Understanding the Future KPI Needs for Digital Supply Chain

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Abstract

Digital Supply Chain (DSC) has emerged as a major source of competitive advantage for businesses in recent years. As a result, significant resources are dedicated to managing, operating, and controlling DSC and its performance using Key Performance Indicators (KPIs). Using a mix-methodology approach, this study, with the help of academic and industry experts, examines the capabilities of existing KPIs to measure DSC performance and determines if there is a need to develop new KPIs. The study also aims to propose new KPIs for effectively measuring DSC performance. The study's findings highlighted the strength of existing KPIs in measuring DSC performance and identified that KPIs related to customer satisfaction are the most important. The study also identified that previous research has overemphasized the need for developing newer KPIs for DSC and that existing KPIs will still be useful in the future. In the end, five new KPIs enabled by digital technologies are proposed. Additionally, a definition of DSC is also proposed to eliminate the uncertainties surrounding DSC and its potential.

Keywords: Digital supply chain, performance metrics, Performance KPIs, performance measurement, digital transformation, digitalization, e-supply chain performance, supply chain 4.0 performance

1. Introduction

Increasing pressure from customers and shareholders to reduce costs and increase profits has forced firms to build a global supply chain by digitally interconnecting physically distant entities. In contrast to the traditional supply chain, where firms are bound by their geography/function and act in silos, the digital supply chain heavily relies on technology (e.g., software, hardware, communication networks) to support activities performed by globally distributed partners to buy, make, store, move, and sell products (Bhargava, Ranchal, and Ben Othmane 2013). Additionally, in a traditional supply chain, technology is used to merely collect, store, and present data, while in DSC, technology is used to make strategic decisions (F. Wei, Alias, and Noche 2019). This adoption of digital technologies significantly increases firm responsiveness, flexibility, productivity, and competitiveness, leading to higher customer satisfaction and profits (Dolgui and Ivanov 2021; Haoud and Hasnaoui 2019; Ishfaq, Davis-Sramek, and Gibson 2021; Jiang and Zhao 2014; Youssef and El-Nakib 2015). On the one hand, introducing digital technologies makes the supply chain faster, more efficient, and more reliable. On the other hand, these technologies introduce a higher level of complexity and variables that need to be controlled and monitored (Kopbayev et al. 2022; Porthin, Liinasuo, and Kling 2020). This complexity results from interconnection among physically separated entities and business operations that now produce a higher volume of data at a greater frequency. The increased speed of delivery of goods and services, coupled with the need to synchronize the system with the whole value chain, adds to the complexity and sensitivity of the supply chain.

Chae (2009) argued that the Performance Measurement System (PMS) could help firms detect problems and areas of improvement by identifying gaps between planning and execution. Over the years, the PMS has shifted its focus from merely measuring and reporting performance to facilitate and taking part in strategic decision-making (Nudurupati, Garengo, and Bititci 2021). These outcomes are achieved by using different Key Performance Indicators (KPIs). These KPIs are used for "*assessing and controlling progress, highlighting achievements, enhancing understanding of key processes, identifying potential problems (e.g., bottlenecks), and providing insight into possible future actions, among others*" (Ahi and Searcy 2015, 361). Cascio (2012) estimated that over 90% of global firms have formal PMSs to control and monitor their performance. Researchers have argued that new complex systems require more sophisticated tools (KPIs) to measure their performance (Cho et al. 2012; Mondragon et al.

2006; Ralston et al. 2015). Surprisingly the literature has not paid enough attention to developing these KPIs. Therefore there is still a need to develop new KPIs for measuring Digital Supply Chain (DSC) performance (Lima-Junior and Carpinetti 2017; Rasool, Greco, and Grimaldi 2022; Shibin et al. 2017).

