Identification and Selection of ICTs for Freight Transport in Product Service Supply Chain Diversification

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Abstract

Following the methodology designed for selecting the best industrial and technological diversification strategy, one of the best methods for achieving the long-term sustainability of companies, this work describes its application in the Service Supply Chains sector, specifically, in Freight Transport in-Product Service Supply Chains. The main contributions of the paper are: (i) the proposal of a taxonomy or functional inventory for ICTs in the Freight Transport Industry (FTI); (ii) the introduction of a new concept, the *technological shrub*, a variant of the technological tree that allows interdependencies between the functionality systems; (iii) the construction of a *technological shrub* for ICTs in a standard FTI firm; and (iv) the multicriteria selection, based on the Analytic Hierarchy Process, of the best diversification strategy that can be incorporated by this standard firm for improving competitiveness. This selection utilises a 'bottom-up' approach.

Keywords: Diversification; Freight Transport; ICT; Product Service Supply Chain; AHP-DSS.

1. **Introduction**

Supply Chain Management (SCM) is one of the topics most widely studied in the field of logistics. SCM has centred on traditional manufacturing-oriented supply chains in which the concept is defined in terms of the events related to the flow and transformation of goods and services from the point of origin to the point of use (Buyukozkan and Cifci, 2011). In general terms, there are four stages: supply of materials; production; storage; distribution and transport.

More recently, researchers have turned their attention to the study of *Service Supply Chains* (SSCs), an approach that alters the manufacturing focus, as it is related to the intangibility, simultaneity, heterogeneity and perishability of the activity (Lo, 2016). The same author contends that SSCs are often characterised by high customer involvement, less structured processing and intangible products that cannot be standardised or stored. Other definitions of SSCs are provided by Ellram et al. (2004) who define SSC management with respect to the management of information, processes, capacity, service performance and funds, from the first supplier to the end-user. Peng et al. (2009) offer a twofold interpretation: in the first, a SSC is seen as the associated service activities of the traditional supply chain; the second demonstrates the application of traditional supply chain theory in the service sector. Cho et al. (2012) argue that suppliers contribute to the production of services as customers that are usually in direct contact.

Tang et al. (2014) envisage an SSC as a network of service organisations engaged in activities that include the supply of the different service components, products or activities and a wide range of participants in both the private and public sectors. At the same time, Wang et al. (2015) distinguish two types of SSCs: (i) *Service Only Supply Chains* (SOSCs) which are defined as the supply chain systems in which the 'products' are pure services (physical products do not play a role); and (ii) *Product Service Supply Chains* (PSSCs), which manage physical products with significant service considerations. Following the latter authors, this paper focuses on PSSCs, more specifically, freight transport companies.

Diversification seems to be an appropriate strategy in several contexts - the common objective being to provide the company with a reduction of the global risk derived from dependence of one or several activities. In addition, the exploitation of synergies in different business and markets supposes a competitive advantage due to the sharing of resources and capacities. However, the decision to undertake a diversification process is full of uncertainty (Muerza et al., 2016) and must be studied in depth. Diversification of service supply chain companies is generally motivated by innovations in *Information and Communication Technologies* (ICTs). The last few decades have been marked by a clear trend towards globalisation and electronic commerce based on the use of new technologies.

Transport represents a third of logistics costs and has a strong influence on the performance of logistics systems (Tseng et al., 2005). ICTs modify parameters of use and operation and their incorporation in companies boosts competitiveness. Freight transportation is a major element of the economy and has had to adapt to changing economic trends (Royo et al., 2016). Freight transport service companies should incorporate ICTs into their services or use them in a process of diversification which would make the company more competitive.

With the objective of adapting to new scenarios and customer requirements, the company must determine if it possesses the suitable resources and technologies for carrying out a new activity. In order to provide an appropriate response to this question, the main aim of this paper is to determine if a freight transport service company could exploit its key ICTs for developing a diversification process based on these technologies. The construction of a functional inventory for ICTs in the freight transport service industry, the identification of the key ICTs for a standard FTI firm and the selection of the best ICTs based diversification strategy following a bottom-up approach are three specific objectives of the paper.

Moreno-Jiménez et al. (2012) and Muerza et al. (2014) proposed a methodological framework that serves as a guide to companies considering a technological diversification process (TDP). Using the TDP methodology described in the previous works and beginning with the technological tree of the firm, we are able to select the services that require innovative ICTs which fit the strategic planning of the company and improve its competitiveness.

