Digital transformation of the purchasing and supply management process

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Abstract

Purpose – The aim of this study was to identify interventions for and mechanisms of the digital transformation of purchasing and supply management (PSM) processes. The digital transformation of tactical and operational PSM processes has often progressed slowly despite the solid knowledge of advanced technologies.

Design/methodology/approach – This study used a qualitative exploratory approach based on 14 interviews with PSM executives from firms that are continuously working toward using advanced technologies in their PSM processes but have not yet gained full strategic benefits from digital transformation.

Findings – This study formulates five propositions regarding interventions and mechanisms that can positively influence the digital transformation of PSM processes. The main intervention in this regard is the renewal of data infrastructure, including platforms. PSM-related data should meet needs from both tactical and operational viewpoints. When applications serve as a source of data, they support digital transformation. Mechanisms such as supplier measurement and process improvement are outcomes of the digital transformation of PSM processes.

Practical implications – This study highlights the importance of common data sets for tactical and operational purchasing. These purchasing data should be owned and served by a cross-functional team. To create this interoperability, a firm needs global governance of open standards.

Originality/value – This study makes a theoretical contribution to the discussion of what kind of interventions positively influence on the digital transformation of PSM processes. Specifically, this study explains the integration needs of data and applications.

Keywords Digital procurement transformation, Purchasing, Supply management

Paper type Research paper

Introduction

The advancement of information technologies (ITs) and applications is increasingly providing efficiency, cost reduction, automation and optimization of the purchasing and supply management (PSM) function (Srai and Lorentz, 2019). PSM process requires technological improvements and maturity, but no massive digital transformation, such as a revolution of advanced technologies or Industry 4.0 has occurred yet. The digital transformation of PSM is a stand-alone technological intervention that has been gaining attention in the literature but is still rarely applied in practice (Flechsig *et al.*, 2022; Handfield *et al.*, 2019; Seyedghorban *et al.*, 2020). In fact, interest in some technologies used in such interventions in practice is dwindling because of the absence of value-adding use cases (PwC, 2022). For many firms, transactional processes are the most digitalized part of the PSM process, even if digital transformation visions promise multiple value-adding features

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beyond transactional process optimization. A lack of process digitalization causes data quality issues and hampers data-driven decision-making (PwC, 2022). The digitalization of the strategic PSM process is considered cumbersome and uncertain because of the lack of visible short-term gains by practitioners (PwC, 2022). Many professionals lack a comprehensive vision of digital transformation in the PSM department despite increasing investments in it (Bienhaus and Haddud, 2018; PwC, 2022). To address this managerial research gap, this study focuses on the digital transformation of PSM processes and how to gain advantages from it.

Research interest in PSM digitalization, especially in the use of technologies, has been growing (Kosmol *et al.*, 2019). Studies have investigated certain technologies, such as robotic process automation (RPA) (Flechsig *et al.*, 2022; van Hoek *et al.*, 2022), Internet of things (IoT) (Legenvre *et al.*, 2020) and big data analytics (Srai and Lorentz, 2019). These excellent works have increased the knowledge of these advanced technologies but have scarcely addressed the integration of these technologies with the existing ITs and organizational structures of PSM processes. Therefore, Hartley and Sawaya (2019) suggest that managers should start their digital roadmap planning by identifying the critical processes and information visibility within PSM processes. Existing procedures and processes must be considered from a system point of view and in light of a firm's current communication channels (Bienhaus and Haddud, 2018). In line with a system point of view, Seyedghorban *et al.* (2020) suggest that since a higher level of digitalization maturity is based on digitally integrated systems, an integrated and boundaryless PSM function represents an important future research stream. Similarly, Flechsig *et al.* (2022) propose that PSM research should investigate the technical and organizational disintegration that exists between different divisions, because this is lacking theoretical underpinnings but impacts the implementation of advanced technologies.

We aim to fill this research gap by addressing the following research question: "What are the interventions for and mechanisms of the digital transformation of the PSM process?" Our theoretical perspective is based on work of Lorentz *et al.* (2021). Digital applications or the use of technologies that enable the PSM function to create value are called interventions (Lorentz *et al.*, 2021; Srai and Lorentz, 2019). Mechanisms are defined as new states or capabilities driven by these interventions, which are actions that may improve performance in the PSM function (Denyer *et al.*, 2008; Lorentz *et al.*, 2021).

