# SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEM OF LOGISTICS SERVICE PROVIDERS. A CONCEPTUAL FRAMEWORK AND RESEARCH AGENDA

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***Abstract***

Currently, intensified globalization and consequent competitive pressures have reemphasized the importance of logistics service providers (LSPs) in managing logistics processes as well as customer and supplier relationships within the supply chain management. This requires them to develop their business performance measurement systems (BPMSs) towards supply chain performance measurement systems (SCPMSs) a scope of which depends on the LSP advancement thus whether it operates as a third-party logistics (3PL) provider, a lead logistics provider (LLP) or a fourth party logistics (4PL) provider. However research on the topic of LSP SCPMSs remains scarce as it usually concentrates on SCPMSs of the focal companies orchestrating the whole supply chain (SC). At the same time LSPs have an exceptional impact on SC performance as the operators connecting the SC links, and since they operate within a portion of or the whole supply chains of the sectors they serve, they need to develop not only the internal BPMSs, but also the external SCPMSs. The present paper aims to consolidate knowledge on supply chain performance measurement systems perceived and developed from the perspective of LSPs and makes a three-fold contribution to the discussion. First, it proposes the LSP SCPMS definition. Second, it develops a research framework that distinguishes key issues which need consideration when examining the LSP SCPMSs, namely the LSP advancement, the LSP SCPMS components such as applied subsystems, approaches, ICT technologies and metrics including methods for metric selection followed by the LSP SCPMS adoption consequences, characteristics and life cycle and finally contextual factors constituting stimuli and barriers for the LSP SCPMS development. Then a research agenda is presented to guide future research on the LSP SCPMSs. This work is designed to inspire researchers to continue expanding the knowledge about how to develop high-performing SCPMSs for different supply chain players including LSPs.

**Key words:** LSP supply chain performance measurement system (LSP SCPMS), logistics service providers (LSPs), research framework

## 1. INTRODUCTION

In today's competitive business environment, logistics service providers (LSPs) play a critical role in the supply chains (SCs) of their customers as the operators connecting the supply chain links. Since they affect SC performance they are increasingly viewed as strategic partners who can play an exceptional role in improving SC performance and thereby provide a sustained competitive advantage. Hence, the growing tendency among firms from all sectors to outsource their logistics activities that are more costly and time consuming to LSPs (Ellram et al., 2006). Outsourcing these activities enables companies to reduce costs and focus on their core activities where they build a competitive advantage over adversaries (Christopher, 2005). LSPs play also a key role in facilitating supply chain integration (Mortensen & Lemoine, 2008; Knemeyer & Murphy, 2004) and in some cases even managing entire supply chains (Jayaram & Tan, 2010). Many researchers claim that supply chain will not be effective unless logistics service providers do not measure and monitor the company performance in a flow of functions (such as transportation and warehousing) rather than individual activities (Robertson et al., 2002). To manage the SC of their customers effectively, LSPs need to analyse the data collected from various sources constantly and convert them into actionable information. This requires them to develop their business performance measurement systems (BPMSs) towards supply chain performance measurement systems (SCPMSs). The scope of logistics processes as well as SC members' relationships which need to be measured and monitored within LSP SCPMS will depend on the LSP advancement thus whether it operates as a third-party logistics (3PL) provider, a lead logistics provider (LLP) or a fourth party logistics (4PL) provider. This means that along with the evolution of logistics outsourcing, particularly the emergence of 4PL providers whose competency is mainly to monitor supply chains, specifically supply chain networks, there is also a growing need for LSP SCPMS development.

According to the resource-based view (RBV), company's strategic resources including tangible and intangible resources play a vital role in a firm to generate sustainable competitive advantage (Wernerfelt, 1984; Barney, 1991; Rumelt, 1991; Peteraf, 1993, Teece et al., 1997; Hall, 1992). A performance measurement system (PMS), likewise a SCPMS, constitutes a bundle of strategic resources which helps companies to develop organizational capabilities (including dynamic and ordinary capabilities; see Teece et al., 1997) and enhance organizational learning enabling identification of areas of concern and success through performance monitoring (Star et al., 2016). In case of LSPs, these capabilities, the development of which is mediated by SCPMS, refer to as logistics service capabilities and capabilities to shape and exploit networks. The quality of these capabilities determines the LSPs' success, however it may also influence the success of other SC members.

The traditional RBV argues that supernormal earnings result from resources controlled by a single firm (Barney, 1991). However, the relational view (Dyer and Singh, 1998), an extension of RBV incorporating social network theory (Eisenhardt & Schoonhoven, 1996; Granovetter, 1985) has expanded this focus, with scholarly attention beginning to recognise the importance of resources which lie outside a firm's boundaries (Duschek, 2004; Mathews, 2003). Complementary resource combinations between partnering firms can be a source of their competitive advantage, with the idiosyncratic nature of the relational assets making it difficult for competitors to imitate (Gulati et al., 2000, via Cousins et al., 2008). This means that collaborative relationships within individual SCs and SC networks, which have been rapidly growing across many industries, may lead to the collaborative advantage. Thus, since a PMS can be a source of a competitive advantage of a single firm e.g. a LSP, a SCPMS may be considered within a framework of the collaborative advantage (Dyer & Singh, 1998), rather than one of the competitive advantage, as influencing a SC performance it may generate advantages to all SC actors. The collaborative advantage is a resource that requires a long-term orientation and may ultimately create greater benefits than a traditional zero-sum based approach to competition (Dyer, 2000). Through cooperation, partners can profit from rents that can only be generated by working jointly (Cousins et al., 2008). The ability of the LSP to derive these relational rents is at least, in part, dependent on how effective the LSP SCPMS is in building and leveraging collaborative partnerships with the SC.

The idea which is behind this conceptual paper is to inspire researchers to continue expanding the knowledge about how to develop high-performing SCPMSs for different supply chain players with the special emphasis on LSPs. The paper is organised as follows. The evolution of LSPs is described in Section 2. Section 3 includes a discussion about the differences between BPMS and SCPMS. An attempt at conceptualizing the LSP SCPMS is made in Section 4. Section 5 presents the LSP SCPMS research framework and agenda and Section 6 ends the paper with the conclusion.