An early attempt by Sambasivan et al. (2009) produced a list of KPIs suitable for measuring DSC performance. Since then, a lot has changed, and newer technologies with various new applications have become integral to the DSC system. Melnyk (2014) and Narayanan & Ishfaq (2022) argued that it is vital for a firm to adopt an appropriate performance measuring method to record and report the system's performance. However, the absence of appropriate KPIs makes it impossible for managers to select the right ones. Prentice *et al.* (2016) suggested developing your own metrics when they are not readily available. Inevitably, recent studies have emphasized the need for newer KPIs for DSC and made calls to develop such KPIs (Ageron, Bentahar, and Gunasekaran 2020; Lima-Junior and Carpinetti 2017; Ralston, Richey, and Grawe 2017; Rasool, Greco, and Grimaldi 2022; Saleheen, Habib, and Hanafi 2018a; Shibin et al. 2017). The lack of appropriate performance measuring KPIs adversely affects the firm's ability to compete (Melnyk et al., 2014). Employing the right KPIs leads to higher firm performance and profit margins (Narayanan and Ishfaq 2022).

In the absence of appropriate KPIs, academia and practitioners rely on the existing KPIs and have assessed the performance of different aspects of DSC (Gilbert et al. 2017; Haoud and Hasnaoui 2019; Youssef and El-Nakib 2015). However, considering the arguments made by Melnyk *et al.* (2014), Prentice *et al.* (2016), and Narayanan and Ishfaq (2022), further investigation needs to be carried out to identify if the existing KPIs are capable of measuring DSC performance or the use of existing KPIs provided flawed findings. Given this context, this study aims to investigate the following three research questions using questionnaire responses and interviews with industry and academic experts.

Are existing KPIs capable of measuring DSC performance?

What are important KPIs for DSC performance?

What new KPIs should be developed to measure DSC performance?

Such empirical testing will contribute to the current debate and identify future directions by improving the theoretical understanding of PMS used for DSC. The manuscript is organized into six sections. The following section, section two, presents the study's theoretical

background. Section three explains the study's methodology and the criteria used to identify experts for this study. Section four is dedicated to the explain process adopted to analyze the quantitative and qualitative data used in the study. This section also reports the results obtained from the analysis. Section five is dedicated to discussing the results of the analysis. This section also explains the academic and practical contributions made by this study. Finally, section six concludes the study reports on the limitation of the study and presents possible future developments.

2. Theoretical background

2.1 Digital supply chain

The increasing use of digital technologies such as smartphones, wearable devices, drones, and self-driving cars has profoundly altered the way we communicate, buy and consume products and services. This has impacted every industry and sector, including the supply chain. Das *et al.* (2019) analyzed multiple cases from different sectors and reported how digitalization has improved and transformed those sectors. This adoption and reliance on digital technologies to perform business activities is referred to as "digital transformation" or "digitalization". These terms describe the integration of digital technology into all business areas to create new or modify existing business processes, culture, and customer experiences, fundamentally changing how firms operate and deliver value to customers (Dolgui and Ivanov 2021; Guptaa et al. 2020; Nahrkhalaji et al. 2018; F. Wei, Alias, and Noche 2019). Studies have reported financial and non-financial benefits of DSC (Haoud and Hasnaoui 2019; Korpela, Hallikas, and Dahlberg 2017; Mededjela, Belalemb, and Neki 2022; Noireaux and Edzengte Edzengte 2020; van Oorschot et al. 2022; Di Vaio and Varriale 2020). As a result, an ever-increasing number of firms are working toward partially or fully digitalizing their supply chains (Guptaa et al. 2020; Wu et al. 2016). In recent years the research on different aspects of DSC has been on the rise. For example, Queiroz *et al.* (2021) Developed a framework to understand the capabilities of DSC and identified seven basic capabilities and six enablers for the successful implementation of DSC. Similarly, Cagliano, Mangano, and Rafele (2021) identified four key drivers for DSC adoption. Agrawal and Narain (2018) surveyed the future technologies and identified eight emerging technologies potentially useful in the digital supply chain and encouraged researchers and practitioners to innovate using these technologies. Farajpour et al

(Farajpour et al. 2022) proposed a six layer framework for DSC strategies that lead to creating DSC features and values for any value chain. On the other hand, Hazen *et al.* (2014) warned managers that with the decrease in costs of digital technologies, the procurement of real-time data has become cheap and improper collection, storage, and use will create problems instead of providing solutions to the firm. Zhang *et al.* (2019) highlighted problems in security and trust that arrive with the use of advanced information technologies in the supply chain.

