republic - domestic supplies (7 companies - 902 types of parts). When the French carmaker was established in the Slovak Republic, the share of domestic suppliers was naturally high; Slovak companies carried out 90% of construction works during the plant's construction. Unfortunately, Slovak subcontractors, who would participate in creating value added intended for export (serial production activities), do not have such a significant role in the production of cars. The leading suppliers related to production in Slovakia are Faurecia, Lear Corporation Seating Slovakia, Plastic Omnium, Visteon Electronics, Eurostyle Systems, Slovakian Door Company, Bourbon Automotive Plastic. Approximately 54% of the company's revenues come from Central and Eastern Europe (V-4 + Romania), 21% of turnover from Slovakia. The priority intention of the French management was to produce at lower costs in the Slovak Republic and subsequently export to other European countries using the barrier-free single market of the EU, which is also confirmed by current export statistics. From the point of view of the territorial structure of PSA exports, most exports are to the EU (80%) and other countries, such as Japan, New Zealand, or Egypt. The transport of vehicles to customers is provided by the subsidiary GEFCO. About 60% of the vehicles produced in PSA Group SVK reach customers by rail, the remaining 40% reach clients by truck.

Table 4.5 The most important Slovak suppliers of PSA Group SVK by number of imported types of parts (2019)

Order	Seller	Town (Region)	Products	Parts (pcs)
1.	Faurecia Automotive SVK s.r.o.	Trnava (TN)	Car seats	279
2.	Adhex Technologies	Senec (BA)	Foam parts	158
3.	Lear Corporation Seating SVK	Prešov (PO)	Seating systems	119
4.	Eurostyle Systems s.r.o.	BnB (TR)	Plastic parts	95
5.	SMRC Automotive Solutions	Nitra (NR)	Modules, cockpits	92
6.	Leadec s.r.o.	BnB (TR)	Technical solutions	81
7.	PSA SVK s.r.o.	Trnava (TN)	Production parts	78
8.	Plastic Omnium Auto Inergy	Nitra (NR)	Fuel systems	54
9.	Eurostyle Systems s.r.o.	LM (LM)	Plastic parts	54
10.	Steep Plast SVK	Nitra (NR)	Plastic parts	52

Source: own elaboration

Faurecia Automotive Slovakia s.r.o. is the most critical Slovak supplier for PSA Trnava. based in Trnava, which manufactures car seats, and exhaust systems and deals with innovations in these areas. It dominates by importing 279 kinds of parts. The second company is Adhex Technologies (158 foam parts), and the third is Lear Corporation Seating Slovakia, based in Prešov. Its main area consists of seating systems, which it imports with 119 parts. The Slovak Republic contributes to the production of cars (the year 2020) by sourcing materials and components approximately 9.43%, with the number of 58 suppliers. However, these are mainly plastic components with a lower rate of value added. The cars are manufactured in Slovakia; they are mainly engaged in domestic assembly. Insufficient expenditures and a weak focus on research and development in the automotive industry (concept I4) represent the lower value added in subsequent exports. Quality education and innovative activity of employees within subcontracting companies are also important.

Employee training and development

Employees´ training and development play a crucial role in the perspective creation of the value added. In 2020, the costs of training employees amounted to €178 000, 63 567 hours, including training for both regular and agency staff. The training with the most funds was: technical training in industrial automation and robotics (Boost school project), legislative training, and English language training. The training with the most significant number of realized hours included the primary activities of the operation - assembly, initial training of newly hired employees, technical training of industrial automation, and robotics (PSA, 2021). Education helps to meet the company's main goals and, of course, also to meet legislative requirements, especially in the field of environment, safety standards, and fire protection, which is also one of the company's main goals. In the dual education system in 2020, there were 43 pupils in the teaching and study fields: Car-repair worker - electrician, mechanic - electrician, and mechanic - mechatronic. As a part of dual education, the Trnava car company cooperates with three secondary vocational schools (SOŠ automobilová Trnava, SOŠ technická Galanta and SOŠ elektrotechnická Trnava). In 2020, 6 new students (PSA, 2021) passed the selection procedure for dual education. For each new employee who joins group PSA Slovakia, the education department will prepare a training plan related to his / her job classification and socio-professional category (PSA, 2021). This plan aims to prepare the best possible employee to acquire the competencies necessary for the performance of their job position.

Natural environment

The negative impact of car production on the environment can not be eliminated, but the company is trying to minimize it. The paint shop is the most critical production process in terms of environmental impact and falls under the law on integrated pollution prevention and control. It is a significant source of volatile organic compound (VOC) emissions to air, wastewater, and hazardous waste (PSA, 2021). In order to limit these effects, the Trnava carmaker uses water-based primarily paints. The paint shop also includes a physicochemical wastewater treatment plant, which treats wastewater from the surface and painting processes. Heavy metals from these waters are precipitated here in the form of sludge. The biological wastewater treatment plant, which is located on the premises of the production centre, treats sewage and industrial wastewater. Sewage sludge is further recovered (PSA, 2021).

Production and COVID-19 Pandemic impact

At the beginning of March 2020, due to the COVID-19 risk, it was decided to stop production unprecedentedly in all European PSA plants. The production line in Trnava did not run for 55 days since March 19. As a result of the shutdown of the production line, more than 72,000 vehicles lost production. At the first production change, the gradual start of production began on May 12. Since Saturday, June 6, as the first carmaker in Slovakia, Trnava returned to production at total capacity (PSA, 2021).

Innovations

A significant milestone in PSA's development activities was establishing the InoLab team in 2020. The main task of InoLab is to connect the traditional production plant with the world of intelligent technologies and the university environment. The main activities of InoLab include:

- development of automation solutions for the production and logistics process,
- digital business transformation,

- building cooperation with universities, technology companies, and state institutions,
- management of EU grants, contributions, and funds,
- cooperation with students of Slovak and French universities (PSA, 2021).

Figure 4.8 Main areas of InoLab in PSA Group SVK

Source: own elaboration

The Trnava carmaker does not carry out activities in product research and development (PSA, 2021)! This is one of the fundamental problems of creating higher value added in the long run. Shortly, the application of research will be an essential part of the carmaker's innovation activities to remain competitive (*Economics of Innovation and Industrial Dynamics*, 2022).

Development perspective

The carmaker's priorities will be indicators of client quality, economic efficiency, and operational performance. In addition to continuing the transformation project "Future in our hands" to increase efficiency from its resources, the priority is the carmaker's partnership with the Slovak government and improving the external business environment in Slovakia.

The good news came at the beginning of 2021: the merger of the Fiat Chrysler Automobiles FCA Group and the Groupe PSA Group, of which the Trnava carmaker is a part, created a new company, Stellantis, on 16 January 2021. This is good news for the future of the carmaker. In addition to the new identity, the company in Trnava is gaining new opportunities from the new global potential.

The merger of two world car players and the emergence of Stellantis, which is the fourth largest carmaker in the world, is not caused by the crisis. It connects the potential of two healthy groups. The goal is not to be big but strong in products and services and thus better prepared for the industry's challenges - compliance with demanding CO_2 limits and meeting customer demand for new and innovative types of mobility (PSA, 2021).

For a more profound and broader analysis of current trends in the automotive industry, the implications of Industry 4.0, and other topics, from the perspective of PSA Group SVK, the work also presents a comprehensive, joint questionnaire (based on consultation), which was sent to the Industry 4.0 department in this company (25 employees - respondents). It consisted of 20 questions and answers a wide range of questions.