## 2. LOGISTICS SERVICE PROVIDERS

Logistics service providers, also called third-party logistics (3PL) providers, provide a variety of logistics related services, including, for instance, transportation, warehousing, distribution and freight consolidation (Domingues et al., 2015). This means that they are usually associated with the offering of multiple, bundled logistics services, rather than just isolated transport or warehousing functions (Leahy et al., 1995). An interesting point of view explaining the differences between the first-, second-, third- and fourth party logistics providers is presented by Lu and Su (2002 via Krakovics, 2008). According to their work 1PL is a small company that executes its own logistics; 2PL is a provider of simple services, such as storage or transportation; 3PL is a logistics operator that offers a whole range of services and management. Its natural evolution is 4PL, which is the single connection between a customer and the logistics operators, being responsible for hiring other 3PL and 2PL, and managing the logistics process end-to-end. Van Hoek and Chong (2001) define 4PL as a supply chain service provider that participates rather in supply chain co-ordination than operational services. It is highly information based and co-ordinates multiple asset-based players on behalf of its clients.

In view of the above, logistics service providers were initially 3PLs. However more recently, a new generation of providers, called lead logistics providers (LLPs) and fourth party logistics (4PL) providers, have radically altered the logistics industry.

They notably offer complete logistics service without necessarily possessing the physical assets (means of transport, warehouses, etc.). These providers are gradually becoming orchestrators within individual supply chains and in the supply chain networks (Fulconis & Paché, 2018). As orchestrators, LLPs and 4PL providers organize and coordinate flows of products for shippers, by mobilizing the logistical capacities of a large number of subcontracting firms.

3PL providers specialize in execution of physical activities linked to transport, handling and storage of products for shippers. These activities may be supplemented by high added value activities like co-manufacturing, co-packing, crossdocking, pooling, reverse logistics, after-sales support and customer service (e.g. customs brokerage) (Jayaram & Tan, 2010). This means that 3PLs are playing ever increasing roles in extended supply chains transforming from movers of goods to strategic value-added entities, what does not change the fact that they generally operate in the road transport sector. Contemporary 3PL arrangements are based on formal (both short- and long-term) contractual relations as opposed to spot purchases of logistics services (Murphy & Poist, 1998).

By comparison, the activities of LLPs and 4PL providers are executed by an LSP that assembles its own resources, capacities and technologies, and those of other providers, to design and steer complex supply chains (DGITM, 2010 via Fulconis and Paché, 2018). Whether they own the means of production, warehouses and trucks (case of LLP) or not (case of 4PL provider), these LSPs mobilize their logistics engineering competencies to optimize flows and select the best providers. They are thus stakeholders that coordinate activities between the shipper, end customer and sometimes other 3PL or 2PL providers. LLPs and 4PL providers may be 3PLs that diversify their offer, management consulting firms, supply chain specialists (global supply chain management) or IT services companies (Fulconis & Paché, 2018). Companies originally specializing in financial services, IT services and management consulting entered the market of logistics services by developing competences in information systems and supply chain planning (Selviaridis & Spring, 2007).

The importance of LSP services has been continuously increasing due to growing number of firms and globalization of their business. The flexibility in service, accuracy in order, and on-time delivery are just prerequisites to compete, while delivery time reduction is real element for the best class logistics networks (Bottani & Rizzi, 2006 via Kumar, 2008).

## 3. BPMS VS SCPMS

The research results indicate that organizations applying integrated performance measurement system as a tool supporting management process achieve better business results than those which do not use it (Lingle & Schiemann 1996; Haffer, 2014). Therefore, during the last decades business performance measurement has been arousing interest of researchers and practitioners of many different disciplines in the field of management such as strategic management, quality management, operations management, process management, human resources management, information systems management, marketing management, finance management and management accounting. Each of these disciplines contributes to the development of performance measurement approaches, methodologies and systems.

At the same time, there is lack of consensus among the representatives of the mentioned disciplines about how to define business performance measurement system (Dumond, 1994). Diversity of the research carried out in the field of performance measurement makes it even more complicated. Such a thesis may be well illustrated by the BPMS definition review found in the literature (Franco-Santos et al. 2007). From an operations management point of view, performance measurement system is usually defined as a set of metrics used to quantify both efficiency and effectiveness of actions (Neely et al., 1995) which is very often defined from four different measurement perspectives: financial, customer, internal, as well as learning and growth (Kaplan & Norton 2004); or as the reporting process that gives feedback to employees on the outcome of actions (Bititci et al., 1997). Strategic management perspective makes it possible to capture two other aspects of the BPMS. Firstly, it reflects the procedures used to cascade down the business performance measures used to implement the strategy within the organization (Gates, 1999). Secondly, the BPMS provides the organization with the information necessary to challenge the content and validity of the strategy (Ittner et al., 2003). From a management accounting perspective, the BPMS is considered to be synonymous with management planning and budgeting (Otley, 1999).

The issue of measuring performance along the supply chain has been raised, probably for the first time, only in the late 90. of the previous century (Van Hoek, 1998). Also, one of the first SCPMS frameworks was proposed in 1999 (Beamon), whereas previous articles had only focused on costing models for inter-firm activities (e.g. Cavinato, 1992; Ellram & Feitzinger, 1997).