2.2 Performance measurement system

Historically, PMSs have received substantial attention from academia and industry (Schleicher et al. 2018). PMS is a formal device to formulate, communicate, monitor, and control firm strategies. The system primarily serves the higher management in evaluating overall firm performance. However, they are also useful for operational managers in improving efficiency and effectiveness (Chan 2003). One of the earliest attempts to systematize the performance measurement process was made by Flappe et al. (1996). The authors proposed a three-step method to develop and use a set of interconnected and consistent Performance Indicators (PIs) to cover all aspects of a business. Since then, the scope of PMS has expanded substantially from measuring/reporting to decision-making (Bréant et al. 2020; Nudurupati, Garengo, and Bititci 2021). As a result, the importance and reliance of firms on PMS have significantly increased. The researchers have proposed several methods to measure firm performance for financial and operational aspects (Akhtar et al. 2022; Hassan and Deraman 2018; Ravulakollu et al. 2018; Yadav, Garg, and Luthra 2021), including supply chain. Due to its importance, a plethora of this research is dedicated to the performance measurement of supply chain systems that are synthesized in several recent literature reviews (Ahi and Searcy 2015; Dias and Silva 2021; Guersola, De Lima, and Steiner 2018; Lehyani et al. 2021; Rasool, Greco, and Grimaldi 2022; Zhu, Krikke, and Caniëls 2017).

The process of managing suppliers, manufacturers, warehouses, and stores to create and deliver goods in the right quantity, at the right location, and at the right time while minimizing system-wide costs and meeting service-level standards is referred to as supply chain management (Simchi-Levi, Kaminsky, and Simchi-Levi 2000). In other words, it is the process that operates all activities of converting raw material into a finished product that satisfies the customer (Potoèan and Mulej 2008). The increased customer expectations for faster delivery, higher quality, and lower price have made it vital for firms to continuously improve, upgrade, and

invest in their supply chain(Guptaa et al. 2020). Many of these efforts focus on making supply efficient, adaptive, and responsive by digitalizing it. In addition, studies have reported several financial (Korpela, Hallikas, and Dahlberg 2017; Qazi, Appolloni, and Shaikh 2022; Di Vaio and Varriale 2020; Youssef and El-Nakib 2015) and non-financial benefits (Hallikas, Immonen, and Brax 2021; Haoud and Hasnaoui 2019) of adopting digital technologies into a supply chain. But this digitalization is not straightforward. Researchers have cautioned that these technologies act as a double-edged sword and can harm firm efficiency and performance if not implemented and managed correctly (Hazen et al. 2014; Zhang, Nakamura, and Sakurai 2019).

To avoid the failures and benefit from digital technologies, their performance needs to be measured using the KPIs that accurately record and report these newer capabilities (Ralston et al. 2015). Melnyk et al. (2014) argued that this is not the case in most firms. The authors stated that even though the managers understand that they are operating in a new environment and need to develop newer KPIs, yet often fail to act on it. Similarly, (Saleheen, Habib, and Hanafi 2018a) also pointed out the drawbacks of existing KPIs. They recommended developing newer KPIs that can capture the performance of today's supply chain. These arguments were also echoed by Rasool et al. (2022) in their recent literature review of digital supply chain performance KPIs. The authors emphasized the need to define new KPIs and validate the existing ones. The following section details the process adopted in this study to validate existing KPIs and propose new ones.

3. Methodology

3.1 Data retrieval

This study adopted a mixed-method approach to expand the breadth of the research and capture insights from a wider audience, as suggested by Greene et al. (1989). Mix methodology offers a good alternative when access to the information and experts is limited, and two different sets of questions need to be answered. The mixed-methodology can incorporate the strengths of both quantitative and qualitative approaches to present meaningful scientific contributions (Almeida 2018; L. Wei and Lin 2017). Furthermore, mixed methods allow researchers to answer two sets of questions using two different methodologies appropriate for each question (Fielding and Cisneros-Puebla 2009). This research focuses on evaluating the capabilities of existing KPIs in measuring DSC performance and investigating the needs for newer KPIs.

Hence mixed methodology is the appropriate technique to answer both questions (Harrison, Reilly, and Creswell 2020) and does not raise any methodological concerns (Leeuw 2005).