Our findings are drawn from qualitative data collected from 14 procurement professionals involved in developing digital PSM technologies. We contribute to the literature on PSM digitalization (Herold *et al.*, 2022; Lorentz *et al.*, 2021; Seyedghorban *et al.*, 2020) by presenting propositions regarding interventions and mechanisms that may positively influence the digital transformation of PSM. Interventions such as a generic data infrastructure, global governance and open standards, PSM data owned and served by a cross-functional team and applications as a source of data positively influence the digital transformation of PSM processes. As a consequence of these interventions, the main mechanisms that improve PSM performance were found to be supplier measurement and process development. Finally, as a managerial implication, we propose that data infrastructure should be the scope of the digital transformation of PSM processes.

Digital transformation

Digital transformation is defined as an ongoing process of strategic renewal using technological advancements to build capabilities that refresh or replace organizational structures and processes (Warner and Wäger, 2019). This transformation may enable PSM to become a value-adding and revenue-generating function with a strategic focus instead of administrative and clerical roles (Seyedghorban *et al.*, 2020). The maturity of the PSM function may improve opportunities for digitalizing the PSM process if it supports the strategic alignment of purchasing and takes account of contingencies in the industry, such as disruptive technologies (Søgaard *et al.*, 2019). According to Frederico *et al.* (2020), each digital maturity level from the initial stage to the cutting-edge stage includes dimensions of managerial and capability support, technological advancements, process performance requirements and strategic outcomes. To derive support for capability development from new technologies, there should be clear measures justifying the improvement of process performance due to the digital transformation (Frederico *et al.*, 2020).

The pathway from administrative and clerical level purchasing to a fully digitally integrated system passes through sequential stages (Seyedghorban *et al.*, 2020). Digital transformation starts with digitization, which is the replacement of a physical version with a digital version, such as paper bills to digital copies (Orellana, 2017; Seyedghorban *et al.*, 2020). Without digitization, there is no digitalization. Digitalization is often defined simply as the use of advanced digital technologies (Lorentz *et al.*, 2021; Srai and Lorentz, 2019). More advanced technologies such as IoT, cloud computing, big data, artificial intelligence (AI), autonomous robots and blockchain, could support procurement processes (Lorentz *et al.*, 2021). Advanced technologies should provide interconnectivity, decentralized decisions, technical assistance and information transparency to the PSM function (Srai and Lorentz, 2019).

The PSM function reaches its highest maturity when digital integration is achieved. It requires digitization and the use of applications, but its main benefits depend on cross-functional, boundaryless integration within and across departments (Seyedghorban *et al.*, 2020). In digital integration, the implementation of digital technologies in each phase of the PSM process leads to cross-functional changes across the organization, a new organizational design and operations and even the development of new business models (Seyedghorban *et al.*, 2020). Srai and Lorentz (2019) identified the highest form of maturity when the PSM function contributes value to supply market knowledge generation and external resource management. Interactive and insightful information could be provided to other departments and customer centricity (both internal and external) could be brought into the PSM decision-making (Bienhaus and Haddud, 2018; Seyedghorban *et al.*, 2020). The IT infrastructure is an antecedent of the adoption of advanced technologies, as its enables the processing and sense-making of large amounts of data (Kache and Seuring, 2017; Kosmol *et al.*, 2019).

Digitalization of the PSM process

PSM is a strategic process within and between companies that includes activities from strategy development to supply relationship management (van Raaij, 2016). The PSM process has been divided into various steps and described variously in the literature as a linear model (van Weele, 2018) or a continuous cycle of tasks (Bäckstrand *et al.*, 2019; van Raaij, 2016). According to van Raaij (2016), the PSM process cycle starts with strategic analyses and strategy development and proceeds to tactical decisions for supplier selection and contracting. The operational phase covers the actions following contracting, including identifying buying needs, purchase orders and making the payment. In this research, we refer to the PSM process when we mean the entire cycle, and we use more specific terms, such as strategic, tactical and operational phases, similarly to van Raaij (2016). It is not clear whether the digitalization of the PSM function brings radical improvement to the process or remains an incremental change (Srai and Lorentz, 2019). Many firms lack a clear digital strategy, and most firms have some uncertainties and fears related to digital transformation (Bienhaus and Haddud, 2018; PwC, 2022). Consequently, bridging old and new technologies requires the capacity to absorb new knowledge at each stage of the digital transformation and necessitates that firms be ready for continuous change (Arcidiacono *et al.*, 2022).