Industry 4.0 and value added in PSA Group Slovakia

The following part was processed based on a questionnaire, which was prepared with employees of Industry 4.0 and digitalization department of the company's production; it can be listed and characterized through the answers to a comprehensive questionnaire and identified key conclusions that this questionnaire and subsequent synthesis of conclusions brought. The first goal of the questionnaire was to find out the knowledge of the employees of the selected company about the Industry 4.0 concept. The second goal was to determine the readiness of PSA Group SVK for the transition to a digital company as a tool for technological - product, and process innovations in the company and thus increase value added in the company. The prerequisite was the establishment of innovative approaches based on the transformation (upgrade) of GVCs at the level of process upgrades and/or product upgrades for value added growth.

Question no. 1 Importance of Industry 4.0 within the Slovak Republic and the automotive industry

Through the first question, the respondents confirmed the crucial role of Industry 4.0 in PSA Group Slovakia and their expectations for the transformation of the industry at the Slovak level, especially in the perspective of several years. It is important to implement this concept and address it at the national level, as innovation and investment in research and development can move the Slovak economy and industry forward. Due to the dominance of the automotive industry in the Slovak Republic and thus the technical industry, the Industry 4.0 concept is significant for the Slovak industry as such. By applying the Internet of Things connection, machines within the company will be able to communicate with each other faster and more efficiently. The whole plant will cooperate and communicate with each other, which will make the production site intelligent. With Cloud and Big Data applications, it will be able to synchronize and receive various requests, data, and "orders" in real-time. The digitization process eliminates excessive consumption of paper and other consumables and enables faster communication. This results in reduced product error rates, better control, and a smoother production processes.

Question no. 2 The importance of Industry 4.0 in PSA Group Slovakia

In the second question, I4 considers this concept crucial for the company, particularly in terms of better and higher quality products, more efficient production, and lower product error rates. For PSA Group SVK, after merging with the fourth-largest carmaker globally, Stellantis, innovation appears to be essential for the future. Through this cooperation and higher capital investments, the company's innovative capacity will be even higher than before. PSA dominates most recently with the InoLab department, which deals with the Industry 4.0 concept.

Its main activities comprise:

- development of automation solutions for the production and logistics process,
- digital business transformation,
- building cooperation with universities, technology companies, and state institutions,
- management of EU grants, contributions, and funds,
- cooperation with students of Slovak and French universities.

Education and training of students/staff for this transition are also very important.

Question no. 3 Society and its approach to digitization

PSA Group's management understands digitization as a better, more comprehensive, and faster interconnection of products, suppliers, customers, and car manufacturers. It is a digital supply chain. In production, the communication offline and machine workers is currently being digitized (it has replaced paper production). Naturally, everything cannot be digitized yet, it is a complicated and lengthy process, but significant changes will be possible shortly. According to several respondents, staff training, relevant training, retraining is crucial.

Question no. 4 Company knowledge of Smart factory, CPS (Cyber-Physical Systems), and Internet of Things (IoT) concepts

These concepts have been known to the company for several years, especially to the I4 department, which uses them daily and considers them the essential elements of production in the Industry 4.0 concept. They perceive cybernetics and artificial intelligence as a system whose task is to ensure mutual interaction and data exchange between production processes, which will lead to autonomous coordination of units and optimization of the set task.

Question no. 5 Readiness of the company (in terms of personnel, technical and technological) for the transition to a digital society

The Trnava carmaker dominates with its excellent infrastructure and has a vast potential to become one of the most innovative companies in Slovakia. It also considers its location concerning distances to critical suppliers and innovators to be a strategic advantage - it is located in the west of Slovakia, i.e., it is directly connected to all modes of transport. It also provides ongoing staff training, dual education, and a broad focus on cooperation with universities. In 2020, it spent 78 000 € for 63,567 hours for the employees, including training for both regular and agency staff. The unrealized in-house research and development represent this company's most significant pitfalls and gaps in the transition to a digital and innovative company. For a better innovation process, it must carry out this research and development shortly. In this context, respondents assess its readiness to transition to a digital society as partial.

Question no. 6 Implementation of the plan for a successful digital transformation and transition to Industry 4.0

PSA Group has implemented almost all steps and mapped its strategy; after the merger with Stellantis, its vision and strategy are even more robust, to produce more quality cars and electric cars in the future. The creation of PSA Group SVK pilot projects are implemented by InoLab, which deals with a wide range of innovations. It can be mentioned, e.g., the virtual reality of building a car and its parts. This company is at the forefront of staff retraining. As already mentioned, more and more is invested in employees every year, especially in education. The fourth step is a perfect data analysis; in this part, the company records significant shifts, especially in supply structures. By mutual acceptance of her vision across the entire production process, she transformed into a digital enterprise, but of course, not at all levels. It is also integrated into the ecosystem; its environmental policy is one of the leading in Slovakia. It uses the ISO 14 001 standard - environmental management. The company adheres to strict limits on the discharge of wastewater or emissions into the air and respects the storage conditions of chemical products.

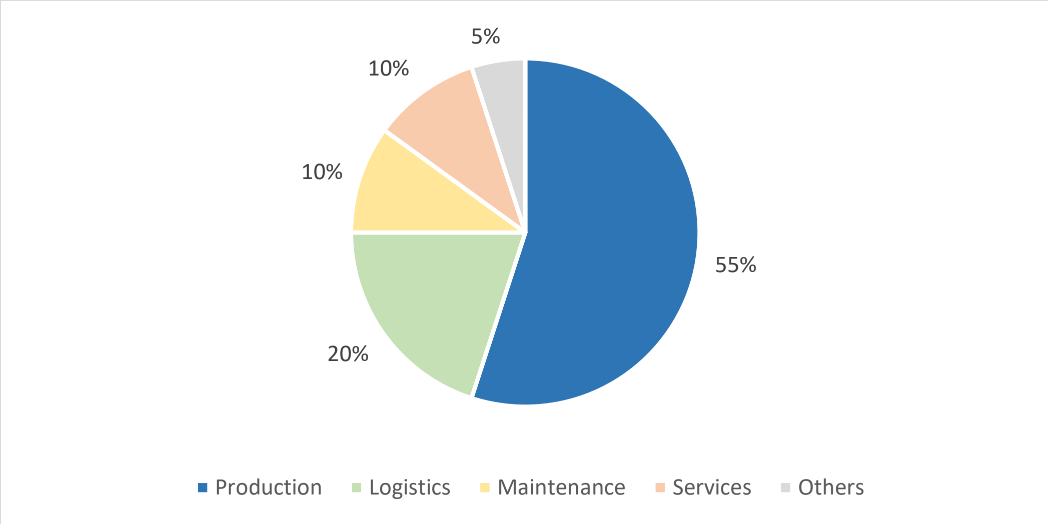
Question no. 7 Digitized activities in society

In terms of options in the questionnaire, all activities are digitized. Namely, it is about digital relationships with suppliers and the entire supply network. Subsequently, it covers the technical preparation of products, where paperless production helps, and the relations with customers, which are also laid at the digital level, especially today.

Question no. 8 Using elements of automation in the company

Automation in PSA Group SVK occurs mainly in the "core" areas, i.e., in the main activities, such as assembly lines with robots (675 robots). With the advent of the Peugeot 208, laser welding, with and without consumables, "Full Kitting," was introduced, supplying the edge of the line in operation (3.5 million parts distributed daily) or laser geometry control. The following chart shows the areas where PSA Group SVK currently focuses most on automation elements.

Figure 4.9 Areas of automation in PSA Group SVK



Source: own elaboration

From the figure 4.9, we can observe the dominance of automation in production, which is about 55%. This mainly concerns robotic processing (675 robots) and laser solutions. Logistics follows this with a 20% share, and maintenance and services with a 10% share. 95% are automated core solutions, and the remaining 5% are other activities.