The KPIs used in this study were acquired from a recent literature review by Rasool et al. (2022) on KPIs for DSC. The authors reviewed the available scientific literature on DSC performance measurement and presented a list of 37 KPIs categorized into four Balance Score Card perspectives. To the best of our knowledge, Rasool et al. (2022) is the only available study that synthesized the performance measurement literature on DSC and presented an exhaustive list of KPIs used in academia. The authors noted that the frequency of use of these KPIs widely varied in the literature and hence recommended validating and further analyzing them before use. In this study, the 37 KPIs were further analyzed by academic and industry experts to understand their appropriateness and future use potential. The following criteria were used to select the experts.

Academic experts: The digital supply chain literature is still in its infancy, and theory is evolving rapidly (Büyüközkan and Göçer 2018). Therefore, to ensure that the academic experts have the most recent information, only those experts with a PhD degree and at least two recent scientific publications (in the last three years) related to DSC were contacted. As a result, 86 academic experts who met the initial set criteria were contacted via email.

Industry experts: Similarly, industry experts' minimum criteria included a college degree and work experience in the supply chain division at a managerial position. The profiles for industry experts were searched on *LinkedIn* using the keywords "digital supply chain" and "e-supply chain". A total of 515 experts meeting the criteria were contacted on *LinkedIn*.

The respondents were asked to participate in an online interview with the research team or complete an online survey. Two reminders were sent to academic experts after the eighth and fifteenth days of the first contact. Due to restrictions from the *LinkedIn* platform, no reminder was sent to industry experts. At the end of the period assigned to this study phase (2.5 months), eleven and thirty-three academic and industry experts filled the survey, respectively. Additionally, two academic and twelve industry experts joined the online interview with the researchers making an effective response rate of 9.6% (Brief profile of the interviewees is presented in Table I). The average working experience for respondents was eight and fifteen years for academic and industry experts, respectively. The demographic location of the respondents varied greatly, with most respondents coming from the US (09), Germany (06), and India (04). The interviews lasted between 35 to 55 minutes. In the online survey, the

respondents were asked to rate the usefulness of each KPI collected from the literature. In addition, they were encouraged to propose additional KPIs that were not available on the list during the survey. Each KPI was also explained to remove ambiguity and difficulties in understanding the KPIs' purpose (the questionnaire sample is available at https://tinyurl.com/DSCKPI). During the interviews, the experts were actively encouraged to elaborate on each KPI's usefulness and problem and suggested better alternatives for future use.

Table I Details of the interviewees

3.2 Data analysis

To answer the research questions, semi-structured interviews were conducted. Semi-structured interviews offer a greater level of control over the pace, style, and order of the questions to the interviewer. At the same time, they enable interviewees to express their opinion in their own words and style (Qu and Dumay 2011). All the interviews were transcribed word by word from the recordings. Once this phase was completed, following the guidelines by Gibbs (2007), the transcripts were coded into themes and subthemes by two researchers independently to extract insightful information from the resulting discussion. As demonstrated by Sweeney et al. (2013), coding by more than one researcher allows for better data analysis that helps to build strong consensus about the data from multiple perspectives. The themes were merged or further expanded after discussion and comparing notes by the two researchers. The resulting themes were compared with the questionnaire data where possible. This triangulation method allowed researchers to analyze the problem from different angles.

4. Data analysis and results

4.1 Expert interviews

In the first phase of the semi-structured interviews, the interviewees were asked to define DSC and list the most important KPIs for DSC. This phase also investigated the opinions of the interviewees on the need for newer KPIs and how different KPIs will perform in the future. The definition and understanding of the DSC varied among the interviewees. However, common themes were the ability to record and produce accurate (meta) data, transparency, seamless integration of stakeholders, and maximized utilization of human intelligence. The

interviewees believed that in the next few years, the DSC would become the norm, and the use of digital tools such as Artificial Intelligence (AI), Machine Learning (ML), and Big Data (BD) would be as common as the use of email today. Expert 8 summarised this discussion by stating that the DSC will be a supply chain "*with the capability to produce real-time information on demand, whenever it is needed, however, it is needed*". Even though all experts were confident that DSC would become the new norm, Experts 7 and 9 warned about the overuse/misuse of the concept. Expert 9 pointed out several examples (shipping industry) where real-time information is not needed but pushed by industry leaders. Expert 3 highlighted that with ever more physical products becoming digital services, the researchers must pay attention to the supply chain of these digital products and not just the digitalization of the physical supply chain.