This is carried out by means of the application of the Analytic Hierarchy Process (AHP). This simple, intuitive and flexible multicriteria technique is one that best captures changes in philosophy (from mechanistic reductionism to evolutionist holism), methodology (from the search for truth to the search for knowledge), and technology (communication networks) that took place in the latter years of the 20th century (Altuzarra et al., 2007). AHP permits the integration of multiple scenarios, actors and criteria, both tangible and intangible. It has also become one of the most commonly used tools in the resolution of complex problems for a number of reasons: it can integrate the small with the large, the individual with the collective, the objective with the subjective, the deterministic with the stochastic, and it incorporates in the model the multiactors' different visions of reality in the solution of the problem (Altuzarra et al., 2010). The selection of the technological diversification strategy comprises an analysis of the competitiveness of the company, the evaluation of its technological and organisational potential and the construction of the technological tree (GEST, 1986). The result identifies and defines the new applications or services.

Following this introduction the paper is divided into four sections: Section 2 outlines the antecedents to the study and the methodology; Section 3 presents an ICT-based diversification case study in the FTI; Section 4 details a procedure for the selection of the best ICT alternatives for diversification; Section 5 gives the main conclusions that can be drawn from our work.

2. Antecedents

2.1. The Freight Transport Industry

Transport is a key factor in the social and economic development of a country; it not only affects industrial location but it also influences the activities of almost all economic sectors. Transportation and warehousing are probably the most significant logistics costs (Marchet et al., 2009). In Europe, the transport industry accounts for about 7% of GDP - 4.4% of this corresponds to transport services and the remainder to transport equipment manufacturing. More than 5% of EU employment is in transport - 8.9 million people work in transport services and 3 million in the production of transport equipment (European Commission, 2009).

Freight transport is a vital part of a supply chain and a key factor for reducing costs and environmental emissions. Transport plays a connective role in several components of a Supply Chain that result in the conversion of resources into end-user goods. A well-managed transport system can ensure that goods are sent to the right place at the right time and satisfy customers' demands (Tseng et al., 2005). The process of freight transportation is complex due to the variety and number of implicated actors: it involves structured third-party logistics service providers (3PLs), couriers and express couriers, small transportation companies, multi-modal transport operators, rail and sea carriers, dispatchers and receivers (Perego et el., 2011).

ICTs in the FTI should be seen as a primary enabling tool for a safe, effective and efficient operation (Marchet et al., 2009). For Vatovec-Krmac (2007) the use of ICTs in transportation supports information transfer, route and mode planning, choice and delivery of products, electronic identification, mobile communication, managing claims, physical automation, tracking and tracing (long distance and multimodal transport). ICTs differ in complexity, ranging from simple electronic communication to interactive and highly intelligent applications in traffic management and control systems and in-value webs for manufacturing industries (Black and Van Geenhuizen, 2006). Furthermore, ICTs affect road freight transportation through the development of e-commerce, e-logistics and e-fleet management (Yoshimoto and Nemoto, 2005).

2.2. Industrial and Technological Diversification

Diversification is a commercial strategy which emphasises the role of management in the search for new business opportunities and activities (Pitts and Hopkins, 1982). Although the concept has been widely studied, there is little agreement on how to define and measure it. Definitions depend on the approach. They may be made in terms of the economic sector (Hitt et al., 1994), the company's business (Ansoff, 1976; Pitts and Hopkins, 1982; Tan et al., 2007), or they may be multidimensional (Ng, 2007). The classical definition is that of Ansoff, who describes the term in function of the growth options of a firm with regards to both products and markets (Ansoff, 1965).

A *Technological Diversification Process* (TDP) is the search for new products and markets utilising the exploitation of the technological potential of the company through the identification of its key technologies, competitive advantages and potential opportunities (Larrodé et al., 2012). A *key technology* is a strategic technology that is controlled by the company, giving it a position of relative dominance compared to its competitors in a given market over a specific period of time.

The resource-based view (Mahoney and Pandian, 1992) suggests that the competitive advantages of a firm are derived from its internal capabilities; corporate resources are used as motors in the search for new business opportunities in products or services. Technological capability is viewed as a critical asset embedded in a firm's product that includes technological knowledge (typically tacit and developed over time) and technological development capability, often based on learning-by-doing and scientific breakthroughs (Wang et al., 2016).