Question no. 9 Transformation of the product portfolio in the company in the last five years

Table 4.6 Car production in PSA Group SVK in a period of 10 years

Year/Model	Peugeot 207	Peugeot 208	Citroën C3 Picasso	Citroën C3	NG Peugeot 208	Total Production
2011	109 219	82	68 375	0		**177 676**
2012	45 576	113 532	55 509	0		**214 617**
2013	-	184 740	63 671	0		**248 411**
2014	-	206 562	48 614	0		**255 176**
2015	-	259 388	43 630	0		**303 018**
2016	-	236 691	35 525	42 834		**315 050**
2017	-	82 445	17 677	235 174		**335 296**
2018	-	111 251	-	240 744	87	**352 082**
2019	-	80 947	-	234 443	55 762	**371 152**
2020	-	-	-	178 276	159 774	**338 050**

Source: own elaboration

As can be seen, the company's car production has increased chiefly each year observed (more than 25%). In 2020, new Citroen C3 and Peugeot 208 models were produced. A total of approximately 338,050 cars were produced. Compared to 2015, production increased by approximately 35,032 cars. The company is mainly engaged in electric cars and the production of batteries (33,334 electric vehicles were produced). Here it is possible to see the impact of the current electromobility trend.

Question no. 10 Increase in data volumes in the company over the last five years

Of these options, more than 50%, as the company switches to a wholly digital environment, means a massive increase in digital communication networks from machines to customer structures. The company also replaced paper production with digitization, which also increased production data volume.

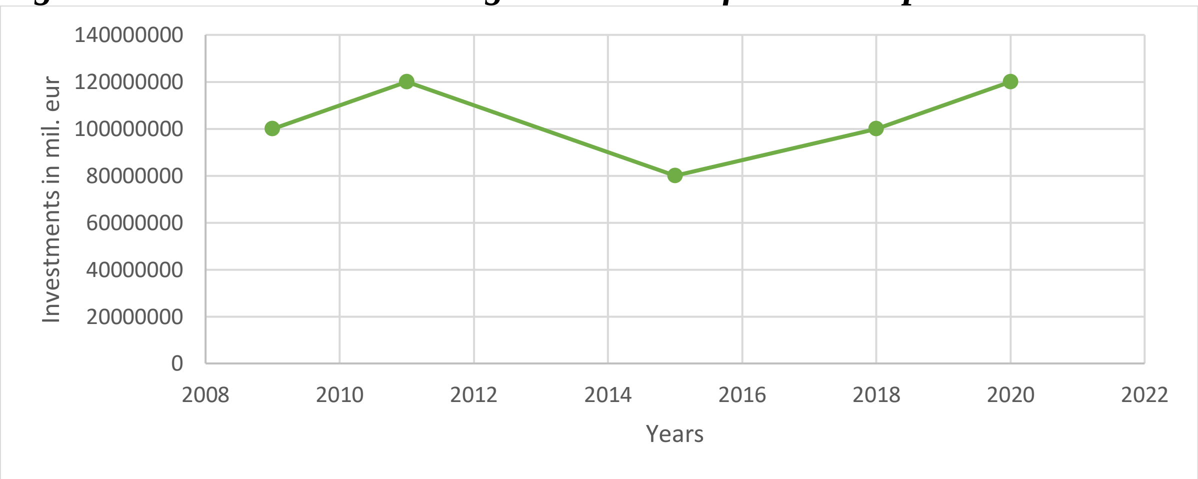
Question no. 11 Investment activity of the company in new technologies, machines, and equipment for the last five years

Selected investments by years:

- Investment in the construction and start of production of the 1st Peugeot 207 model: €700 million.
- Investment in the start of production of the Citroën C3 Picasso: €100 million.
- Investment to start production of the Peugeot 208: €120 million per year (2011).
- Investment to start production of the new Citroën C3: €80 million (2015).
- Investment to start production of the new generation Peugeot 208 and e-208: €100 million (2018).

The total amount of the group's investments in Slovakia: more than 1.2 billion €

Figure 4.10 The most interesting investments of PSA Group SVK



Source: own elaboration

The company currently invests heavily in electromobility (battery production) and the environment (over 20% compared to last year), also develops the projects and technologies in laser solutions, automated logistics systems, and the like.

Question no. 12 Success of shortening the product innovation cycle

This is a debatable issue; due to the COVID-19 pandemic, all production at the company was suspended. Also, in today's energy crisis and under the constant shortage of semiconductors, it is questionable how to shorten the innovation cycle.

Once the company has the relevant information and enough raw materials, it is possible to apply techniques to shorten the innovation cycle of the production process. Examples are SixSigma (define, measure, analyse, improve and perform control) or production environment analyses.

Question no. 13 Method of registration of finished products

Finished vehicles are registered by a combination of sensors that sense them as they leave the last production line and then head to the warehouse to take them away. A worker also intervenes here who performs a record and marks the final model with a "reader" device (electric form + communication totem).

Question no. 14 Opportunities for retraining PSA Group Slovakia employees to achieve the required skills

As already mentioned, approximately €178,000 was invested in staff training and development in 2020, amounting to 63,567 hours. These are in particular:

- Technical training in industrial automation and robotics (Boost school).
- Legislative training.
- English language learning.
- Basic crafts of operation - assembly.
- Initial training of newly hired employees.

In 2020, the corporate project "Boost school AUT / ROB" was launched, which is intended for maintenance workers in production plants to increase industrial automation and robotics competencies. He is also involved in dual education; currently, PSA Group SVK has 49 dual education students.

Question no. 15 The company's interest in the topic of electromobility

Electromobility is currently the driving force of the company. Of the complete package of manufactured vehicles, 33,334 were electric, with the e-208 monogram. Last year, the battery factory completed 35,922 battery packs. The investment to start the new generation Peugeot 208 and e-208 amounted to €100 mil. (2018). The first battery assembly plant was also exhibited and applied in Trnava.

Question no. 16 The latest innovations of PSA Group Slovakia in connection with I4.0

Establishment of InoLab in 2020, transition to paperless production and digital network supply structure. Also, the construction of a hall for battery production and investments in laser welding and "full-kitting." Also worth mentioning is the quietest press shop in the Group PSA, laser geometry control, ecological paint shop, and predictive maintenance.

"PROCE55" is an innovative, agile software for maintenance management and mobile maintenance in Industry 4.0. It provides an online overview of production, provides accurate and objective data from machines, and integrates various systems. It is dominated by high adaptability to specific innovative processes. The application of Industry 4.0 innovations can significantly streamline the production process. It shortens its time, increases quality, and strengthens subsequent product control. To detect errors, the company uses a plant quality indicator ("DVT").

Question no. 17 Respondents' estimate of the potential of Industry 4.0 and the Internet of Things to become the standard

It is difficult to predict this development, but I4 staff stated that it is feasible by 2025. With the growing interest in electric cars, they expect the process will accelerate and gain importance. They unequivocally agree that this will have a significant impact on the automotive industry, especially in the Slovak Republic. They also point to the importance of supporting legislation, education, research, and development, because without this support, its application and potential to become a standard is unclear.

Question no. 18 Use of European Structural and Investment Funds by PSA Group Slovakia

Currently, from the perspective of Industry 4.0, PSA Group SVK has received an investment in a new segment B production program at its production centre in Trnava (2021). The gradual start of production of the new production program of segment B is planned for 2023. In order to significantly contribute to increasing carbon neutrality, a large part of the production program will also be represented by fully electric motors. Industrial investment in the new production program will also mean a significant mobilization of activities related to innovation, further application of Industry 4.0 technologies, reduction of energy intensity, and environmental protection (PSA, 2021). Of course, the company used them (to a limited extent), for example, EU funds for employee trainings.