Our theoretical perspective is based on the work of Lorentz *et al.* (2021 pp. 178), which discusses digital applications, or the use of technologies (called interventions) and capabilities driven by interventions (mechanisms). The mechanisms of the digital transformation of the PSM process are shown in Table 1, which is based on the work of Lorentz *et al.* (2021) and other recent works. Recent studies have shown that internally oriented mechanisms are emphasized more (process improvement, coordination and control and strategic alignment) than mechanisms based on external data such as supply market knowledge management (Lorentz *et al.*, 2021; Srai and Lorentz, 2019). Next, we discuss the interventions connected to these mechanisms.

Digitalization in transaction management is considered a reduced administrative effort to increase the efficiency and quality of purchase order management (Srai and Lorentz, 2019). The digitalization of purchasing has evolved from simple eProcurement to the automation of the entire process, where purchasing orders are placed automatically after inputting into a system without human touch (Glas and Kleemann, 2016; Hartley and Sawaya, 2019; Viale and Zouari, 2020). Efforts have been made to electronify such processes through electronic data interchange (EDI) integrations and data standards between enterprise resource planning (ERP) systems and suppliers (Gunasekaran and Ngai, 2003; Haug *et al.*, 2010). Many-to-many communications on procurement platforms have simplified the daily business tasks of the PSM function but require implementation efforts from both sides (Bienhaus and Haddud, 2018; Kosmol *et al.*, 2019).

Lorentz *et al.* (2021) found that in particular the internal complexity of the PSM function drives the digitalization of the PSM process, and it is evident that digitalization increases cost efficiency in organizations with decentralized procurement (Patrucco *et al.*, 2021). Savings and efficiency objectives drive automation-oriented process improvements, such as shortened cycle times, efficient use of procurement resources and error reduction (Lorentz *et al.*, 2021). To reduce the complexity, firms can utilize social media and software as service-based platforms to support internal and external communications and for automating and formalizing the PSM process. This will improve the purchasing coordination and control, result in better use of contract terms, reduce maverick buying, speed up process throughput

Table 1. Mechanisms by which digitalization creates value for the PSM function

Mechanisms	Procedure	Procurement process phase	Source
Supplier capability assessment	Supplier selection	Tactical	Allal-Chérif *et al.* (2021), Lorentz *et al.* (2021), Srai and Lorentz (2019)
Coordination and control	Contracting	Tactical/ Operative	Lorentz *et al.* (2021), Seyedghorban *et al.* (2020), Srai and Lorentz (2019)
Transaction management	Procure-to-pay	Operative	Allal-Chérif *et al.* (2021), Bienhaus and Haddud (2018), Glas and Kleemann (2016), Hartley and Sawaya (2019), Srai and Lorentz (2019)
Process improvement	Procure-to-pay	Operative	Allal-Chérif *et al.* (2021), Seyedghorban *et al.* (2020)
Sourcing analyses	Specification of needs	Strategic	Bienhaus and Haddud (2018), Handfield *et al.* (2019)
Strategic alignment of internal needs and external supplier resources	Supply strategy development	Strategic	Allal-Chérif *et al.* (2021), Lorentz *et al.* (2021)
Supply market knowledge management	Supply market intelligence	Strategic/ Tactical	Handfield *et al.* (2019), Seyedghorban *et al.* (2020), Srai and Lorentz (2019)
Supplier relationship management (SRM)	SRM	Continuous	Kosmol *et al.* (2019), Srai and Lorentz (2019)

Source(s): Table by authors

and free resources for strategic tasks and management (Lorentz *et al.*, 2021). Effective contract management structures the procure-to-pay workflow cycle and can control errors and conflicts between invoices and purchasing orders and negotiated terms (Allal-Chérif *et al.*, 2021; Handfield *et al.*, 2019). Source-to-contract applications are useful for developing sourcing strategies and organizing calls for tenders and reverse auctions (Allal-Chérif *et al.*, 2021).