A company with related diversification generally seeks opportunities to build on its core competences and develop technology in a related area (Kim et al., 2013). According to the latter authors, the use of knowledge combinations outside the core technologies results in a reduction in the ability to use this knowledge profitably and impedes innovative productivity. In addition, *technological diversity* may influence the ability of companies to combine their stock of knowledge with new components resulting in new developments (Quintana-García and Benavides-Velasco, 2008).

Moreno-Jiménez et al. (2012) and Muerza et al. (2014) proposed a three-phase methodological framework, using the firm's key technologies, for the development of a technological diversification process. It was designed to be complemented by a fourth and final phase associated with the evaluation of the selected diversification strategy.

- **Phase 1:** Evaluation of the technological diversification suitability.
    - Stage 1.1: Problem formulation.
    - Stage 1.2: Evaluation of multicriteria suitability.
- **Phase 2:** Selection of the technological diversification strategy.
    - Stage 2.1: Confirmation of diversification suitability.
    - Stage 2.2: Construction of the technological tree.
    - Stage 2.3: Selection of the technological strategy.
    - Stage 2.4: Knowledge extraction and recommendations.
- **Phase 3:** Implementation of the diversification strategy.
    - Stage 3.1: Design of the business strategy.
    - Stage 3.2: The implementation process.
- **Phase 4:** Evaluation of the selected diversification strategy.

The objective of Phase 1 is to evaluate the suitability of a TDP and to identify the suitability of a product development strategy (innovation) and a market development strategy (internationalisation), in accordance with the Ansoff matrix (Ansoff, 1965). If the company is considered as suitable for a diversification process, the next phase involves a more profound analysis to confirm the initial assessment and extract the information needed to draw up the technological tree.

This phase consists of an analysis of the technological (TP) and organisational potential (OP) of the company, an inventory of technologies and the selection of the key technologies. The *technological tree* represents the technological development capacity of the company through its key technologies. The tree roots symbolise generic technologies that are susceptible to different applications in various fields of activity; the trunk is the technological and industrial potential of the company; the branches are the sectors of industrial activity; the sub-sectors and products are represented by the fruit (GEST, 1986).

Moreno-Jiménez et al. (2012) and Muerza et al. (2014) differentiate the *technology tree for a key technology of the company* (there are as many trees as the key technologies owned by the company, and the *technological tree of the company* which integrates the technology trees of all the key technologies.

In this paper, when we use the term *technological strategies*, we are referring to the technological alternatives that can be extracted from the technological tree of the company. These alternatives can be obtained directly (individual fruits or products) or by combinations of fruits from different branches and sub-branches. Once the technological tree is drawn up and the technological alternatives for the diversification process have been identified, the next stage selects the best strategy (products or combinations of products) for the harvest.

Muerza et al., (2014) defined: (i) A ‘Bottom-Up’ or technology-based orientation; and (ii) A ‘Top-Down’, or market-based orientation. The knowledge extracted from the selection of the best strategy is used in the implementation of the diversification strategy which should be evaluated during this operation. Using the taxonomy proposed for ICTs in the FTI, this paper concentrates on the construction of an ICT based technological shrub (a new variant of technological tree) for a standard FTI firm (Stage 2.2 of the methodology), and the selection of its best technological strategy (Stage 2.3) following a bottom- up approach.

2.3. Information and Communication Technologies (ICTs)

Information and Communication Technology (ICT) is a generic term that encompasses a wide range of systems, devices and services used for data processing, telecommunications equipment and services for data transmission and communication. The most powerful attribute that ICT offers to individuals and organisations is intelligence (Kenney and Curry, 2001), i.e. the capability to collect, process, distribute, steer and monitor value chain processes in different locations. ICT is used interchangeably with Information Technology (IT) when referring to the tools used to gather information, analyse and utilise it to increase the performance of the supply chain (Cho et al., 2012). ITs are seen as a company resource, a source of competitive advantage which can serve as a catalyst for change. ICTs are tools for control and management of both internal and external resources (Vatovec-Krmac, 2007).

ICTs play a fundamental role in today's society; they have been successfully applied to a wide range of areas including education, industrial production, and trade. Veselko and Jakomin (2005) believe that the importance of ICTs lies in the following: (i) they are becoming a '*conditio sine qua non*'; (ii) they increase transparency and efficiency; (iii) they enable quick responses, efficient consumer responses, mass customisation and lean and agile manufacturing. Vatovec-Krmac (2007) refers to ICTs as the hardware, software and network technology that is generally seen as supporting human actions or the human performance of business activities.