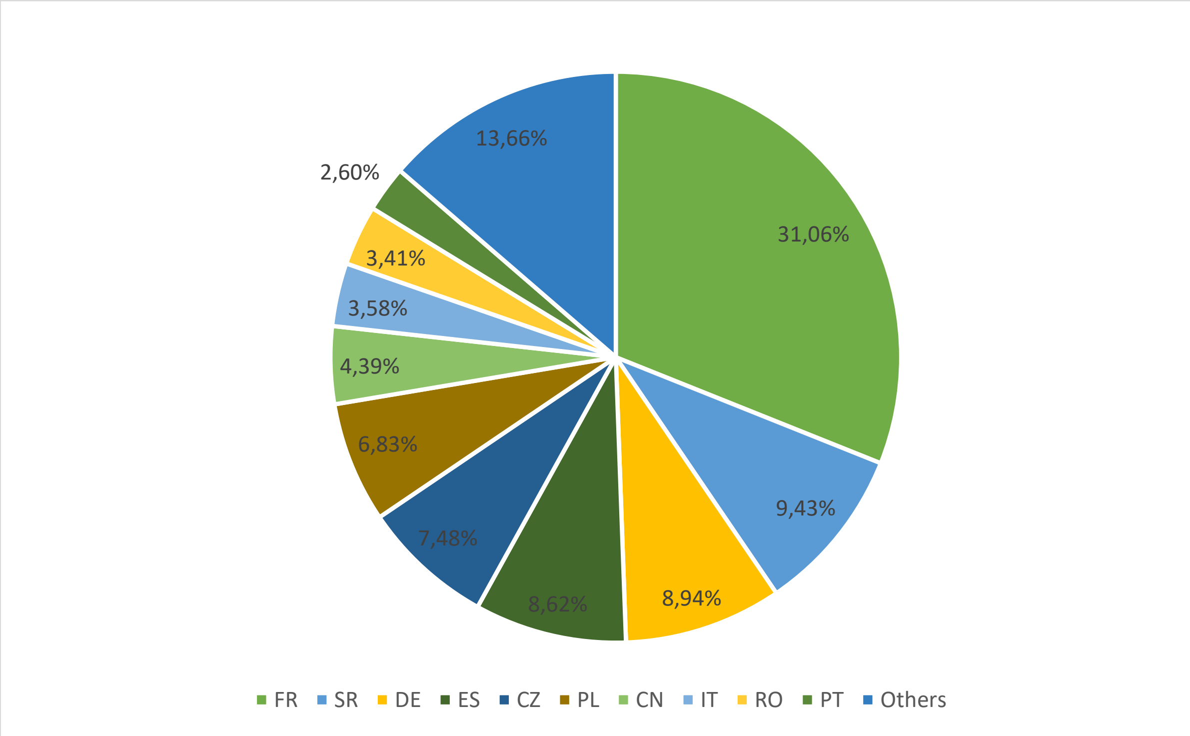
Question no. 19 Positive and negative impacts of Industry 4.0 according to respondents

According to experts, I4 certainly brings more positives, such as higher competitiveness, cost minimization, lower stocks, higher production efficiency, etc. Respondents included the possible loss of some job positions as negatives/threats. They also confirm the need to apply this concept in its entirety and shortly, mainly due to higher competition from neighbouring countries.

Question no. 20 The impact of 4th generation industry on exports in terms of the amount of added value within PSA Group Slovakia and its potential

The Industry 4.0 concept positively affects the car company's exports. It can transform it into an intelligent, digital enterprise in which all parts of production, machines, and people are connected in real-time, which enables higher production efficiency, lower error rates, and production costs. As a result, the company can dominate with a higher number of quality goods with a quality supply network. These segments will also positively affect its subsequent export and contact with customers.

Figure 4.11 Percentage of value added by country for C3 and 208 vehicles (2020-2021)



Source: own elaboration

Based on the analysis of available company data for the years 2020-2021, we found that the percentage of value added for C3 and 208 vehicles consists of several countries; the parent country of the company creates the highest value, i.e., France (31.06%), followed by Slovakia with almost 9.5% share, it is mainly assembly work. French suppliers dominate only thanks to the fact that it is a French carmaker; the vehicles were invented right here, and the most modern technologies were applied for their design, design, etc. The Slovak Republic will probably not reach the same level of value added as France, as it is not the parent country of the company, but the Slovak goal must be to maximize the share of value added of Slovakia in the production process and increase this share every year.

By applying innovations and essential research and development, with which the company does not yet dominate in Slovakia, the products will achieve higher value added. They will be more desirable on the global market. This will make the car company an innovator and set the trend for its competition. However, it is questionable when and how the Slovak government and overall legislation will be able to respond to this trend in order to support companies with innovative policies, better conditions, and laws. In particular, two parties, the company and the state are needed to make the innovative concept a reality. Respondents consider this to be a weak point of the Industry 4.0 concept in the territory of the Slovak Republic. Legislative conditions are currently insufficient and, in some places, chaotic compared to the outside world. When companies have the necessary capacities for their research and development, only then will the path of the Slovak Republic grow exponentially in terms of added value.

Proposals and recommendations

There is a strong need to spread the idea of Industry 4.0 across all sectors so that these industries understand and benefit from it. The vision and one of the most important goals of the Slovak industry is to combine research and development activities, together with innovation, including broad-based application, which will enable the contribution of all relevant technologies, knowledge, and skills from industry and enterprises in various sectors to society and quality of life in Slovakia (MESR, 2021). Comprehensive analyses must achieve all this, and it is necessary to create a so-called "Slovakia's Intelligent Industry Platform." We can understand this Platform as the leading and managing body of Industry 4.0, consisting of a group of experts, which will consist of key actors and government bodies. The right step would be to appoint ambassadors for each sector, with the aim of continuous improvement and support for implementing expert recommendations (MESR, 2021). The main document of this Platform would be an "action plan" that would be specifically designed for a specific area. This plan would bind the platform and set long-term goals in the field of various strategies of energy, materials, nanotechnology, robotics.

Table 4.7 Comprehensive table of recommendations

Areas	Recommendations
Awareness raising and cooperation	1. Information campaign
	2. Support for IoT experimentation
	3. I4 Implementation Manual
	4. Better promotion
Industry Research 4.0	1. Support for applied research
	2. Research agenda for Industry 4.0
	3. Sector-oriented consortia
	4. Efforts to reduce the amount of rest. N and R&D
Smart Factory	1. Support for the introduction of new technologies and materials
	2. Standardization (reference architecture)
	3. New models and their entry into dod. strings
	4. Use of Big Data
Financing	1. Better funding mechanisms
	2. Address the needs of the research agenda
	3. Innovative public procurement
	4. Implementation of pilot projects
Labor market and education	1. Analysis of the main requirements of the present
	2. Creating predictive curricula
	3. Providing more specialized skills
	4. Following the European agenda (new skills)
Legislation and E-Government	1. Continuous development of skills in the public sector
	2. Commercial use of data (Big Data)
	3. Active participation of the government in supporting the implementation of I4
	4. Proposal of a transparent VS digitization plan

Source: own elaboration

Environmental policy, which is also essential in matters of progress, must also be remembered and addressed.