Similarly, Expert 7 was concerned about practitioners who failed to grasp the DSC concept and its potential. Expert 7 commented, "*it's not simply automating the supply chain, but it's also switching that over. So that where humans are involved, they're actually applying human insight and intelligence, and not just using a human to insert the number and or go check meter or something like that"*. This insight highlighted the problem associated with digitalization, where digital technology is merely used to automate/digitize tasks instead of automated decision-making.

This lack of understanding was also reflected in other questions; for example, when asked about developing newer KPIs for the DSC, the academic experts emphasized that we already have sufficient KPIs. On the other hand, the industry experts believed that newer KPIs would be needed, and a hybrid system of old and new KPIs would prevail. These new KPIs will measure data points unavailable in traditional supply chains, such as real-time data sharing and customer feedback. Similarly, the existing KPIs will remain in service, but the capabilities needed to measure these KPIs will evolve. For example, Expert 12 said, *"things like inventory, cycle time, and efficiency will always be important, but in the future, we will measure them using different capabilities"*. This argument was in line with the academic experts who emphasized developing newer capabilities to measure the same KPIs instead of developing new KPIs. This approach was also visible while listing the most important KPIs for the traditional and digital supply chain. Most experts listed KPIs related to customer satisfaction as the most important ones in both types of the supply chain. For example, Expert 1 stated, *"the purpose of the supply chain is to deliver ultimate customer experience in whatever shape or form. The supply chain is a business support function. Good supply chains save money, great supply chains make money,*

So you can only make money if your customers are happy". Surprisingly, the experts emphasized the need to reduce the number of KPIs and encouraged researchers to merge several KPIs and measure them effectively with the help of digital technologies. They believed that substantial resources are needed to deploy all KPIs, and in a competitive business environment, the resources are scarce and need to be consumed wisely. On this expert-two commented, *"It's not the volume. It's the critical data points, and that changes for every industry, every person, every company"*.

Similarly, expert one commented, *"it's not how many times you measure it. It is how, where, and why you measure it"*. These insights were in line with the suggestions of (Melnyk et al. 2014) and (Hazen et al. 2014), where authors recommended focusing on the quality of KPIs instead of quantity. However, one important thing that emerges from these discussions is the puzzlement of the experts and the lack of clarity in the use and strength of the KPIs. For example, experts believed fewer KPIs should be used in any PMS, but they quickly suggested additional KPIs when asked. These insights partially disconfirm the need for DSC KPIs discussed in previous studies (Lima-Junior and Carpinetti 2017; Rasool, Greco, and Grimaldi 2022), where authors suggested developing new KPIs for every aspect of the supply chain without considering the usability of the existing KPIs. Furthermore, the discussion with experts revealed digitalization's problematic and complex nature. Even though they are certain that the supply chain will become digitalized soon, they are uncertain about what the future will look like and how this digitalization will be achieved.

4.2 Questionnaire responses

The respondents were asked to select the important KPIs from the list of 37 KPIs proposed by (Rasool, Greco, and Grimaldi 2022). During the interviews, the experts recommended reducing the number of KPIs by measuring only the most relevant data points. The survey respondents also confirmed this opinion by rating a limited number of KPIs as useful from the list. As a result, the 37 KPIs were divided into three categories depending on the selected frequency. The KPIs selected by 80% or more respondents were categorized as "very strongly recommended".

Similarly, selection rates between 60%-79% were categorized as "strongly recommended". Finally, the KPIs with a selection rate between 40%-59% were categorized as "recommended" KPIs. There were no KPIs with a selection rate of less than 40%. Table II presents the summary of these results. In contrast to the scientific literature, where more focus is placed on measuring the internal and financial performance of the digital supply chain (Rasool et al. 2022), the

experts (both during interviews and questionnaire responses) emphasized the focus should be on the customer and their satisfaction, not the firm and its performance.

The questionnaire results were in line with the insights from the interviews, where experts emphasized the need for fewer KPIs to make PMS efficient and less complex. This is also evident in the results reported in Table II, where fifteen out of thirty-seven KPIs tested fall under the "recommended" category, while only seven are in the "very strongly recommended" category.