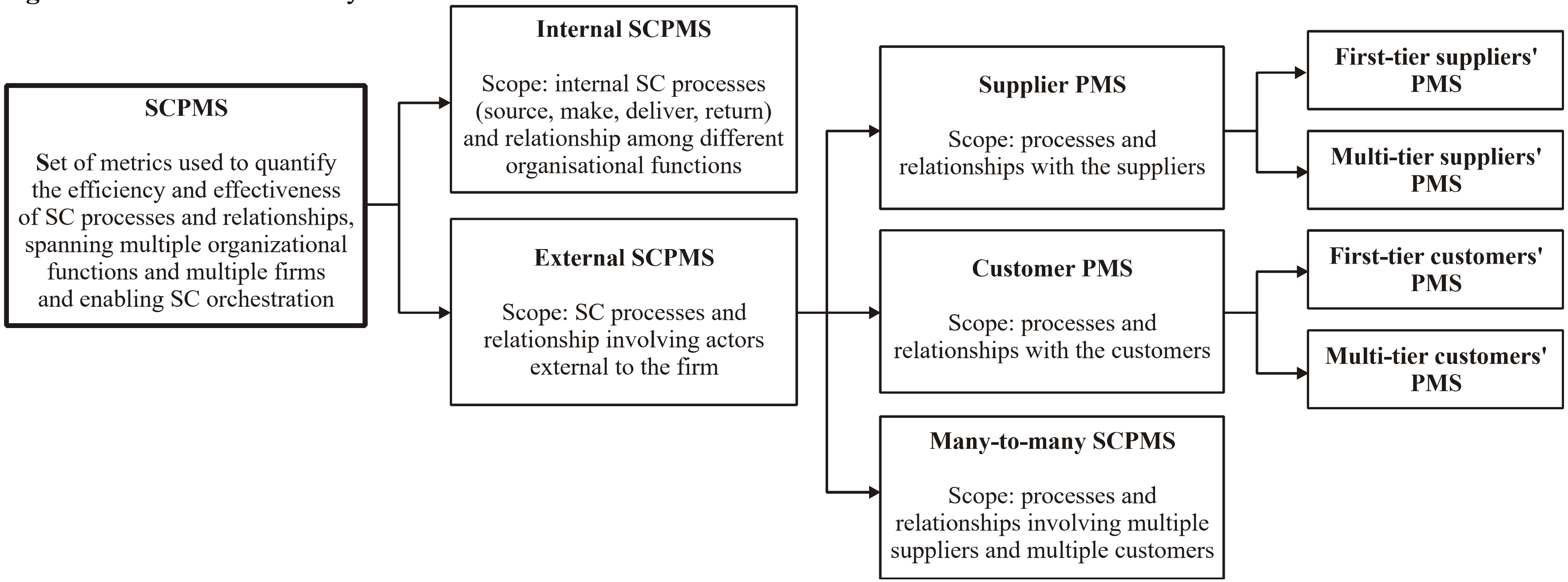
The definition of SCPMS goes beyond the one of BPMS (see Figure 1). While a BPMS, according to the above-mentioned definition, is a set of metrics used to quantify the efficiency and effectiveness of actions aimed at supporting the implementation of strategies at various levels, a SCPMS is defined as a set of metrics used to quantify the efficiency and effectiveness of supply chain processes and relationships, spanning multiple organizational functions and multiple firms and enabling SC orchestration (Maestrini et al., 2017). Thus a SCPMS is a much more complex system comparing to a BPMS which is usually referred to as one of the SCPMS components namely the internal SCPMS. In such a case its role is to monitor and control the processes that take place within the firm's boundaries (the source-make-deliver sequence according to the SCOR model).

Instead, the external SCPMS is intended to monitor and control the inter-firm processes and relationships and can be further decomposed into a supplier PMS and a customer PMS (Maestrini et al., 2017). A supplier PMS can be defined as a set of metrics measuring the efficiency and effectiveness of suppliers' actions and the goodness of the relationship with them (Hald & Ellegaard, 2011; Luzzini et al., 2014), whereas a customer PMS as a set of metrics measuring the efficiency and effectiveness of customers' actions and the goodness of the relationship with them. Within external SCPMS companies usually focus on the immediate supplier or customer rather than encompassing multiple SC tiers (e.g. supplier's suppliers or customer's customers), because of technological barriers or relational inertia (Barratt

& Oke, 2007; Barratt & Barratt, 2011). Nevertheless, synthetic information on critical performance from various downstream or upstream parties (avoiding information overload) could improve the alignment of the extended SC, thus achieving both single-firm and overall SC objectives (Maestrini & Luzzini, 2015).

Lastly, many-to-many SCPMS which is a set of metrics used to quantify both the efficiency and the effectiveness of inter-firm processes shared by multiple buyers and multiple suppliers (Maestrini et al., 2017) needs to be indicated as another category of external SCPMS according to the most recent studies (Stefanović & Stefanović, 2011, Raj & Sharma, 2015; Cecere, 2014). This type of SCPMS can be found in such industries as automotive, pharma and retail. In these cases the SCPMS is usually developed as a web- or cloud-based solution by a third-party IT service provider for the benefit of all supply chain actors and is promoted by a focal company or an industry association as a shared tool to solve specific SC challenges. The system enables a flexible many-to-many type of interaction, whereby it can be decided which type of information is shared and by whom (Maestrini et al., 2017).

**Figure 1.** Definition and subsystems of SCPMS




Source: Maestrini et al., 2017, adapted by the author

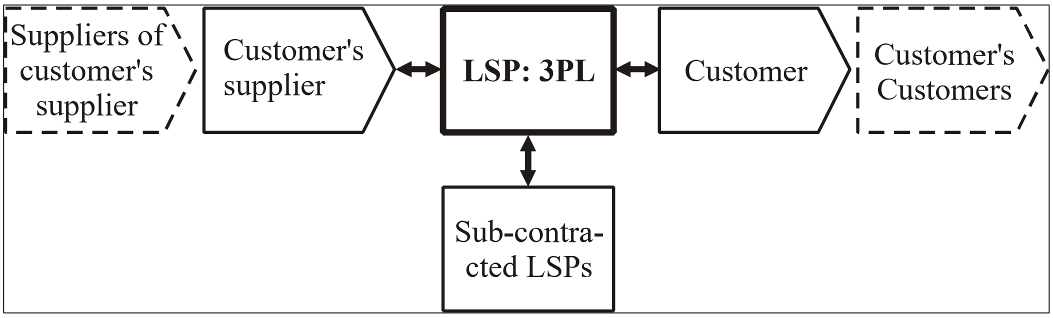
## 4. LSP SCPMS – DEFINITION AND SUBSYSTEMS

Despite the increased interest in applying and improving SCPMS, the number of researchers investigating the whole life cycle (design, implementation, use and review) of SCPMSs is still not sufficient, as most works focus on the SCPMS design phase, with particular emphasis on the identification and description of metrics (Maestrini et al., 2017). In case of the most sophisticated SCPMSs equipped with external SCPMSs, such as multi-tier SCPMSs and many-to-many SCPMSs, there is no literature and research evidence or it is anecdotal (Maestrini et al., 2017). There are also only few studies in SCPMS referring to LSP industry (e.g. Choy et al., 2008; Kayakutlu & Buyukozkan, 2011; Jothimani & Sarmah, 2014), as the majority of LSP studies refer to BPMS, unlike SCPMS (Sun and Hu, 2010; Wong et al., 2014; Wang et al., 2015; Domingues et al., 2015; Joo & Yun, 2017). At the same time, since LSPs may operate within the whole supply chains of the sectors they serve, they need to develop not only the internal, but also the external SCPMSs. Hence, LSPs, being a strategic SC member of their customers, not only develop critical performance indicators set for assessing their logistics operations, but also create a PMS for measuring the capability of other members within the chain by focusing on sub-contracted LSPs and customers' suppliers (Choy et al., 2008). Thus they develop the external subsystems of their SCPMSs which enable them to orchestrate a whole or a part of SC depending on their advancement as the LSPs, reflected in three generations of providers: from 3PL through LLP to 4PL.