The objective of *Intelligent Transportation Systems* (ITS) is to provide innovative services for the different modes of transport and traffic management. They are generally defined as a combination of the application of ICTs, the related infrastructure and the legislative/policy framework necessary for optimising transport efficiency and operational sustainability in the future (Giannopoulos, 2009). ICT solutions can increase the data flow and information quality while allowing real-time data exchange in intelligent transportation systems and traffic networks (Crainic and Kim, 2007).

In Europe, research on ITS is led by the European Committee for Standardisation CEN/TC 278- Intelligent Transport Systems, which is divided into a large number of working groups: Electronic Fee Collection and Access Control; Man-Machine Interfaces; Automatic Vehicle Identification and Automatic Equipment Identification; Architecture and Terminology; Systems for the Recovery of Stolen Vehicles; eSafety; Cooperative ITS; Freight; Logistics and Commercial Vehicle Operations; Public transport; Traffic and Traveller Information; Traffic Control; ITS Spatial Data; Road Traffic Data; and Dedicated Short Range Communication.

The introduction and implementation of ICTs in logistics companies is usually motivated by an attempt to reduce costs and improve service (Perego et el., 2011). Utilisation is conditioned by the objective of more efficient freight transport, with lower consumption of resources in terms of labour, fuel, space etc. whilst maintaining or improving the level of service provided to the customer. Sternberg et al. (2014) associate ICTs in freight transportation with innovation in which the specific mechanisms for improving efficiency at both the individual (lorry and driver activity) and aggregate level should be clearly recognised.

In recent years, the implementation of ICTs in transport systems has increased, giving rise to new approaches and models. The value of ICTs is in dealing with critics that may appear during the process of transporting goods to their final destination and in addressing other issues related to the overall transportation performance (Marchet et al., 2009). Black and Van Geenhuizen (2006) discuss the impact of ICTs on transport demand in accordance with use:

- *E-business* (b2c), *e-marketing and customer services*: ITCs reduce transport demand for ordering and delivery of non-material goods, however, more customers around the globe means more routes with smaller loads.
- *E-business* (b2b): Electronic global ordering increases delivery distances with smaller loads. The influence of transport derived from the reorganisation of value chains depends on underlying models.
- *In/outbound logistics and real-time guidance in freight distribution*: Better performance with time aspects that may increase transport distance. Also, a decrease in the number of trips through chaining and load matching.
- *Configuration of value webs*: Impact on transport demand depends on underlying optimisation, e.g. transport costs, production and delivery time, product quality.
- *Remote development and design, and remote diagnostics*: A reduction in the travel demands of R&D personnel, although it is not a substitute for informal creative meetings. ITCs reduce the travel demands of service engineers but this is limited due to legal issues concerning responsibility, liability of partners and network shortages.

3. ICT-based Diversification in the Freight Transport Industry

Assuming the technological diversification suitability of a firm (Phase 1 of the methodology) and an analysis of the TP and the OP of the company with results that satisfy the requirements of the group of experts (Larrodé et al., 2012; Muerza et al., 2014), during Stage 2.1 an inventory of the company's technologies is made and the key technologies are identified.

3.1. Inventory of ICTs in the Freight Transport Industry

After an exhaustive review of the published literature, this section presents a functional inventory of ICTs utilised in the FTI. Giannopoulos (2004) highlights the technologies of the last ten years which have had an impact on contemporary traffic and transportation organisation: (i) GSM (the European system for mobile telephony and data transfer) and other relevant technologies for mobile communications and positioning; (ii) Broadband communications; (iii) First and second generation Internet services; (iv) Dedicated short-range communications (DSRC); (v) General packet radio services (GPRS); and (vi) a series of continuous improvements in speed and capacity for computers and software.

Tseng et al. (2005) suggested that the most commonly used ICTs were: (i) Global Positioning Systems (GPS), for monitoring and dispatching lorries; (ii) Geographic Information Systems (GIS) which provide the basic geographic database for easier and faster deliveries; and, (iii) Advanced Information Systems, which supply real-time information for both managers and delivery workers. For these authors, the benefits derived from the integration of the three systems are better service quality, a reduction in unnecessary trips and an increased loading rate.

Black and Van Geenhuizen (2006) categorise a number of types of ICT innovations in three sustainability areas: (i) *Excessive Driving* - signalisation and navigation systems; (ii) *Congestion Relief* - video surveillance and response, variable message signs (VMS), advanced traveller information systems, advanced drivers' assistance (ADAS) and dedicated short range communication; (iii) *Fatality Reduction* - accident sensors, extended viewing systems (radar, sensors, infra-red), speed advisory/ control, advanced drivers' assistance (ADAS), automated guided vehicles (fixed/in-vehicle).