Recommendations for Slovakia in terms of environmental policy:

1. The Slovak government needs to create favourable conditions for businesses to become green, which is in its interest to attract foreign investment to ensure economic growth and employment.
2. Businesses in Slovakia must press the government to create the proper regulatory framework for greening.
3. The car headquarters needs to work with its suppliers in Slovakia to help them adapt to new technologies and production processes through retraining and skills upgrading.
4. Retraining and improving the quality of staff to meet the job requirements of the emerging e-mobility sub-sectors requires new training programs and cross-cutting cooperation between the public and private sectors and academia.

Based on the answers from a comprehensive questionnaire, it is possible to characterize a high level of knowledge about the latest trends in PSA Group Slovakia and a quality workforce that is ready for the challenges of this concept.

The conclusions of the questionnaire confirm the significant impact of I4 on the company's product portfolio growth with value added growth and point to insufficient state support, especially in the areas of education, financing ("R&D"), and legislation.

Concerning proposals and recommendation, there are two concepts. The first in terms of the implication of Industry 4.0 for Slovak industry, follow the need of Slovakia to innovate, apply the latest available technologies, change educational programs and thus achieve high value added in the industry and subsequent exports of the goods and services through the Action Plan. The second concept is devoted to the environmental policy of the Slovak industry, its importance, and its impact. Based on implementing these proposals and recommendations, the Slovak Republic can acquire the proactive character of an innovative country, otherwise, it will remain an "assembly country."Slovak SMEs operating in the automotive industry have a shallow rate of added value, and the challenges in Industry 4.0 will only exacerbate this problem. This may ultimately affect the dynamics of economic growth in the Slovak economy, as automotive exports account for more than a third of total exports. This problem has its roots in an issue that has been the subject of economic research for a long time and has been significantly described in the case of smartphones´ gross exports (and low added value) from the PRC (Xing & Detert, 2010 or more recently Gereffi, 2021b). To design possible solutions for the problem of Slovak companies in further research is the space to examine the wider application of the suppliers´ network of domestic SMEs and their participation in global automotive chains in V-4, especially in Slovakia. In this country, some natural factors (economy size, geography, etc.) explain the lower share of value added domestic companies in gross exports and some specific factors remain uncleared. The research potential lies in identifying the strategic path of development among the upgrading strategies proposed by Humphrey & Schmitz (2002). The correctness of the set strategy for policymakers in the Slovak Republic will also depend on other significant investments both in the Slovak automotive industry and on investments in complementary commodities supporting innovations in the sector (especially the production of batteries for BEVs). A crucial aspect of Slovak companies' progress in value added seems to be an investment in innovation, both at the commercial and state budget levels. Therefore, the extent to which there is a significant causality between the volume of expenditures in the automotive industry of the Slovak Republic in innovations in ACES trends and the increase in value added in exports raises crucial space for further research.

5 Conclusions and policy recommendations

5.1 Conclusions

The scientific monograph discussed the importance of global value chains primarily in V-4 countries and focused on a perspective of the automotive sector after COVID-19. This sector is undergoing several dynamic changes caused by the global pandemic, unprecedented disruptions in the global supply chains covering foreign destinations and the persisting trend of value chain fragmentation. The research focused on three key issues (questions):

1. To what extent do V-4 companies participate in the automotive GVCs? (answered primarily within chapters 1, 3 and 4),
2. What are the likely impacts of COVID-19 on GVC participation of V-4 businesses? (answered primarily within chapters 2 and 4),
3. How to improve the position of national SMEs in automotive GVCs? (answered primarily within chapters 4 and 5).

The authors fulfilled the main goal of the scientific monograph by answering the above questions, and their partial outputs are described in more detail within the subsequent sections, which are logically arranged in the context of the research questions. Outputs in the field of global value chains with an emphasis on the region (V-4) and a specific sector (automotive industry) have their potential in economic research within the V-4 region, as this sector represents a key share in GDP creation and gross exports. After an in-depth analysis of the relevant theoretical background, the specific meaning of this monograph can be observed in the use of a range of research methods in individual chapters. The outcomes were not limited only to quantitative approaches, but the authors also verified their findings and recommendations by compiling case studies based on specific issues from economic practice in the automotive industry.

Participation in GVCs

There are several ways to measure the involvement of countries in international trade. The traditional way is to measure the gross trade; another option, a more quality one, is to assess the value added embodied in the economic exchange. The traditional way does not capture all ways of participation of firms and countries in complex economic relations. Therefore, a preferred way to examine the position of countries in the world economy is to show their involvement in global value chains.

Global value chains are borderless production systems created due to the fragmentation of production processes and the global dispersion of tasks and activities. These production systems can be sequential chains or complex networks, and their scope can be global or regional (despite their name). The spread of GVCs is more significant in some industries where activities can be more easily separated, such as computers, electronic and electronic equipment, manufacturing of transport equipment, or production of chemical and pharmaceutical products. However, GVCs increasingly involve activities across all sectors, including services. GVCs are typically coordinated by transnational corporations (multinational enterprises), with cross-border intra-firm trades within their subsidiaries, affiliates, branches, and contractual partners.

Recent studies by renowned authors in GVCs research point to four possibilities of active government stimulation of domestic companies´ participation in GVCs and, through this engagement, to ensure greater participation in value creation, thus economic growth of the national economy and consequently the domestic standard of living. The path to value added growth is possible through product upgrading, process upgrading, functional upgrading (new features), and chain or intersectoral upgrading. Governments can positively stimulate automotive clusters in V-4 through better formal rules and regulations concerning the innovation policy, industrial, trade, investment regulations, and competition policies. As V-4 own large OEMs can not be set up in the short- and medium-term at the level of the largest automotive investors in the region, there is greater involvement of the domestic suppliers' network, which must respond to contemporary trends and the unprecedently challenging situation in the automotive industry from 2020.

The most common measure of a country's participation in GVCs is the global value chains participation index, the sum of backward and forward participation indices. The former index refers to the position of a recipient of foreign components (semi-finished products) used in domestic production and then exported. In contrast, the latter denotes the role of a supplier (manufacturer) of semi-finished products used to manufacture final products abroad that are exported to third countries. The backward participation index is the total participation of foreign inputs in gross domestic exports. It can therefore be considered participation in the downstream parts of GVCs. On the other hand, the forward participation index allows measuring the participation of domestically produced inputs used in third countries' production in the gross domestic exports. It may be considered as the participation in the upstream parts of GVCs.

A relatively high value of the backward participation index with a relatively low value of the forward participation index usually means that the country imports foreign semi-finished products, converts them (via, e.g., assembly and packing) into final goods, and exports them. It is reasonable to assume that such a country is internationally competitive in terms of wages, and therefore assembly plants are located there. On the other hand, it is not a leader in innovation. As a result, it buys technologically advanced semi-finished products abroad. Such a country is usually not the home country of the large transnational corporations but hosts their foreign subsidiaries. On the other hand, a relatively high value of the forward participation index with a relatively low value of the backward participation index means that the country is an essential supplier of components used in international production. Such a situation is characteristic mainly for relatively technologically advanced countries, which produce semi-finished products for the needs of foreign assembly plants, i.e., economies with a well–established position of suppliers of technologically advanced products and services, and home countries of the largest transnational corporations, carrying out most of the world's research and development works.