The role of purchasing will be extended to collect, analyze, and process internal and external data within organizations to support complex decision-making processes (Bienhaus and Haddud, 2018). Hence, the purchasing function evolves to a strategic interface promoting efficiency, effectiveness and profitability for the whole organization. Öhman *et al.* (2021) found that the way data, analytics knowledge and PSM knowledge are brought together impacts the analytics capability of the PSM function. A firm's structure and collaboration between its departments are crucial for analytics, together with data and tools (Öhman *et al.*, 2021). The effective use of information processing technology helps with data integration, storage and management for decision-making (Lorentz *et al.*, 2021).

Handfield *et al.* (2019) identified the changes in the PSM process for the digitalization and integration of analytical solutions regarding data governance and management, spending management, contract management and supply market intelligence. They found that data management and storage are challenging for many companies because internal data, such as spending, ERP, financial, or contract compliance data, are low-quality or prone to errors (Handfield *et al.*, 2019). The existing reporting format might be not suitable for advanced analytics or visualization (Handfield *et al.*, 2019). For instance, detailed spending data at the category level might be difficult to obtain (Handfield *et al.*, 2019). Data lakes or platforms and centralized data management are necessary to create cross-functional analytics opportunities (Öhman *et al.*, 2021). Knowledge of analytics and PSM decision-making needs must be combined (Hallikas *et al.*, 2021; Öhman *et al.*, 2021). Data management may require the use of a third-party service for data cleansing and coding of algorithms for data integration in the PSM function (Handfield *et al.*, 2019). Moreover, attention should be paid to having a data infrastructure that allows the interoperability of different functions regarding data usability (Machado *et al.*, 2021).

AI can provide recommendation engines for supplier selection based on large data sets and multiple criteria (Allal-Chérif *et al.*, 2021). For example, AI can facilitate managing ethical, ecological, logistical, or financial supplier risks (Allal-Chérif *et al.*, 2021). In the context of new product development, firms may utilize AI in decision-making during supplier pre-selection procedures (Wehrle *et al.*, 2022). AI enables buyers to monitor public and private data sources related to supplier performance (Allal-Chérif *et al.*, 2021). Predictive analytics and AI drive decision-making interventions not only for supplier capability assessment but also for alignment between internal needs and external supply resources (Lorentz *et al.*, 2021). AI solutions might respond to inquiries about documents and reduce these operational tasks of communication (Allal-Chérif *et al.*, 2021).

Applications of supply market intelligence could increase knowledge of supply market dynamics. Supply market knowledge impacts company strategies and risk management, which can offer competitive advantages and resilience (Handfield *et al.*, 2019; Zouari *et al.*, 2021). For example, AI could search the internet for sustainability issues regarding a firm's suppliers, and firms can respond quickly in the case of sustainability violations (e.g., Audi (2021)). Capabilities in external data analytics seem to co-evolve with the digitalization of the PSM process (Hallikas *et al.*, 2021). External data are often more unstructured than internal data, which limits their applications (Hallikas *et al.*, 2021).

Methodology

To address our research objective of identifying interventions for and the mechanisms of the digital transformation of the PSM process, we conducted a qualitative exploratory study based on interview data. An explorative approach facilitates understanding of complex phenomena that are not yet fully defined, such as digital transformation of PSM processes (Shumon *et al.*, 2019). Next, we justify our interviewee selection and describe the context analyzed. Subsequently, we describe our data analysis procedures.