If a LSP operates as a typical 3PL provider between at least two links of the supply chain i.e. connects the 3PL customer with customer's supplier providing them with a variety of logistics related services, then it may naturally develop its PMS towards first-tier external SCPMS such as first-tier PMS of customers and customers' suppliers as well as first-tier LSP suppliers' PMS which encompasses sub-contracted LSPs. The scope of such a 3PL SCPMS is shown graphically in Figure 2. Of course, it may need to be extended along with growing number of customers within the same supply chain or the other ones.

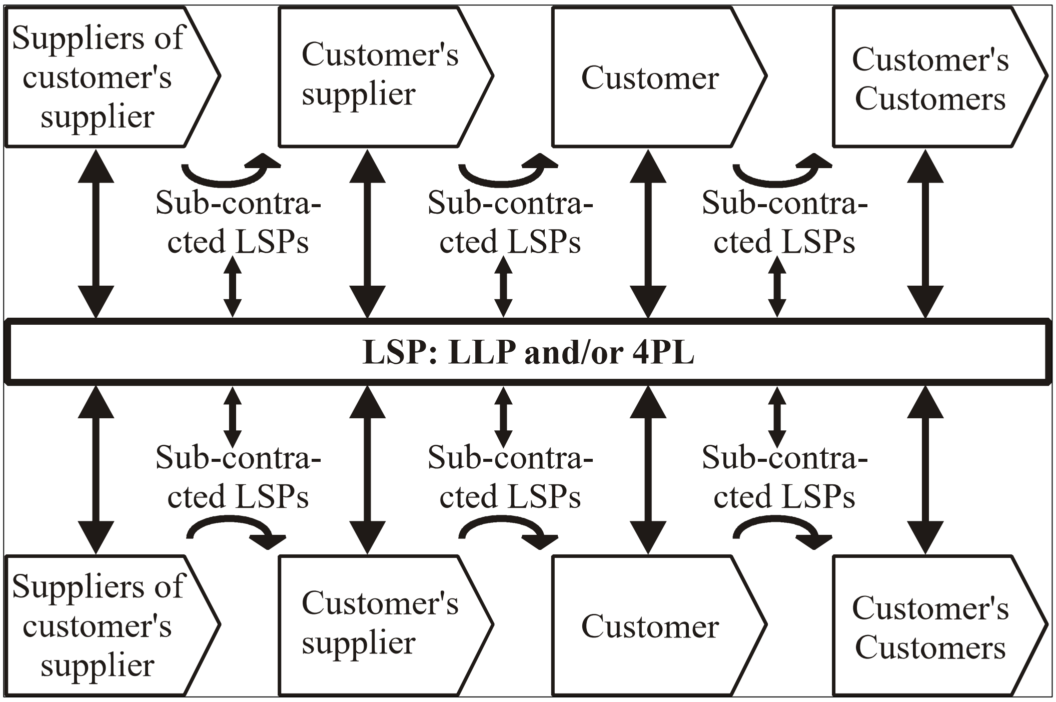
If a 3PL provider evolves and becomes a lead logistics provider (LLP) or a fourth party logistics (4PL) provider, than its PMS also needs to be upgraded. It can be potentially supplemented with such external subsystems as first-tier or multi-tier PMS of customers and customers' suppliers, first-tier or multi-tier LSP suppliers' PMS as well as many-to-many SCPMS. At the same time SCPMSs of LLPs and 4PL providers may encompass actors of different SCs making these providers the orchestrators in the supply chain networks (Fulconis & Paché, 2018). The scope of a LLP/4PL SCPMS is shown graphically in Figure 3.