Vatovec-Krmac (2007) published the following list of the most important ICT elements used by logistics companies: computers; the internet; intranet and extranet; wireless communication/radio frequency systems; cellular phones; finance/accounting systems; bar coding; product scanning; laser technologies; electronic data interchange; vehicle routing; vehicle tracking systems; computer applications for fleet management and optimisation of delivery tours; loading plans; transport management systems; warehouse management systems; enterprise resource planning; supply chain management software; on-board computers; hand-held computers; global positioning systems; automated guided vehicles; automated storage and retrieval systems.

In consideration of their area of application, Giannopoulos (2009) analysed developments in ITSs for freight transport and differentiated between: (i) *E-Business-oriented systems*, including information and decision support technologies, two-way communications, electronic data interchange, computing and data handling technologies, advanced planning and operation decision support systems; (ii) *Freight Operation* (proprietary) *systems*, the traditional logistics systems operating on the level of a single large and, usually, global operating forwarder or integrator; (iii) *Intermodal Transport operating systems* (spanning a number of modes and actors); (iv) *Site-specific ICT systems*, commonly operated at sites such as ports and terminals, terminal gates, freight distribution centres, border crossings etc.; (v) *Transport and other Public Administration related systems*, including systems that implement safety, security or revenue mechanisms and are run by public or private administrations such as customs or port authorities; (vi) *City logistics*; and (vii) *E- Freight.*

Marchet et al. (2009) group the main ICT applications for freight transportation companies into four types, in accordance with the key areas that emerge from the literature: (i) Transportation Management (TM); (ii) Supply Chain Execution (SCE); (iii) Field Force Automation (FFA); and (iv) Fleet and Freight Management (FFM).

Based on a review of 44 papers published between 1994 and 2009, Perego et al. (2011) specify: management systems (e.g. enterprise resource planning and TM applications); B2B systems (e.g. SCE applications); optical identification systems; and Mobile and Wireless systems (e.g. Wi-Fi, mobile technology, global positioning, and radio frequency identification) for FFA and FFM.

Sternberg et al. (2014) studied the technologies and transport information systems that can be observed in practice: (i) *Mobile Communication Systems* (MCS) -mobile terminals, on-board computers, voice communications, network infrastructure, peripheral devices and software interfaces; (ii) *Decision Support Systems* (DSS) -computer systems that assist decision-makers such as routing and the matching of drivers and loads. This includes Enterprise Resource Planning (ERP) systems used for planning, initiating, carrying out, monitoring, and invoicing commercial transactions in the transportation industry; (iii) *Automatic Vehicle/Equipment Identification Systems* (AVEIS) - communication systems consisting of a transponder that is programmed with identification, authorisation, and other types of information unique to the user, equipment, and application; and (iv) *Electronic Data Interchanges* (EDI) which provide intercompany computer-to-computer communication of data, such as Barcoding and RFID.

Finally, and most recently, Harris et al. (2015) gave us examples of the use of ICTs in multimodal transport and freight transport: inventory management systems; transport routing; scheduling (also known as Distribution Requirement Planning); billing systems; electronic data interchange (EDI); and Web-based systems. They also undertook a review of EU FP projects in ICT developments for multimodal transport and identified the technological trends in this area: cloud computing; wireless/mobile communication technologies, Internet, radio-frequency identification (RFID) and near field communication (NFC) based on RFID technology; Web3.0 and social networking; Interface technologies, including augmented reality (AR).

Based on a review of the previous literature, a functional inventory of ICTs in the FTI is proposed in Table 1. This taxonomy consists of 3 functionality systems (information, telecommunication and computing), 6 applications areas (2 for each system) and 49 technologies.

(Insert T able 1 by here)

Table 1. Functional inventory of ICTs in the freight transport industry.

3.2. Case Study: A standard FTI company

This section applies the technological diversification methodology proposed by the authors to a standard transportation firm whose main business is less-than-truckload transport (LTL) in the groupage market - traditional services with point-to-point delivery. Groupage involves collecting goods from a variety of sending customers; the goods are grouped by a sending agency and delivered to the customers. It is a system that optimises freight shipment when the amount of goods is insufficient to fill a whole container. Groupage is characterised by the size of the units transported (ranging from a single package to batches of several tonnes) and the fact that it entails the transport of parcels from a number of shippers to several recipients.