Data collection

Data were collected from Finnish procurement professionals working in large- or medium-sized firms (Table 2). The selection of firms did not account for how well developed their digital transformations were. After the analysis, we found that these firms were in the digitalization stage rather than the digital integration stage. We conducted 14 semi-structured interviews with chief purchasing officers (CPOs), directors, and managers who had developed the purchasing IT. The number of participants is sufficient for exploratory research (Keränen and Jalkala, 2013; McCracken, 1988). The interviews were conducted face-to-face or via video calls. All interviews were recorded and transcribed verbatim with permission from the interviewees. The interview protocol included questions about what tasks the interviewees performed in each PSM process step and how digitalization was used in these tasks. The interviewees were also asked to identify the challenges encountered during the digitalization of the PSM process and how they continued developing the process. The PSM process steps were discussed during the interviews by showing van Raaij's (2016) illustrative figure.

Firm	Personnel	Sector	Position of interviewed	Interview type and duration
A	6500 globally	B-to-C hand tools	Lead of indirect purchases (ER)	F2F, 51 min
			Director of sustainable sourcing (KM)	F2F, 55 min
B	1800 globally	Chemicals	CPO (FC)	online, 1 h 24 min
C	20000 globally	Biomaterials	Sourcing and procurement developer (JL)	online, 1 h 15 min
			Lead of purchasing IT (JM)	online, 1 h 26 min
D	33585 globally	Construction	CPO (JN)	online, 1 h 23 min
E	8500 globally	Food supply	Manager of purchasing IT (JP)	F2F, 1 h 21 min
F	9500 globally	Biomaterials	CPO (JT)	online, 51 min
G	4000 globally	Food supply	CPO (KR)	F2F, 59 min
H	300–400 globally	Pharmaceuticals	CPO (MK)	online, 1 h 8 min
I	1300 in subsidiary company, part of global group	Telecommunications (hardware)	CPO (MV)	online, 1 h 10 min
J	1100, Finnish company	Construction	CPO (RI)	online, 1 h 3 min
K	16000 globally	Biomaterials	Manager of IT support for purchasing (RV)	online, 2 h 12 min
L	24000 globally	IT services	CPO (TP)	online, 44 min

Source(s): Table by authors

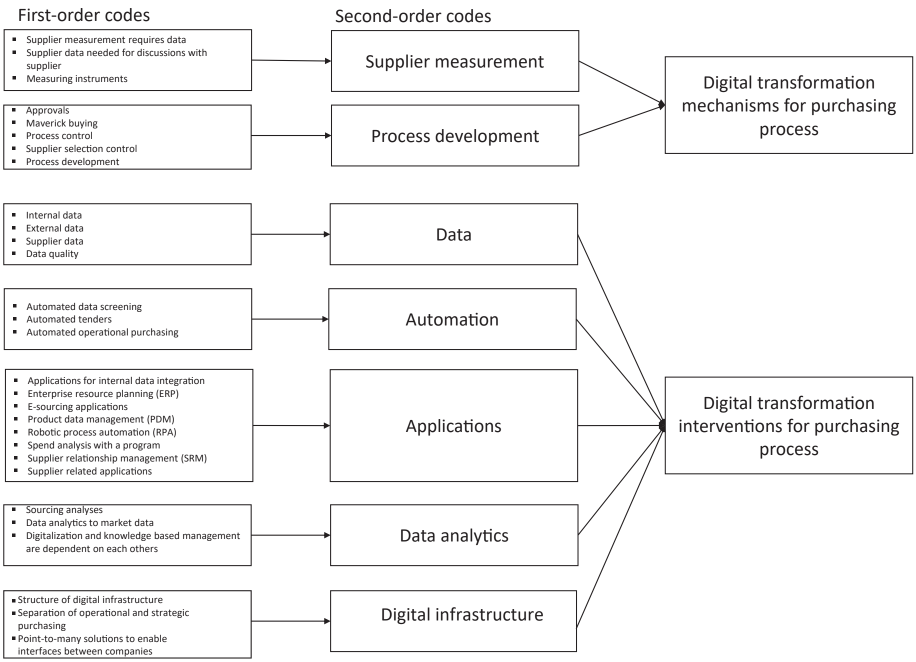
Table 2. Purchasing professionals interviewed

Data analysis

The data were coded and analyzed using NVivo software. The data analysis started with an inductive coding of the interventions and mechanisms. Interventions are defined as digital applications or the use of technologies that enable the PSM function to create value (Lorentz *et al.*, 2021; Srai and Lorentz, 2019). Mechanisms are defined as new states or capabilities driven by interventions, which are actions that may improve performance in the PSM function (Lorentz *et al.*, 2021).