**Figure 2.** Scope of SCPMS for LSP: 3PL




Source: the author

**Figure 3.** Scope of SCPMS for LSP: LLP and/or 4PL

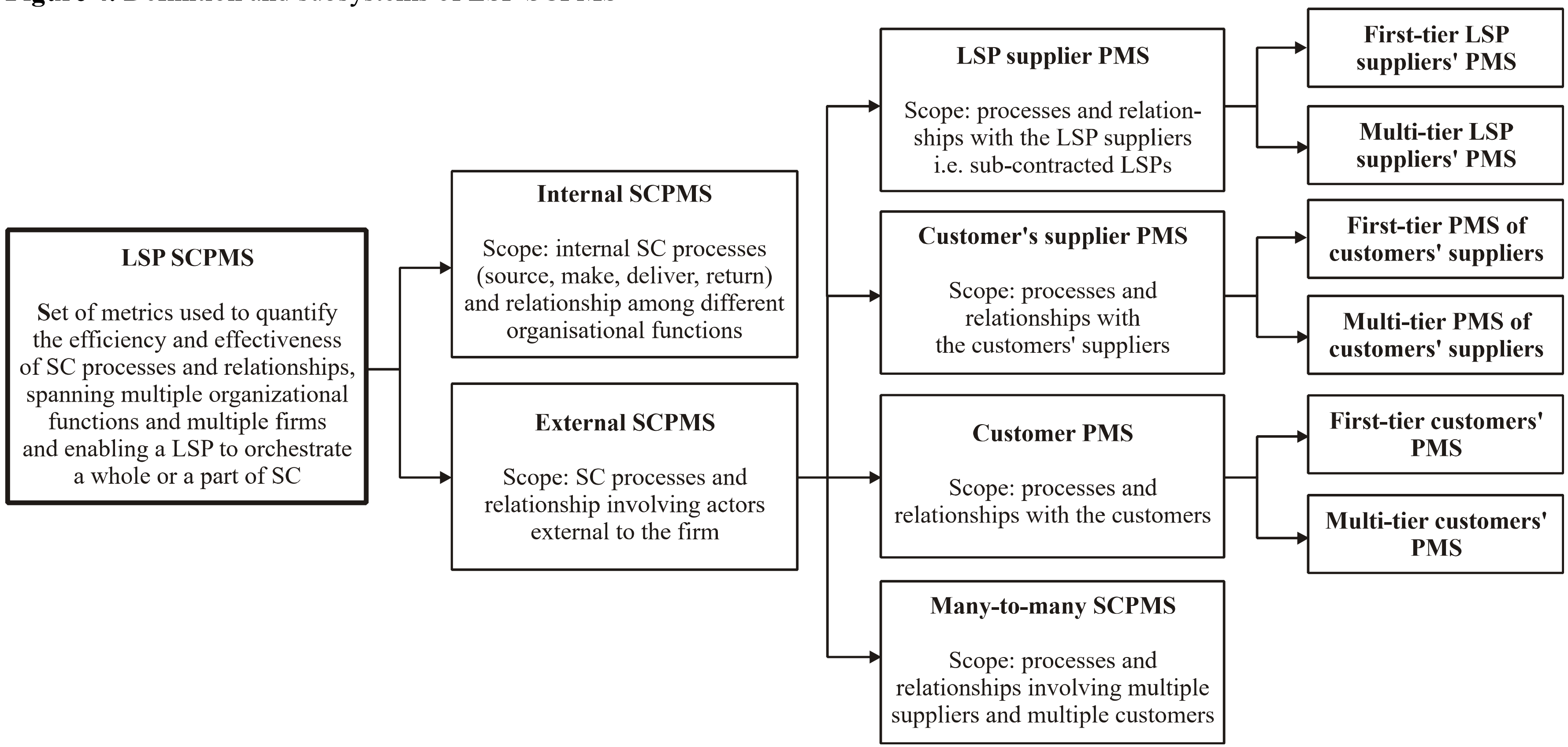



Source: Fulconis & Paché, 2018, adapted by the author

In view of the above, it is proposed to define a LSP SCPMS as a set of metrics used to quantify the efficiency and effectiveness of SC processes and relationships, spanning multiple organizational functions and multiple firms and enabling a logistic service provider to orchestrate a whole or a part of SC. The definition and structure of the LSP SCPMS along with a scope description of each subsystem is presented in Figure 4.

Taking into account the level of complexity that an LSP SCPMS might reach, the system is split into its different subsystems, as a single LSP might be willing to monitor not necessarily the entire set of processes involving all the SC tiers but only one portion of a supply chain it serves. Thus in the first layer two subsystems are distinguished, namely the internal and external SCPMSs. The role of an internal SCPMS is to monitor and control the processes that take place within the firm's boundaries (the source-make-deliver sequence according to the SCOR model) and

**Figure 4.** Definition and subsystems of LSP SCPMS




Source: the author (based on Maestrini et al., 2017) relationship among different organisational functions. In turn, the external SCPMS is intended to monitor and control the inter-firm processes and relationships.

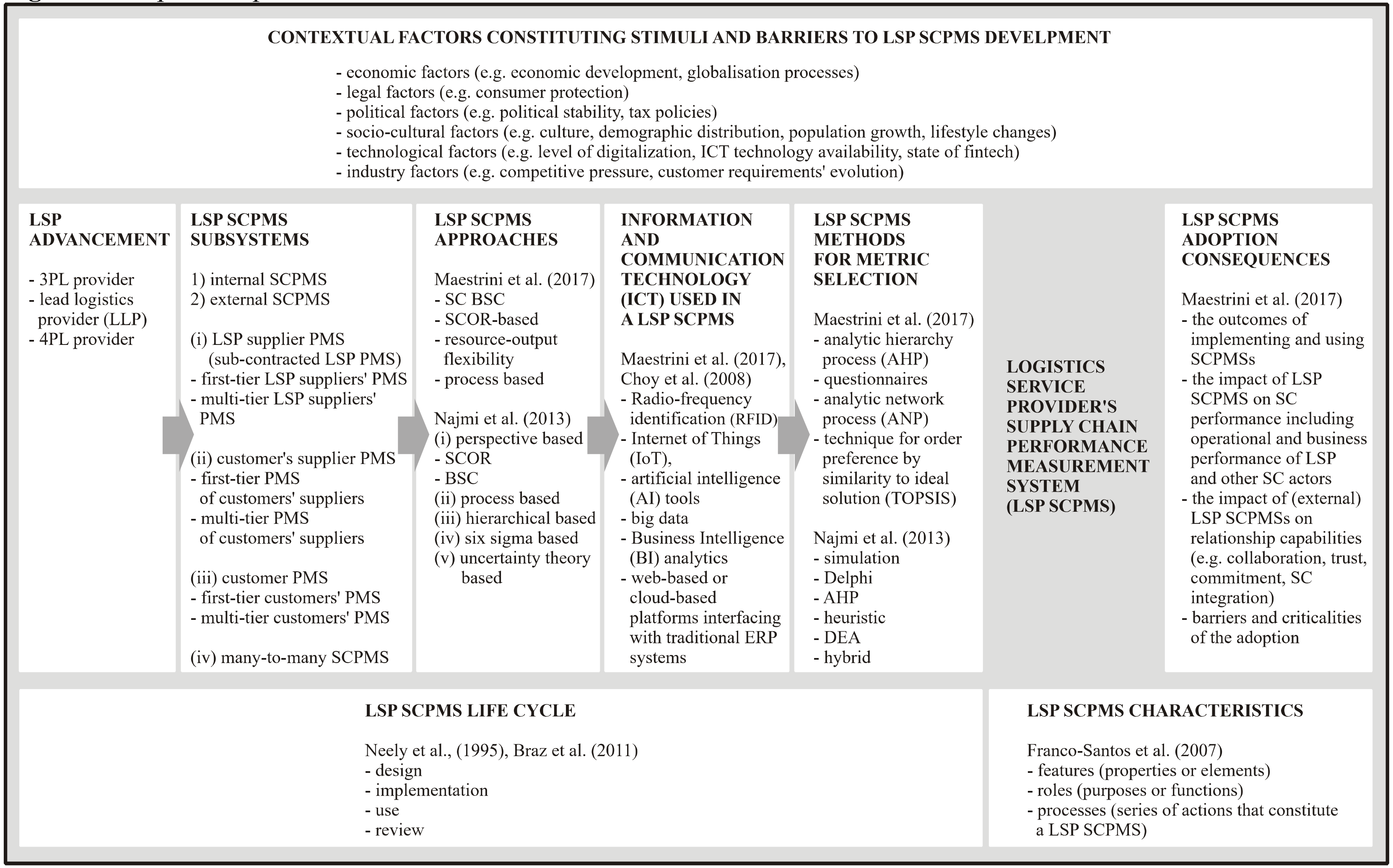
In the second layer only external SCPMS is further decomposed into (i) a LSP supplier PMS, (ii) a customer PMS, (iii) a customer's supplier PMS and (iv) many-to-many SCPMS. As regards three first foregoing components, they can be defined as a set of metrics measuring the efficiency and effectiveness of actions of (i) LSP suppliers, (ii) customers and (iii) customers' suppliers, respectively, and the goodness of the relationship with them. Instead, a many-to-many SCPMS is a set of metrics used to quantify both the efficiency and the effectiveness of inter-firm processes shared by multiple buyers and multiple suppliers. In this case the SCPMS can be developed as a web- or cloud-based solution by a third-party IT service provider for the benefit of selected or all supply chain actors and is promoted by a logistics service provider as a shared tool to solve specific SC challenges. In case of 3PL providers these actors could be only first-tier partners i.e. the LSP suppliers such as the sub-contracted carriers, the LSP customers and their suppliers. In case of LLPs and 4PL providers a many-to-many SCPMS could encompass multiple SC tiers including LSP suppliers' suppliers, LSP customers' customers and suppliers of customers' suppliers. A distinction between the first-tier and multi-tier partners included in the LSP SCPMS is drawn in the third layer of the scheme presented in Figure 4.