The range of services offered by this type of firm would suggest considering a standard company to serve as a general framework in the LTL groupage market for the development of ICT-based industrial and technological diversification processes. This standard company reflects one of the most outstanding characteristics of its sector: mastery of the three functionality systems (information, telecommunications and computing) gathered in the taxonomy (Table 1). The interdependence of these three systems and the variety of services mentioned above suggest the construction of a new technological tree model adapted to these requirements: the *technological shrub* (Section 3.3).

According to the methodology followed for the TDP, the identification of the key technologies and the construction of the technological tree are carried out jointly by the *Analysis Group* (AG) and the *Firm Group* (FG). In the particular case of the standard company considered, these key technologies, the corresponding associated services, as well as the criteria and valuations used in the AHP for the multicriteria selection of the best diversification strategy, have been provided by the three AG experts. This analysis is based on the professional experience of the specialists (technical director and manager) of the firms that have previously carried out diversification processes with this group of experts (AG).

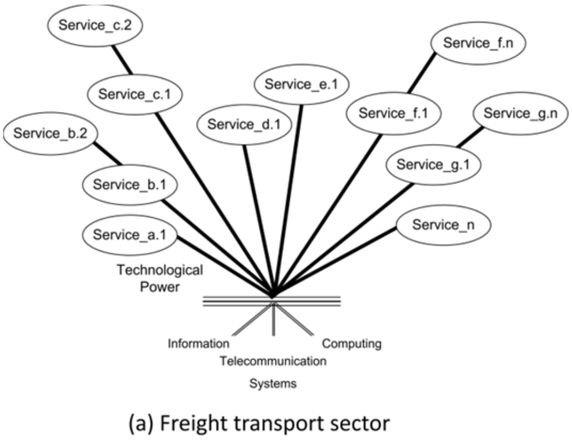
The procedure followed in this case study for a standard company can be applied in any LTL groupage company by specifying in each particular case the key technologies, services offered, criteria and valuations. This task will be performed, according to the methodology followed for the TDP, jointly by the experts of the AG and the specialists of the FG.

3.3. Technological Shrub

The development of the technological tree of ICTs in the FTI is a highly complex problem with interest in several contexts (institutions, sectoral boards, freight companies…) that must be studied in-depth. This tree should focus on the sector's key technologies, whose lifecycle is still in the early phases, and also on emerging technologies. However, the graphical representation of these technologies is different to that proposed by Muerza et al. (2014) because of the three functional systems identified for ICT in the FTI (Section 3.1): Information, Telecommunication and Computing Systems are dependent upon each other when offering a service. This dependence implies that the representation is more a *shrub* than a tree (see Figure 1 (a)), with many branching stems (sub-technologies) and fruits (services).

Based on the ICTs inventory outlined in Section 3.1, as a starting point for the identification of business possibilities for a technological diversification process, the experts of the AG select for this case study the following two key technologies: KT1. *Fleet management systems* which are referred to the best use and organization of the fleet resources (software-controlled), and KT2. *Mobile communication shipped*, derived from the on-board computers, devices and software that the company owns (installed hardware).

According to these technologies, the technological shrub (Figure 1 (b)) is constructed. For the standard firm considered in the case study, the AG experts identified three services or alternatives for each of the two key technologies. For the KT1 (Fleet management systems): A1. *Daily pick and delivery*, typical in pharmacies and banks; A2. *Express parcel*, such as express delivery service; A3. *Home delivery*, typical delivery service of a supermarket, and for KT2 (Mobile communication shipped): A4. *Customer order tracking*, which is the process of gathering and organizing information related to customer orders; A5. *Shipment tracking*, information about the delivering process; and A6. *Display deliveries*, used to show the deliveries to the customer.



(Insert Figure 1 by here)

Figure 1. Technological shrub scheme of ICTs

4. Selection of the best ICT diversification strategy

Once constructed the technological shrub of the company, different diversification strategies (applications, services or portfolios of services) are fixed as alternatives of the decisional problem. Its determination (Muerza et al, 2014) may be provided by the group of experts who collaborates in the diversification process (bottom-up approach), or by the group of specialists from the company itself (top-down approach).

In both cases, the selection of the best diversification strategy will be carried out using one of the most widespread multicriteria techniques due to its realism and flexibility (it works with multiple scenarios, actors and criteria - tangible and intangible): The Analytic Hierarchy Process (AHP). Obviously, other multicriteria approaches can be employed in order to select the best diversification strategy, but the potential of AHP from a cognitive orientation strongly suggests its use (Yepes et al., 2015).