Excerpts from transcriptions were coded to initial codes when purchasing digitalization was discussed in terms of mechanisms or interventions. These initial codes were mainly short words or phrases from the data record —that is, an in vivo coding approach was followed (Miles *et al.*, 2014). The initial codes also included descriptive coding, especially the names of the applications (Miles *et al.*, 2014). After that the initial codes were grouped together according to their similarities. Each group of initial codes was given a name of first-order code, such as "supplier measurement requires data." Subsequently, first-order codes were aggregated according to their similarities under the label of second-order codes (Gioia *et al.*, 2013). The analysis process involved creating a coding scheme table containing first-order codes and their definitions and it is provided as supplementary file (Cloutier and Ravasi, 2021). The data structure in Figure 1 provides graphical presentation of how the analysis progressed from raw data to digital transformation themes of the PSM process (Gioia *et al.*, 2013).

In parallel with the main coding process, initial codes were set to the PSM process phases. Phases from van Raaij's (2016) PSM process model were used to structure the initial codes in the PSM process phases if an interviewee mentioned that intervention or mechanism together with a PSM process step. This can be understood as sub-coding the initial codes (Miles *et al.*, 2014).



Source(s): Figure by authors

Figure 1.
Data structure

We followed several procedures to ensure the validity of our findings (Yin, 2014). Construct validity was ensured by monitoring a chain of evidence from the initial codes to the conclusions. To analyze our findings, we used a replication logic to find similarities between interviews. We extracted more abstract-level propositions from a set of study findings, and these propositions can pertain to newer situations other than the firms of this study (Yin, 2013). We performed pattern matching between our categorization and previous theoretical categories of interventions and mechanisms. For example, mechanisms such as supplier measurement and process development were compared with those described by Lorentz *et al.* (2021), although their study had a more detailed set of mechanisms. Data, automation, applications and analytics have also been discussed in previous works (Handfield *et al.*, 2019; Lorentz *et al.*, 2021).

Findings

Our data analysis yielded five propositions regarding the digital transformation of the PSM process. Propositions 1 to 3 are related to data infrastructure, global governance and open standards and applications as a source of data. Proposition 4 is based on observations of how purchasing data should be owned and served by a cross-functional team. Proposition 5 describes mechanisms by which digitalization creates value for the PSM process. On the basis of these propositions, we discuss what kinds of changes have a positive influence on the digital transformation of the PSM process.

Data infrastructure as a platform

Digital infrastructure can be defined as "the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function" (Tilson *et al.*, 2010, p. 748). The digital infrastructure of a firm is not mainly developed for or to focus on purchasing needs but often prioritizes sales, marketing, delivery, or accounting needs (ER, FC and KM). No common infrastructure is available on which further digital transformation could be based in supply management departments. Hence, our interpretation is that the main intervention for the digital transformation of the PSM process is to change the surrounding digital infrastructure, especially the data architecture. Within the data infrastructure (a subdimension of digital infrastructure), the data architecture describes how data stores are organized and accessed in the firm (Choi *et al.*, 2018).

Problems with data reflect problems with digital infrastructures, especially from the perspective of tactical purchasing. In the worst-case scenario, data are transferred manually in files, which adds errors (KM and FC). Similarly, if the system does not provide accurate, reliable, or up-to-date data, managers may create their own files for their tasks (KM, KR and FC). Without transparency, other units that need the same data may have their own copies. Instead of one reliable data set, many data are fragmented into separate files or embedded in applications for specific purposes, such as sustainability analyses of suppliers (KM and JP).