There are four significant drivers of participation in GVC: factor endowments, geography, market size, and institutions. First, the factor endowment includes a complex group of reasons concerning the company's resource-seeking strategy, which refers to the country's natural resources, the labour force, or advanced technologies. The importance of endowment, especially regarding labour force availability and cost, was confirmed by multiple empirical studies. Nevertheless, the effect of differences in labour costs has weakened considerably in recent years when there has been a marked increase in wages in low-cost countries. Highly skilled scientists and engineers are becoming increasingly difficult to obtain in developed economies, causing fragmentation and transfer of processes in search of opportunities to take advantage of skills. In the past, companies used to carry out knowledge-intensive processes since knowledge possessed by the firm was treated as an essential and strategic resource of the firm. Over time, this approach has changed, and many firms began to source knowledge from foreign contractors, dependent (captive offshoring) and independent (offshore outsourcing) ones. Low-skilled labour and foreign capital are critical drivers for backward participation in GVCs. Countries highly supplied with low-cost labour participate in the labour-intensive manufacturing segments of GVCs. Natural resources drive forward GVC integration when foreign investors seek necessary resources in the host country. As a result, foreign capital boosts host country integration in GVCs. It also stimulates upstream sector developments.

Second, companies participating in GVCs take into account distance from other branches, proper infrastructure, and effective communication; thus, geography is one of the critical drivers of GVC. The most important reasons include geographical proximity, market size, and distance, which ensure timely delivery and efficiency of production organization.

The market size constitutes the third driver of GVC participation. The development of GVCs has been encouraged by the liberalization of international trade and the decline in transportation costs. With this respect, tariff reduction results in the growth of the market size and boosts trade in intermediate goods; consequently, the number of processes in the host country rises. Lower tariffs on manufacturing goods in the destination market foster the host country's backward GVC participation.

Fourth, the GVC participation is developing faster in countries that participate in preferential trade agreements (PTAs). It enhances the quality of institutions in the host location because PTAs design legal and regulatory frameworks and harmonize customs procedures and IP protection rules. The GVCs are particularly sensitive to the quality of contractual institutions. Effective policies to attract FDI result in capital inflows, technology development, and management skills improvement. Sectors relying more on contract enforcement see faster growth in GVC participation in countries with better institutional quality.

Czechia, Slovakia, and Hungary are more integrated with global production networks than Poland, as expressed by the values of the GVC participation index. In all V-4 countries, there are more backward than forward linkages, while the ratio of forward to backward participation is decreasing, with the highest result achieved by Poland. V-4 countries are relatively more attractive as a place for processing intermediate goods than as producers and exporters of intermediate goods subsequently used in production and exports of other countries, as indicated by a low ratio of forward to backward participation in GVCs. Services are considerable contributors to exports in all V-4 countries as represented by over 50% share of value added in services in gross exports of all V-4. However, the manufacturing sector is more involved in GVCs than services in all V-4 countries, as indicated by the GVC participation index on the sectoral level. The industries most involved in GVCs in V-4 countries include forward linkages: wholesale and retail trade, motor vehicles, and scientific/technical activities; while in backward linkages, these are motor vehicles, computer/electronic products, and other machinery and equipment.

Characteristics of V-4 countries in regard to the involvement in automotive GVCs

Czechia constitutes a noticeable producer of passenger cars and buses in the EU market with a share of around 10% and 20%, respectively. The said sector is highly export-oriented (ca. 91% of total production was exported in 2021), with a prominent role played by the EU markets. Germany alone absorbs 33% of the production. Due to the crucial role of the automotive industry in GDP, employment, exports, and value creation, there is a sizeable interdependence between the performance of the Czech automotive sector and the overall economic performance of that country. Hence external shocks (e.g., supply chain disruptions, economic downturn, shortages in raw materials) faced by the automotive industry have subsequent impacts on the Czech economy and vice versa. Given the low shares of domestic value added in exports of both intermediary and final products and production, Czechia plays the role of integrated periphery within the automotive GVCs, with the core activities in final assembly. Together with a high level of foreign control and ownership, it adds to the risk of the middle-income trap, for the strategic business decisions regarding the R&D and innovation activities location are made abroad. The potential of governmental policies and measures targeted at the promotion of upgrading within the GVCs is significant, but their effects can be limited.

The most important car producer in Czechia is Škoda Auto a.s. By 2000, Volkswagen got complete control over the company. The Czech automotive industry is different from the other CE countries because Škoda Auto is a corporate headquarter with its own R&D centre, it is a lead firm organising its international production network, sales, and marketing. In the mid-2000s, Toyota and PSA (TPCA) and Hyundai Motor started production in Czechia. On January 1st, 2021, Toyota Motor Corporation became the only owner of the Toyota Peugeot Citröen Automobile Czech s.r.o. Apart from car producers, there is an extensive network of suppliers. Tier-1 suppliers are usually MNEs supplying modular, which follow the lead firms (e.g., Bosch, Brose, Hella, Continental, Valeo, Faurecia, and Witte).

As far as Hungary is concerned, the automotive industry plays a significant role in the Hungarian economy regarding employment, value added and exports. Hungarian automotive production is closely integrated into the global value chains. Similar to other European semi-periphery economies, the automotive industry in Hungary is assembly-oriented. It also means that lower manufacturing functions predominate in the function-based hierarchy of the global value chain. It has not changed in recent years, and technology development has predominantly remained function-driven.

The development of the Hungarian automotive industry within the socialist bloc was dominated by bus and heavy vehicle production and component manufacturing. Presently the Hungarian automotive industry is dominated by component manufacturing and car assembly. There are four automotive OEMs:

Opel (engine production), Audi (auto assembly, internal combustion engine, and EV engine production), and Suzuki (auto assembly) were established in the 1990s, while production at the Mercedes plant (auto assembly) started in 2012. Hungary's fifth automotive OEM is planned to be built by German BMW. Many global suppliers are present in the country (including Bosch, Continental, Denso, Knorr-Bremse, Lear, Johnson Controls, Valeo, ZF), which serve mainly external markets. Most of the investments are today in the production of batteries for electric vehicles. Since 2016, a total of 5.29 billion EUR has been invested in the battery industry, and some 13,757 new jobs have been created (ITM 2021).

According to the presented statistics, transnational corporations play the leading role in the Polish automotive sector, and domestic firms are small and medium enterprises. The leading OEMs in the automotive sector in Poland are Fiat Chrysler Automobiles, Opel, Volkswagen, MAN, Volvo, Toyota, Mercedes-Benz, and Scania. About 60% of the total production in Poland accounted for the manufacturing of intermediaries. A considerable part of produced intermediaries is transformed into final goods in the Polish automotive sector. Global suppliers present in the country are e.g., Kirchoff Automotive, Valeo, Lear Corporation, ZF concern, Brembo, and Nexteer.

The automotive industry in Slovakia is a fast-developing sector, the contribution of which is currently substantial for the Slovak economy, especially for the export competitiveness of Slovakia. The automotive industry's share in Slovak exports equals approximately 34.6%, representing a 2.3% share in global vehicle exports. The dominance of this sector has caused the integration of the Slovak industry into global value chains in the automotive industry, but with less significant integration of its subcontracting capacities in the creation of added value of exported vehicles. The vast majority of car production in Slovakia is divided among the four most significant car manufacturers in Slovakia – Volkswagen Slovakia, a.s., Kia Motors Slovakia, s.r.o. and PCA Slovakia, s.r.o. The motor vehicle industry accounts for approximately 13.1% of the total value of Slovakia's gross production and 6.6% of the total value added. Apart from OEMs, it comprises many suppliers, e.g., Mobis Slovakia, Continental Matador Rubber, SAS Automotive, Continental Matador Truck Tires, Schaeffler, ZF Slovakia, Hanon Systems Slovakia, Yura corporation, Lear Corporation, Adient Slovakia.

The impact of COVID-19 pandemic on GVCs

The disruptions to the GVCs in 2019 and the following years under observation were linked to the pandemic either directly (e.g., closing of borders and limitation to people's movements) or indirectly (e.g., the growing demand for electronics causing the insufficient supply of semiconductors). The pandemic of COVID-19 affected the automotive industry in all V-4 countries. However, there is no evidence of relocation of GVCs to Central European countries as an effect of Covid-19.