AHP is a multicriteria method used to organize the information and reasoning in a decision making process. It structures a problem as a hierarchy in which the first node corresponds to the goal, the intermediate levels represent the criteria, sub-criteria and attributes, and the final level comprises the different alternatives. Conventional AHP provides in a ratio scale the priorities of the elements being compared. Its methodology consists of four steps (Saaty, 1980):

(1) Modelling the problem or hierarchy construction.

(2) Valuation or elicitation of judgments.

(3) Prioritization or derivation of local and global priorities.

(4) Synthesis or derivation of total or final priorities of the alternatives.

One of the more notable characteristic of the AHP (Aguarón and Moreno-Jiménez, 2003) is that it measures the inconsistency of the actors when eliciting judgments corresponding to the paired comparison matrices (PCMs) (second step of the methodology).

The AHP has been used in the supply chain environment (Cho et al., 2012; Palma-Mendoza and Neailey, 2015) and the selection of technology (Suh et al., 1994; Kim et al., 2010; Amer and Daim, 2011).

For the case study, the construction of the hierarchy and its assessment was developed by the three members of the AG, experts in FTI and multicriteria decision making, using the Expert Choice software (EC v11.1). These experts, by consensus, selected the most relevant attributes to the problem and structured them into a hierarchy which includes the goal, criteria, sub-criteria at different levels, and alternatives.

Considering the goal is the selection of the best diversification strategy, the rest of the hierarchy is determined by four criteria: C1: Economic (ECO), C2: Social (SOC), C3: Environmental (ENV) and C4: Operability (OPE) and twelve sub-criteria: SC1.1: Profitability (PROF), SC1.2: Opportunity in the technology implementation (OPOR), SC1.3: Risk (RISK); SC2.1: Utility provided to customers (UTIL); SC2.2: Service Accessibility (ACCE); SC2.3: Social Acceptability (ACEP); SC3.1: Environmental Impact (IMPA); SC3.2: Clean Technology (CLEA); SC3.3: Project Reversibility (REVE); SC4.1: Existence of the necessary material means (MATE); SC4.2: Human Resources Knowledge (KNOW) y SC4.3: User-friendliness (FACI). The different alternatives have been identified by the group of experts, therefore, it will be followed a bottom-up approach for the selection of the best ICT for a TDP, where judgments are provided by consensus on a direct manner.

In total, six alternatives were studied corresponding to two different key technologies (KT1: Fleet management systems, KT2: Mobile communication shipped): A1: Daily pick and delivery; A2: Express parcel; A3: Home delivery; A4: Customer order tracking; A5: Shipment tracking; A6: Display deliveries.

The local priorities and the global priorities can be seen in Figure 2. The final or total priorities of the alternatives were (also see Figure 2): w(A1) = 0.148; w(A2) = 0.165; w(A3) = 0.122; w(A4) = 0.190; w(A5) = 0.206; and w(A6) = 0.169, and A5 was selected as the best service by the TDP. The ranking of alternatives shows that those based on hardware are the preferred (A5>A4>A6>A2>A1>A3) for a TDP. Moreover, the best alternative or diversification strategy is A5: Shipment tracking. Obviously, as is required in the AHP methodology, all the PCMs present acceptable inconsistencies.

(Insert Figure 2 by here)

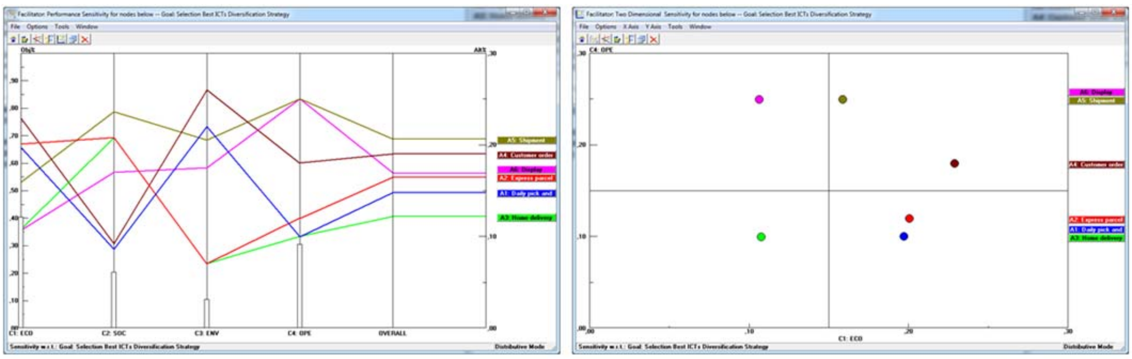
Figure 2. Local, global and total priorities of the alternatives

Expert Choice includes different graphical sensibility analysis tools for supporting the study of the stability of results. The *performance graphic* (Figure 3(a)) gives information on the total priorities of the alternatives and their global behaviour with respect to the criteria.