Table II Classification of KPIs

4.3 Additional KPIs

The experts (interviewees and questionnaire respondents) were asked to provide any additional KPIs that they believed would be useful in measuring the DSC performance not listed by Rasool et al. (2022). Cumulatively, the experts (during interview and questionnaire responses) suggested 130 new KPIs (referred to as metrics for ease of understanding). As expected, most of the metrics suggested belonged to the customer (42) and financial (36) perspectives. However, careful analysis of these metrics shows that most suggested metrics focus on measuring the same aspect of performance already covered by the original list of KPIs. For example, experts suggested "on time full delivery", "delivery on-time in full", "in full delivery", etc. from a customer perspective. However, this performance metric has already been measured by the "delivery reliability" KPI from the original list. Additionally, several experts classified the metrics from the wrong perspective. For example, "warehouse utilization" and "cost of acquisition" were placed in customer perspective instead of internal and financial perspective, confirming the earlier statement of lack of understanding and confusion among experts regarding PMS and DSC. Some experts also commented on the original KPIs and proposed making them quantitative and robust.

After combing through the proposed new KPIs by experts, it was realized that 104 out of 133 new ones could be covered by the original list of 37 KPIs proposed by Rasool et al. (2022). However, out of the remaining 29 KPIs suggested, seven did not make any sense and were not usable in any analysis ("benchmarks", "promotion advice", "out-of-box sales potential", etc.). Therefore, the remaining 22 KPIs can be merged to propose four new KPIs. These new KPIs

and their definitions are presented in Table III. The examination of these four new KPIs revealed that three out of four are unmeasurable without digital technologies and were never an option for the traditional supply chain. Moreover, the experts suggested including a KPI to measure the supply chain's digitalization level, as shown in Table III. This KPI will keep an eye on the digitalization level of the firm and will guide it towards achieving the digitalization goal.

Table III: New proposed KPIs for DSC

5. Discussion

The survey results and interview transcripts uncovered several insights presented in Figure 1. The framework presented highlights the importance of each type of KPI and demonstrates how new and existing KPIs will be used to measure DSC performance by enabling new capabilities. The following subsections present the academic and practical contribution of the study.

Figure I The framework of KPIs for the digital supply chain

5.1 Academic contribution

Headd & Saade (2008) and Podsakof et al. (2016) emphasized the importance of having an appropriate definition and argued that its absence could distort the results and negatively impact theory building. However, the definition of the DSC is still somewhat opaque, and experts have a different understanding of what DSC is and what level of digitalization is required to call a supply chain digital. Studies in the past have attempted to distinguish digital from traditional supply chain and proposed definitions (Büyüközkan and Göçer 2018; F. Wei, Alias, and Noche 2019; Wu et al. 2016). However, these studies derived their inspiration from the academic literature and have not received industry-wide acceptance. Therefore the first academic contribution of this study is to propose the following definition based on the interviews' insights and comments on questionnaire responses by experts (academic and industry). "*DSC is a seamlessly interconnected transparent supply chain that independently performs decision support activities to minimize human input needs"*. This definition, in contrast to the available definitions, simplifies the goals and requirements for the DSC.

Another academic contribution of the study was answering the questions about the need for newer KPIs for DSC. The theory of supply chain performance measurement has been evolving for several decades. Saleheen et al. (2018b) reviewed the most prominent performance measurement systems available and categorized them into financial and non-financial. The authors argued that the top management needs financial KPIs to make strategic decisions while middle management requires operational KPIs to perform day-to-day activities. In contrast to the previous studies that emphasized the need for developing newer KPIs for DSC (Ageron, Bentahar, and Gunasekaran 2020; Lima-Junior and Carpinetti 2017; Rasool, Greco, and Grimaldi 2022), this study concludes that the need for newer KPIs is not as eminent as considered earlier. A hybrid PMS consisting of new and existing KPIs will be needed in the future. This PMS will use existing KPIs but will require newer capabilities and measuring tools. The need for new KPIs will also depend on the industry and application. In most cases, the traditional supply chain does not have the capabilities to deploy these new KPIs. Therefore this study points to an important direction for future studies where more attention should be paid to developing new capabilities rather than new KPIs. Additionally, answering the calls made by recent literature, this study also proposes five new KPIs specifically oriented to DSC performance measurement. This result responds to the calls made by recent studies. Finally, the study also provided evidence to support the argument made by Elrod et al. (2013) and Chae (2009), where authors suggested reducing the number of KPIs used in PMS. Using fewer KPIs will increase focus on important aspects and reduce the complexity of PMS. The overuse of data was also a concern raised by experts during interviews.