In Hungary, the performance of the export-led automotive industry was directly affected by temporary closures and declining demand due to COVID-19. Due to the pandemic, supply chain outages caused factory closures and production difficulties. In 2020, the number of assembled cars fell by 18.4% compared to the previous year. However, supply chain disruptions due to COVID-19 have been a long-standing problem. Thus, the year 2021 did not bring the expected boom in production. Factories in Hungary have been forced to reduce or stop production several times due to raw material and parts shortages.

In Czechia, the decline in the number of produced vehicles due to the stop on production was mainly in April 2020. The annual drop in the number of produced cars and LCVs between 2019 and 2020 was 19%, with 1,152,901 produced vehicles compared to 1,427,563 in 2019. The whole industry suffered a turnover decline of 13%. Yet it is crucial to note that this figure includes only firms in the NACE 29 group. The automotive industry includes firms from other production groups and the services sector. Therefore, the estimated total impact was even more sizeable.

In Poland, the decline was mapped in the production of all means of transport, i.e., passenger cars, buses, trucks, and road tractors, in 2020 compared to 2019. However, the number of engines produced in 2020 was higher than in 2019, and the number of containers, trailers, and semitrailers fell slightly. The analysis of the industry shows that the decline in 2020 vs. 2019 was more substantial for intermediaries (about 17%) than for final goods (about 9%), which confirms Forrester (bullwhip) effect.

Slovakia is the least diversified country in terms of the product portfolio within the V-4 region (exclusive production of the passenger cars). In Slovakia, the production in terms of the number of produced cars declined by 10.6 %. A massive shortage of semiconductors caused a production slow-down and closures of several production sites, which negatively influenced car production and cut the Slovak GDP by 1.2 %. The Russian invasion of Ukraine caused some supply disruptions in the intermediates produced in Ukraine. Significant absorbance of the ACES trends in the Slovak production was only partially reflected by the increased production of BEV and PHEV in Slovakia during the pandemics. Based on the pandemic supply disruptions and political development, some western European car producers are considering investing in significant battery production capacities in Slovakia, which could be considerable potential for the sustainable presence of the industry OEMs in Slovakia. Generally, COVID-19 is not the most severe Slovak automotive competitiveness sustainability problem. The most challenging issue is the e-mobility and the ability of the Slovak suppliers to reflect the requirements of future mobility.

Development of GVCs and upgrading

The automotive industry is experiencing sharp changes in production conditions. The ACES transformation model is decisive: the massive "A" - autonomous vehicle elements, "C" - connectivity and the growing share of vehicle electronics, the expected "E" - electromobility and the impact on manufacturers' product portfolio and the "S" - shared mobility services, where we anticipate a gradual change in the business model and a decline in the priority of vehicle ownership. The trend will play a vital role in the process of better SMEs engagement within the automotive global value chains of the V-4 region.

Higher value added can be achieved through upgrading in which innovations play a crucial role. The emergence of electromobility may allow the companies to step out of the supplier role. We can observe some differences in each company's global and regional strategies. After 2016, there has been a noticeable change in investment, with significant improvements in electromobility and new automotive solutions. The current expansion of automotive production is fuelled by the upswing of demand for some conventional and mainly electric vehicles and by massive investment inflows in the battery industry.

Hungary shows a remarkable production capacity in battery cell production, but the demand for batteries is lagging, perspective battery producers consider massive FDI flows to Slovakia. The leading investors in the production of battery cells for electric vehicles in Hungary are the leading Asian (primarily South Korean) companies. Hungarian industrial policy is inconsistent and fails to coordinate its elements. Some policy components (supporting firms' digitalisation and advanced manufacturing solutions) try to foster the upgrading of incumbent automotive actors and enable a high-road integration of the industry into global value chains. The direct impact of these investments is a process upgrading of resource efficiency and operational excellence. Indirect impacts, such as the increased digital maturity, entail functional upgrading.

Science, technology, and innovation policy programmes, subsidies for hiring researchers and the procurement of high-value testing equipment, and/or fostering industry-university collaborations can also increase parent companies' commitment to delegate high-value assignments to local subsidiaries. It could promote functional upgrading. By contrast, the policy instruments stimulating FDI attraction and retention are characterised by a race-to-the-bottom behaviour. These instruments maintain the dependent market economy model serving the needs of global investors by keeping labour costs low and labour market flexible, and environmental regulations loose. The main problem with this is that it effectively hinders the achievement of the other efforts: those of upgrading.

If automotive investors are encouraged to capitalize on the low-cost features of the V-4 location (primarily Slovakia, Czechia, and Hungary), they are not motivated to upgrade their local activities and invest in collocating research, design, and other quality activities to local production sites. Apart from these, the upgrading of vocational and higher education seems to be neglected, which can hinder the industry's evolution towards a high-road trajectory. Automotive companies find it increasingly hard to hire skilled employees: IT specialists and engineers and technicians with domain-specific and programming skills and operators with at least medium technical competencies. The state should leverage its bargaining power and encourage investors to establish research centres specialising in electric vehicle battery research and to engage in innovation collaboration with local universities (a higher share of BEV on production is in Slovakia). This kind of proactive stimulation of a high-road development should be prevalent not only in the battery manufacturing industry but also in the government-industry relations across the automotive industry

Potential upgrading will be feasible by better absorption of the Industry 4.0 trends implementation by the car producers and their suppliers. The case studies have shown the potential for product upgrading to meet the growing demand for hybrid and fully electric vehicles. Although the demand for electric vehicles is still low in the region (EVs represented merely 11% and 1.2% of passenger cars and buses produced in Czechia in 2020, respectively), there is a clear future course towards electromobility. Concerning the EU plans embodied in the Green Deal and the “Fit for 55” initiative, the production landscape and car parks within the EU are heading towards complete zero-emission transport. Nonetheless, as the Czech automotive industry has been so far highly concentrated on the production of ICE-powered vehicles, it is vital to promote the establishment of utilities necessary for the shift toward EV production, such as giga-factories for EV battery production.

5.2 Policy recommendations

Policy measures should indeed address the issues identified in the SWOT analysis embodied in Table 5.1. The virtues of V-4 automotive sectors can generally be characterized by favourable geographic location, close to the main export markets and the centre of the European Union. FitchSolutions (2020a – 2020d) also points to a low production risk (economic, political, logistics, and operational), especially in Poland, but also in Czechia and Slovakia, and high rewards, reflected in the costs and availability of utilities necessary for automotive production, manufacturing capability, competitive labour costs, and labour force pool. Yet the latter two factors are weaker in Czechia & Slovakia and Slovakia & Hungary, respectively.

The listed weaknesses can be considered in the high dependence on the EU as the export market that absorbs the majority of automotive production and persisting focus on the production of ICE-powered vehicles. Given the ‘Fit for 55’ initiative of the European Commission, from 2035 on, the ICE-powered vehicles will not be sold within the EU, which to date constitutes the crucial export market for V-4 automotive production. In addition, the automotive sector is characterized by a high degree of foreign ownership and control. It can limit the effectiveness of policy measures, for the strategic business decisions are made at the foreign headquarters and do not necessarily reflect the national interests of V-4 governmental policies in terms of upgrading, enhancing innovation, and R&D activities on their territories.