Considering the set of the four criteria (Cj: j=1,2,3,4), where w(ECO) = 0.400; w(SOC) = 0.200; w(ENV) = 0.100; w(OPE) = 0.300, it can be seen that there are three non- dominated alternatives: A5, A4 and A2, and three dominated: A6, A3 and A1 (A5 $>_{Cj}$ A6; A5 $>_{Cj}$ A3; A4 $>_{Cj}$ A1, $\forall$j=1,…,4). When considering a specific criterion, the following dominations can be appreciated for the three non-dominated alternatives: A5 $>_{Cj}$ {A4, A2} for j= 2,4; A4 $>_{Cj}$ {A5, A2} for j= 1,3; A2 $>_{C1}$ A5 and A2 $>_{C2}$ A4. Using this interactive graphical tool, it is easy to see, for example, that: (i) An increase of over 30% for the priority of the Economic criterion (w_1=0.52), alternative A4 would be the best, and (ii) an increase of 50% for the priority of the Economic criterion (w_1=0.60) and 40% for the Social criterion (w_2=0.28), alternative A2 would be the best, but the likelihood of this last change is very small. In both cases, a phenomenon of rank reversal is produced.

The *bi-dimensional chart* (Figure 3 (b)) reflects the graphical localisation of the alternatives in a bi-dimensional plane where the axes are two of the criteria selected by the decision maker. In the case study, with the two most important criteria, which represent 70% of the criteria's weighting, selected as axes, a slight dominance of alternative A6 with respect to alternative A5 in the Operational criterion, and a clear dominance of alternative A4 with respect to the others in the Economic criterion, can be observed.

The sensitivity analysis confirms that the ranking A5>A4>A6>A2>A1>A3 is robust and that from a bottom-up perspective "Shipment Tracking" (A5) is the best strategy for the technological diversification process.



(a) (b)

(Insert Figure 3 by here)

Figure 3. Sensitivity analysis: Performance and Bi-dimensional graphics

According to the results obtained, the incorporation of new technology in the distribution processes, especially the alternatives stemming from key technology 2, (KT2: Mobile communication shipped) are the most suitable for carrying out a diversification process and making the company more competitive. Nevertheless, it should be pointed out that the case study refers to a framework of reference (standard firm) which should serve as a starting point for its application in a specific company in the sector (LTL).

5. Conclusions

Following the methodology designed by the authors for selecting the best industrial and technological diversification strategy, one of the best methods for achieving the long-term sustainability of companies, this work describes its application in the Service Supply Chains sector, specifically, in Freight Transport in-Product Service Supply Chains. Furthermore, based on a review of the literature, a functional inventory for ICTs in the FTI has been carried out in accordance with the three main functionalities: (i) Information, (ii) Telecommunication and (iii) Computing Systems, which are inter-dependent when offering a service. The identification of such dependence has allowed us to introduce the concept of a *Technological Shrub*.

The three main contributions of the paper are: (i) the proposal of a taxonomy or functional inventory for ICTs in the FTI; (ii) the construction of a *technological shrub* for ICTs in a FTI firm; and (iii) the multicriteria selection, based on the AHP, of the best diversification strategy that can be incorporated by the company for improving competitiveness. The *technological shrub* is constructed in line with the main functionalities associated to the ICTs in the FTI. The selection of the best diversification strategy utilises a ‘bottom-up’ approach.

Due to the fact that this research has been carried out on a generic standard company in a given sector, the key technologies, the services offered, the criteria and the valuations obtained by the group of experts may serve as the starting point in the discussion process to be carried out with the group of specialists of the specific company being analyzed. The use of the technological shrub permits analysis of the high variety of different typologies of services offered by the companies in the FTI, and avoids the need to develop the technological tree in each of its key technologies.

Finally, this bottom-up view of the problem complements the top-down vision followed in previous works (Moreno-Jiménez et al., 2012; Muerza et al., 2014), which basically was based on the opinion of the group of specialists of the company, who proposed the initial set of alternatives that should be considered when contemplating a process of diversification based on technology.

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