As far as the issue of SCPMSs is concerned, it is necessary to emphasize that the existing frameworks usually take into consideration a perspective of the focal actors of supply chains. Thus, it is anticipated that the foregoing definition of LSP SCPMS and its subsystems, which focuses on the perspective of LSP industry, may add value to the scientific discussion about SCPMS development and clarify the scope of the further research.

## 5. CONCEPTUAL FRAMEWORK AND RESEARCH AGENDA

Now that the definition of logistics service provider's supply chain performance measurement system was developed, a broad framework of LSP SCPMS will be proposed (see Figure 5). Elements in the framework include the LSP advancement, the LSP SCPMS components such as applied subsystems, approaches, information and communication technology (ICT) and metrics including methods for metric selection followed by the LSP SCPMS adoption consequences, characteristics and life cycle and finally contextual factors constituting stimuli and barriers for the LSP SCPMS development. These elements of the framework are recognized as issues worth considering in research on LSP SCPMSs. However it should be stressed that they are not fully complementary as they have some common parts, e.g. ICT technology used in LSP SCPMSs can be considered as the contextual factor determining the development of these systems or the methods used for metric selection in LSP SCPMSs are the foundation of uncertainty theory based approach applied in system design. Different configurations of the framework components may be used when designing a research and formulating research questions. In the following sections, a short description of each element of the framework will be provided as well as directions for further research will be pointed out.

**Figure 5.** Graphical representation of the framework for LSP SCPMS




Source: the author

The contextual factors constitute the overarching setting and are listed on the upper part of the framework. Contextual factors consist of economic factors, such as the level of economic development (developed economies, economies in transition, and developing economies), globalisation processes, economic growth rates, financial crises, levels of employment, interest rates or inflation rates; legal factors (e.g. consumer protection), political factors (political stability, terrorism, tax policies, etc.), socio-cultural factors (such as culture, demographic distribution, population growth rates, lifestyle changes), technological factors (level of digitalization, accessibility of ICT technology including state of fintech, etc.), and industry factors (competitive pressure, customer requirements' evolution, etc.). Within a group of these factors stimuli and barriers for the LSP SCPMS development may occur.

As regards the LSP advancement (described in chapter 2) it is interesting how the LSP SCPMSs differ depending on whether a logistics service provider operates as a third-party logistics provider, a lead logistics provider or a fourth party logistics provider. These differences may concern the approaches adopted, subsystems developed (described in chapter 4), ICT technology used as well as methods for metrics selection applied. Especially an application of the external SCPMSs needs to be recognised. More probably 3PLs develop first-tier PMSs and LLPs as well as 4PLs apply multi-tier PMSs, however this should be examined. The question is also how great an insight into the operations of the SC partners on the next tiers is needed in order to manage effectively the SC information and material flow. Do LSPs apply many-to-many SCPMSs on first-tier level or maybe only on multi-tier level? Do they develop web- or cloud-based solutions by themselves or they outsource them from a third-party IT service provider. What kind of ICT technology they use to assure access to real-time data and efficient SC management?

The LSP SCPMS approaches determine the types of metrics to be adopted and the SCPMS component to be tackled. According to Maestrini et al. (2017) the SCPMS approaches recurring most often in the literature include the following:

- Supply chain balanced scorecard (SCBSC). The well-known four dimensions of the BSC developed by Kaplan & Norton (1992) (i.e. finance, customer, internal business process, learning and growth) are shaped according to the scope of supply chain management (SCM), by considering: SCM goals, end-customer benefit, financial benefit, SCM improvement. The idea behind the SCBSC is to design an SC strategy coherent with the business strategy, including critical success factors within the four performance dimensions above.
- SCOR-based. The supply chain operations reference (SCOR) model developed by the Supply Chain Council (SCC) in 1996 is an important reference for both researchers and practitioners in the area of SCM. An SCOR-based SCPMS provides a balanced set of performance measures: cycle time metrics, cost metrics, service quality metrics and asset metrics. These metrics are then grouped according to the five distinctive management processes, namely plan, source, make, deliver and return. In some cases metrics are also classified according to their strategic, tactical or operational nature. This approach aims to link the internal SC (make) with the external upstream (source), downstream (deliver) and return (reverse) SC.

- Resource output flexibility. This approach is based on the above-mentioned work of Beamon (1999). Three performance areas are considered: resources (various dimensions of cost are monitored, e.g. distribution cost, manufacturing cost, with the purpose of fostering efficiency); output (various dimensions of customer service are reported); flexibility (it measures the ability to respond to a changing environment). This approach is thought to assess the SCM capabilities of a specific firm and keeps a mainly internal perspective.
- Process-based. The unit of analysis is the supply chain process: demand management, order fulfilment, manufacturing flow management, procurement, demand forecasting and so on. Quantitative and qualitative performance measures to assess the efficiency and effectiveness of each supply chain process are proposed. These processes entail activities performed by different actors and thus include multiple firms in the evaluation process.