Table 5.1 SWOT analysis of automotive sector in V-4 countries

Strengths	**Weaknesses**
• Geographic location • Historical traditions in the automotive industry and mechanical production • Established position in suppliers' networks • Low labour costs (PL, HU) and high productivity rate • High rewards (PL, CZ, SK) • Production capacity (CZ, PL) • Strong position of the V-4 countries in their value chains • High rates of participation in GVCs • High forward linkages in "motor vehicles" (CZ, HU, SK) • Membership in the EU	• High reliance on the EU as an export market • Relatively high focus on ICE-powered vehicles production • High foreign ownership and control • Low share (except PL) and decreasing domestic value added • Noticeable interdependence between macroeconomic situation and automotive sector performance • Low ratio of forward to backward linkages
Opportunities	**Threats**
• Setting up gigafactories for EV battery production • Closer cooperation with technical universities and research institutes • R&D centres establishment • Low business operations risk • Automation and robotization • Involvement of immigrants from Ukraine as a workforce • Perspective on non-EU export markets • Growing integration with global production networks • Displacement of some production facilities from Asia and Russia • Lasting state subsidies and government investment incentives policy (HU, SK)	• Labour force shortage (SK, HU) • Supply chain disruptions due to raw materials shortage (rare earths, semiconductors) • Future infectious diseases or pandemic • Middle-income trap • Russian invasion to Ukraine and risk of spilling it across borders to V-4 • Political instability or conflicts in Asia • Green deal and 'Fit for 55' putting an end to the production of ICE-powered and hybrid vehicles • Inflation and economic recession as a result of primarily COVID-19 and Russian invasion • Energy security and energy costs in the EU • Insufficient number of specialists, especially STEM (HU, SK) • Low investments in R&D, especially GERD (government expenditure on R&D) • Sustainability of key foreign automotive investors • A mismatch between the V-4 supply and EU demand in terms of the EV market

	• Non-participation in the euro area (CZ, HU, PL) • Competition from Asian automotive producers • Disorganization in transportation as a result of lack of containers and the rising cost of transportation

Source: authors

The V-4 are considerably in charge of the assembly activities within the GVCs, which is reflected, *among other things,* in the low domestic value shares in exports and production compared to the EU or OECD averages. There is a noticeable risk of the middle-income trap. The economic performance of the automotive sector influences the overall macroeconomic situation in the V-4 countries and *vice versa*. It stems from the prominent role the automotive sector plays in the V-4 economies as to the share in employment, exports, and GDP creation. The foresaid interdependence may multiply the negative impacts of external shocks on automotive industries.

As far as the opportunities are concerned, building the gigafactories of EV batteries could foster the region's position in EV production. However, battery production is not an activity associated with the high value added. Investments into robotization, automation, and investment incentive schemes implemented by the governments, targeted at R&D and innovation, could help automotive producers to upgrade within the GVCs. Routine tasks comprising low-skills, and highly repetitive activities are expected to be eliminated by advanced manufacturing technologies. Although the first phase of this process is already over, there is still no meaningful growth in technological unemployment since automation has been implemented in response to increasingly pressing labour shortages that have already jeopardised production. Future investments in further automation are necessary for upgrading the quality of work at the existing automotive manufacturing plants. Automation and digitalisation are indispensable also for improving the competitiveness of the local subsidiaries.

The immigration wave resulting from the Russian invasion of Ukraine started on February 24, 2022 could be seen as an opportunity that could contribute to solving labour force shortages. Yet the question remains as to the sectoral structure of the Ukrainian labour force available and the net effect of the costs of living of Ukrainian refugees in recipient countries. Furthermore, as the ICE-powered vehicles production prevails, the openness of non-EU markets to imports from V-4 and the competitiveness of V-4 in these markets is important. The fact is that the average MFN tariff applied to imports of transport equipment is mostly non-zero (Statista, 2021, p. 22).

The threats the V-4 automotive sectors might be faced with consist in the supply chain disruptions arising from the semiconductors shortages and Russian aggression in Ukraine, accompanied by the related trade and economic sanctions and likely oil and gas supply disruptions. In addition, Ukraine constitutes an important supplier of neon necessary for semiconductors production, while Russia plays a key role in palladium and nickel productions, which are necessary for ICE-powered and EV battery production, respectively (Reuters, 2022). Apart from the supply chain disruptions, the Russian invasion might spill the military operations and conflict across the borders to neighbouring Poland or Slovakia. It represents a sizeable potential risk not only to the automotive industry but the overall economies of the said countries.

The electricity generation mixes, to a noticeable extent dependent on oil, gas, and coal, especially in Poland (more than 80% in 2020) and Czechia (roughly 50%) (IEA, 2022), might not contribute to a sustainable transition to the exclusive role of EVs in newly registered vehicles from 2035 onwards. Yet the current political situation, dependency on Russia as the prominent supplier of oil and gas to the EU under scrutiny, and budget constraints may lead to the postponement of Green Deal implementation. As the V-4 seems to be on the verge of the middle-income trap, the threat is also represented by the Asian automotive producers, who are price competitive and gain increasing ground in global automotive production at the expense of the EU, see, e.g. (ACEA, 2021).

Concerning the SWOT mentioned above, we suggest focusing mainly on the below-listed areas of policy recommendations (three policy recommendations for each field):

Labour market and education system:

1. to adjust the key policies within the legislation better reflecting the new required positions (jobs) for the automotive industry till 2030;
2. to carry out education system changes since assembly and factory workers are identified as job positions that are very likely to be redundant (as a result of automation, digitization, and robotization of the industry);
3. to develop a concept for employing and retaining a workforce from the third countries (primarily Ukrainian citizens) in the automotive industry.

Innovation activity of the automotive suppliers:

1. to anchor the priorities of R&D needs in the legislation related to the automotive industry so that the necessity of adaptation to technological changes as well as the role of V-4 countries in GVCs is more accentuated;
2. to establish a platform (also fiscal incentives) for cooperation among the automotive sector suppliers and technical universities, and R&D institutes that can promote innovations, spill-overs, and knowledge transfer;
3. to create platforms and R&D centres to spread awareness of innovation trends in the automotive industry (primarily e-mobility) and share R&D

outputs reasonably among Tier 1 to Tier 3 suppliers. In particular, it is vital to support networking in the field of R&D - the active support of R&D centres, stimulation for knowledge sharing, and cooperation among companies in the automotive industry.

Regulation and legislation:

1. to propose specific legislation (similar to investment incentives) related to the financing and implementation of research activities in the automotive industry controlled by foreign TNCs that would motivate the implementation of R&D activities in the V-4 host economies;
2. to minimize bureaucracy in the area R&D related costs and to design fiscal incentives for entrepreneurs to motivate them to undertake R&D activities in automotive production;
3. to anchor the specific position of domestic universities and research institutions in foreign automotive manufacturers' eyes to boost and deepen the cooperation between OEMs and these institutions in the V-4 region.

Financing of the innovation activities:

1. to propose a specific action plan for financing and expected outputs of the automotive suppliers' innovation activities in the field of e-mobility and the emerging requirements for innovative domestic products;
2. to strengthen the input of government funds (GERD) as well as business spending in automotive innovation (BERD) through strengthening the research grants financed by public funds;
3. to direct the government bodies' support to the involvement of V-4 business entities in the use of framework programs (EU schemes) in order to support domestic R&D activities.

Other:

1. to educate the entrepreneurs and students (as future entrepreneurs or employees) about GVCs to raise their awareness of issues connected to the international production fragmentation and its consequences;
2. to propose investment incentives for the battery and related parts producers to establish the respective e-mobility production in the V-4 region;
3. to share best practices and success stories of neighbouring countries in the field of automotive industry innovations;
4. to adjust the export policy so that it promotes domestic automotive suppliers in the third countries' markets.

List of tables and figures

Tables

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