5.2 Practical contributions

The fast-paced business environment has left managers busier than ever with fewer resources to spend on tasks, not directly contributing to profit generation. As a result, measuring the right performance indicators has become even more crucial for PMS success. The main contribution of this study for practitioners is the identification of "very highly recommended" KPIs presented in Table I. Table I highlights the seven KPIs that managers should focus on while deciding what to measure. Another insight for the practising managers from the analysis was that KPIs related to customer satisfaction are the most important ones. The scientific literature focuses on the KPIs related to a firm's operational and financial performance, as highlighted by Rasool et al. (2022) in their literature review. The study also proposes five new KPIs useful for DSC. These KPIs will be useful in measuring DSC performance and understanding the current level of digitalization for the supply chain and how far it is from the firm goal. By

deploying this KPI, managers can diffuse ambiguity in the DSC definition and have a uniform and comprehensive understanding of DSC and its potential. As a result, they can adopt the right strategies and technologies to achieve the desired DSC level.

This study also debates that more is not always better. Fewer well-placed KPIs to measure critical business activities will produce better results than measuring every aspect of a business. This insight encourages managers to focus on only important aspects of a business. The study also highlights that there is no need to reinvent the wheel regarding DSC's performance measurement. Instead, new capabilities can be built on top of existing PMSs systems and develop new KPIs only when needed to take advantage of digital technologies. This can be achieved by developing a better understanding of DSC and its capabilities and avoiding under or overestimating its value.

6. Conclusion and limitation

The firms' reliance on sophisticated supply chain systems has significantly increased in the last decade. Subsequently, the supply chain has become the main source of competitive advantage (Bi, Kam, and Smyrnios 2010; Büyüközkan and Göçer 2018). As a result, significant technological advancements have digitalized supply chain systems in the last two decades. On the one hand, these technologies make the supply chain efficient, reliable, and responsive (Dolgui and Ivanov 2021; Haoud and Hasnaoui 2019; Mededjela, Belalemb, and Neki 2022). On the other hand, they make the system complex and sensitive (Kopbayev et al. 2022; Porthin, Liinasuo, and Kling 2020; Rasool, Greco, and Grimaldi 2022). This study investigated the usefulness of existing KPIs and the need for new KPIs to measure the performance of this new and complex supply chain, commonly referred to as DSC. To this end, semi-structured interviews and survey questionnaires were conducted with academic and industry experts. The responses provided several insights.

Firstly, the study discovered that the need for newer KPIs for DSC is overemphasized in the literature. The experts believed that a mix of new and already existing KPIs would become a norm in the future, and new KPIs enabled by digital technologies will be needed. Second, the study proposed five new KPIs enabled by digital technologies that will be useful in measuring DSC performance. Experts suggested these KPIs in response to the researchers' call to report KPIs not reported in the original list. Third, the study exposed that understanding and meaning greatly vary among experts. As a result, the different industries have a widely different levels of commitment and expectations from DSC. To harmonize these differences, a definition for

DSC was derived by synthesizing the interview transcripts and comments on questionnaire responses. Fourth, the 37 KPIs used in this study were divided into three categories, namely "very strongly recommended", "strongly recommended", and "recommended", by analyzing responses to the questionnaire. The categorization will help practitioners identify important KPIs to focus on when limited resources can be dedicated to managing PMS. Lastly, the study discussed that, contrary to general practice in literature, the emphasis is placed on measuring internal and financial performance. The experts believe that the KPIs related to customers and their performance are the most important.

This study is not without its limitations. First, although the recent literature review by Rasool et al. (2022) on performance KPIs is comprehensive but may still have shortcomings. This might have prevented some KPIs from being included in the study for further analysis. Second, the selection criteria and database used to identify experts also have limitations. It is acknowledged that the wider search may have included a more diverse selection of experts in the study. Furthermore, more interviewees would mitigate the interviewer's biases during the semi-structured interviews. Also, more responses to the questionnaire would be useful in better classifying the KPIs into three proposed categories.

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