Najmi et al. (2013) in their proposal of the SCPMS approaches point out like Maestrini et al. (2017) three identical approaches, namely, the process-based as well as SCBSC and SCOR-based approaches, with the last two under the perspective-based brand, as well as three additional approaches which are as follows:

- Hierarchical based. An example of this approach is a use of the hierarchical metrics. In this case they are classified into strategic, tactical and operational levels of management. They can be next grouped in cells at the intersection of planning level and the supply chain activity (i.e. plan, source, make/assemble, and deliver) or the category of BSC (i.e. finance, customer, internal business process, learning and growth).
- Six sigma based. Six-sigma approach was developed by Motorola in 1987 (Xu, 2008). The six-sigma metrics can be used for performance measuring of various processes and entities on a common scale and for benchmarking against world-class standards. Six-sigma approach makes it possible to measure the overall performance of supply chain system processes and cascade down to the lowest level, where those activities of a sub process within an individual organization process take place. The common six-sigma metrics are dpo (defects per opportunity), dpu (defects per unit), z-value or the sigma value, throughput yield, rolled throughput yield, etc.
- Uncertainty theory based. The models of SC performance evaluation system which are developed on the basis of this approach are expected to consider fuzzy environment. For this purpose the authors apply different methods such as a fuzzy set theory model (Chan & Qi, 2003) favouring fuzzy ratios for selecting measures, a fuzzy preference matrix (Parkan & Wang, 2007) to derive decision makers' subjective ranking of the metrics or a fuzzy resolution approach (Chen and Larbani, 2005) to focus on the SC performance with respect to various alliances among partners.

The next issue in the proposed framework are the methods used in LSP SCPMSs for metric selection. Concerning the metrics, most approaches entail both financial and non-financial as well as both quantitative and qualitative metrics. In this respect, a consistent stream of literature addresses the process of metric selection in SCPMSs, proposing the application of mathematical algorithms and techniques. Some of them were mentioned above when describing uncertainty theory based approaches to system design. According to Maestrini et al. (2017) the techniques that literature most often refers to are as follows:

- Analytic hierarchy process (AHP). AHP method, proposed by Saaty (2008), is a widely used method for decision making. It is a framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to the overall goals and for evaluating alternative solutions by pairwise comparison. It has been used several times to help decision makers in KPI selection. When the AHP is performed in a fuzzy environment, application of fuzzy AHP (FAHP) is recommended.
- Questionnaires. A method consisting of a series of questions with the purpose of gathering information from different respondents and making a proper synthesis to guide decision making.
- Analytic network process (ANP). The ANP is a more general form of the AHP used in multi-criteria decision analysis. The AHP structures a decision problem into a hierarchy with a goal, decision criteria and alternatives; on the other hand, the ANP structures the decision problem as a network of possibilities. Like the AHP, it is developed through a system of pairwise comparisons to measure the weights of the components of the structure and finally to rank the alternatives in the decision. When the ANP is performed in a fuzzy environment, application of fuzzy ANP (FANP) is recommended.
- Technique for order preference by similarity to ideal solution (TOPSIS). TOPSIS is proposed by Chen & Hwang (1992) and is one of the principal techniques for MCDM problems. The TOPSIS method is used for normalization and final ranking. It defines two kinds of solutions: the ideal solution, and the negative ideal solution. The ideal solution is regarded as the maximal benefits solution; it consists of all best values of criteria. On the contrary, the negative ideal solution is treated as the minimal benefits solution; it is composed of all worst values of criteria. TOPSIS defines solutions as the points which are nearest to the ideal point and farthest from the negative ideal solution at the same time. (Jothimani and Sarmah, 2014). This technique can be applied to compensate for the imprecise ranking of the AHP.

Najmi et al. (2013) in their proposal of the methods used in LSP SCPMSs for metric selection point out like Maestrini et al. (2017) AHP as well as five additional techniques which are as follows:

- Simulation. The main objective of using the simulation technique for SC performance evaluation and modelling is learning about the interrelations among parameters in the SC. Such a supply chain simulation study can be used, for example, to evaluate alternative supply chain designs with respect to quality, lead-times and costs as the key performance parameters (Persson & Olhager, 2002).
- Data envelopment analysis (DEA). There are diverse applications of DEA in the SC performance evaluation process, e.g. it can be used as a tool for measuring SC efficiency (technical and cost ones) based on inputs and outputs variables (Wong & Wong, 2007) or as a benchmarking tool for supply chain performance measurement (Wong & Wong, 2008).

- Delphi. This technique can be utilized to tackle the SC performance evaluation problem. The Delphi technique is a systematic, interactive forecasting method, which allows obtaining forecasts from an independent panel of experts, over two or more rounds. An example of Delphi technique application can be the study of Bigliardi and Bottani (2010) where authors adopted this technique with the aim of obtaining a high degree of consensus on the key performance indicators to be included in a model for the food supply chain management.
- Heuristic techniques. Heuristic techniques are not a formal problem-solving model as such, but can be used as an approach to problem solving, where solutions are not expected to produce a perfect or optimal solution. They find application also in the SC performance evaluation. The study of Angerhofer and Angelides (2006) is a good example of heuristic techniques utilization. The authors modelled the constituents (i.e. topology, levels of collaboration of the stakeholders, processes, supporting technology, and the business strategy employed) of a collaborative supply chain, key parameters they influence and performance indicators.
- Hybrid techniques. When developing the models for SC performance measurement also hybrid techniques can be used, e.g. the Choquet integral operator and MACBETH techniques extended by considering the SCOR model break-down for expressing the overall performance of a SC (Berrah & Cliville´, 2007).

The next element of the presented framework is ICT technology used in LSP SCPMS. According to various authors (Choy et al., 2008; Maestrini et al., 2017; Tan et al., 2006), diverse information technology solutions are being used in SCPMSs to quickly and reliably collect and analyse data, starting with basic technologies and ending with more advanced, namely RFID, Internet of Things (IoT), artificial intelligence (AI) tools, big data, Business Intelligence (BI) analytics and web-based or cloud-based platforms, which are able to interface with traditional ERP systems. Indeed, the role of ICT technology is of primary importance to configure and implement any PMSs and external SCPMSs in particular (Nudurupati et al., 2011).

To measure supply chain performance in the LSP industry, firms need to incorporate parameters on operations efficiency and service effectiveness to ensure that they have a balanced framework (Lai et al., 2004). Also, a more symmetrical balance between internally focused and externally oriented measures is needed for the design of performance measurement system in the SCM (Choy et al., 2008). Additionally, as LSPs offer their customers a wide range of logistics services such as transportation, warehousing, inventory management, etc., which may be partially or fully sub-contracted and preferably are integrated, or bundled together, by the provider, there is a need to measure and monitor the company performance in a flow of foregoing functions rather than individual activities. At the same time it is shown by a recent literature survey on logistics and supply chains that there is still a big gap on reconsidering inter-functional and inter-company measures (Sachan & Datta, 2005). It all makes the complexity of LSP SCPMS need to grow.

Therefore, the role of a real-time Business Intelligence (BI) approach to SC analytics, supporting firms such as LSPs that are service oriented and seeking customer loyalty and retentions, cannot be overestimated. (Jothimani & Sarmah, 2013). Lastly, also AI tools, IoT, big data and web-based or cloud-based platforms have played an increasingly important role in today's industrial applications as facilitators of the SC performance measurement process (Tan et al., 2006, Maestrini et al., 2017).

As regards the next element of the prososed framework which is SCPMS life cycle, when conducting a research in LSP SCPMSs all four stages of their life cycle shoud be taken into account, namely (Neely et al., 1995; Braz, et al., 2011): (i) SCPMS design: answering the questions of what to measure and how to select the limited set of metrics, information on the unit of analysis of the measurement process, the performance dimensions to tackle, the specific metrics to adopt, the overall SCPMS approach; (ii) SCPMS implementation: the procedures to follow to put the SCPMS in place; (iii) SCPMS use: actions stimulated by the measurement process; (iv) SCPMS review: the process of reviewing performance measures and targets.

Another proposal is to examine LSPs for the characteristics of their SCPMSs. Franco-Santos et al. (2007) provide the main characteristics of a PMS: features (properties or elements); roles (purposes or functions); and processes (series of actions that constitute a PMS). The features are the performance measures and the supporting infrastructure, which can vary from manual to automated mechanisms, to acquire, collate, sort, analyse, interpret, and disseminate appropriate information to the decision makers. There are five roles: (i) measuring performance, (ii) strategy management, (iii) communication, (iv) influencing behaviour, and (v) learning and improvement. The processes can be grouped into five categories: (i) selection and design of measures, (ii) collection and manipulation of data, (iii) information management, (iv) performance evaluation and rewards, and (v) system review (Braz, et al., 2011). It would be interesting to determine these characteristics for LSP SCPMSs.

The last component of the proposed research framework are LSP SCPMS adoption consequences. According to Maestrini et al. (2017) they include: (i) the outcomes of implementing and using SCPMSs; (ii) the impact of LSP SCPMS on SC performance including operational and business performance of LSP and other SC actors; (iii) the impact of (external) LSP SCPMSs on relationship capabilities (e.g. collaboration, trust, commitment, SC integration); (iv) barriers and criticalities of the adoption.

A research agenda on LSP SCPMSs including possible research questions is presented in Table 1.

**Table 1.** Research agenda on LSP SCPMSs

| Possible research questions | SCPMS life cycle stage | Research method | Approach |
|---|---|---|---|
| What is the level of LSP SCPMSs advancement as regards applied subsystems, approaches, ICT technologies, metrics including methods for metric selection as well as characteristics (features, roles and processes)? | Design | Survey | Theory testing |

| | | | |
|---|---|---|---|
| What is the impact of a LSP advancement on a LSP SCPMS advancement? | Design | Survey | Theory testing |
| How do LSP SCPMSs vary depending on a generation level of LSP (3PL, LLP or 4PL)? | Design and implementation | Case study (multiple) | Theory building |
| How do LSPs design and implement their external SCPMSs including first-tier PMSs, multi-tier PMSs and many-to-many SCPMSs as regards such issues as: an ICT system infrastructure, a scope: single supply chain process vs multiple supply chain processes and roles and attitudes of different supply chain tiers on the platform? | Design and implementation | Case study | Theory building |
| What are the stimuli and barriers to LSP SCPMS development? | Implementation and use | Survey | Theory testing |
| How do LSPs deal in their SCPMSs with such issues as: reliability of data collection and performance calculation; frequency and formality of the reporting; systematic review of metrics and targets? | Implementation and review | Survey<br><br>Case study | Theory testing<br><br>Theory building |
| What is the impact of LSP SCPMS on SC performance including operational and business performance of LSP and other SC actors? | Implementation and use | Survey | Theory testing |
| What is the impact of (external) LSP SCPMS on supply network relationships (companies on different tiers, companies within the same tier) and relationship capabilities (e.g. collaboration, trust, commitment, SC integration, etc.)? | Implementation and use | Survey | Theory testing |

Source: the author (based on Maestrini et al., 2017)

## 6. CONCLUSION

The LSPs are changing. They are becoming indispensable entities in supply chain monitoring, and even in the implementation of business-to-business cooperation strategies whose organizational response corresponds to specific structural forms (Fulconis and Paché, 2018). Well known for almost 30 years, these forms are described as network organizations or virtual organizations (Christopher, 2016). This means that advanced LCPs are able today to radically transform the organization and functioning of supply chains. Especially LLPs and 4PL providers are capable of using their acquired monitoring expertise to implement innovative logistical architectures without the need to possess multiple physical assets, or resources (Fulconis and Paché, 2018). This expertise is obviously based on their ability to acquire, collate, sort, analyse, interpret, and disseminate appropriate information to the decision makers within the whole supply chain network. LSPs develop this ability through their SCPMS development enabling integrated evaluation of information and material flow.

This work was designed to inspire researchers to continue expanding the knowledge about how to develop high-performing SCPMSs for different supply chain players including LSPs. An application of the proposed framework may help in better understanding of how LSPs develop their SCPMSs and what the impact of them is on SC performance, supply network relationships and relationship capabilities.

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