Many interviewees had developed visions of a single database or a similar system that could contain all reliable and up-to-date data (JT, KR, MK, RI, TP, KM and JL) as none of the firms currently has a single database for all data. The logic is to have one master data set pertaining to a supplier that could be used for multiple applications while ensuring transparency and data quality through the data architecture (JL, KM and TP). The data architecture should be created and working before any data analytics (JT). Malleable data structures that are applicable across functional units, categories and other departments in the firm are needed (KM and TP). Data structure, the contents of data sets and how to use them are the main focus areas to develop toward establishing shared databases. However, this may take several years if the starting point is fragmented systems, with which a database could be set up in fragments because of limited resources and dependencies between IT systems (JT). Some firms had established projects to integrate data sets, including dashboards and the use of ERPs as main sources (MV). However, ERP does not necessarily contain data in an accessible format or all necessary data for tactical purchasing, and tactical purchasing also brings external data into a firm. Strategic PSM needs are less developed in ERP modules, but adding them is a challenge because ERPs are often maintained by operational departments (MV).

When we highlight the purchasing function's need to consume varying data sets that were created elsewhere in the organization, we conclude that the data infrastructure should serve as a platform to positively influence the digital transformation of the PSM process. Different teams with various functions could create and consume data sets autonomously by using the platform. These data sets must be interoperable, and the complexity of building such data sets is solved by global governance and open standards (Machado *et al.*, 2021).

Interoperability is also essential for interfaces between companies. Similar to the internal infrastructure, data transfer from and to suppliers should be based on technologies that allow many receivers and senders to share common technologies (JL, RV and RI). There should be flexibility to exchange information with a supplier through systems that ensure point-to-many connectivity (JL). Thus, the connectivity would not be built between a buyer and only one supplier but multiple suppliers that follow the same application or standard to communicate (JL). For instance, suppliers could receive purchase orders more smoothly through these interfaces (ER).

One interviewee thought that application programming interfaces (APIs) might be much more important in the future than one-to-one integration of systems (RI). The PSM process steps, including supplier communication, would benefit from standardized methods of sharing all information. However, no single standard has been established, and multiple standards, including traditional electronic data interchange (EDI), are still applied. On the basis of these findings, we propose the following:

P1. Data infrastructure as a platform positively influences the digital transformation of the PSM process.

P2. Global governance and open standards for interoperability positively influence the digital transformation of the PSM process.

Applications as a source of data

Many interviewees mentioned that the PSM function suffers from fragmented applications (JP, JL, KM, RI and TP). There are multiple systems for supplier data, such as SRM systems that allow for documenting supplier data and handling documents in the RFx process, including RFI and RFQ (FC and KR). E-tender or e-sourcing systems are often separate from SRM, but these applications should have fluent data transfers between them (KR). Many other applications contain supplier data or need them as input, such as a spend program, contract management program, ERP, but many PSM units struggle with data transfer between these (JP). Because of fragmented applications, creating an overall view or data enrichment is difficult with fragmented and non-commensurable data sets (FC, JN, JT). Thus, the depth of digital advancements in the interviewees' PSM units had remained at a basic level (spend analysis and price comparisons between suppliers) instead of at the level of more advanced methods such as big data analytics (ER, FC and RV).

Table 3 provides an overview of applications in the interviewees' firms. The two smallest companies in our data set, firms H and J, had fewer IT systems in their strategic purchasing when compared to other firms. This indicates how an operational PSM process is usually

Table 3. Overview of applications

Firm	Interviews	ERP	E-procurement (supplier providing)	EDI	Purchasing system/e-sourcing/e-tendering	SRM	Contract management	Sector
A	ER, KM	x	No	No	No	No	Database, electronic signatures	B-to-C hand tools
B	FC	x	No	No	No	x	Contracts are saved to SRM, indirect purchases to another system	Chemicals
C	JL, JM	x	x	x	e-sourcing/e-tendering	Supplier portal	Database, electronic signatures	Biomaterials
D	JN	No	x	No	purchasing system	Supplier portal	Electronic signatures	Construction
E	JP	x	No	No	e-tendering	No	Contract management system, electronic signatures	Food supply
F	JT	x	No	x	purchasing system/e-tendering	No	Part of the purchasing system	Biomaterials
G	KR	x	x	No	e-sourcing/e-tendering	x	Contract management system	Food supply
H	MK	x	No	No	No	No	Database	Pharmaceuticals
I	MV	x	x	No	x	No	Database, electronic signature	Telecommunications (hardware)
J	RI	x	No	No	No	No	No	Construction
K	RV	x	No	x	No	No	Contract management system	Biomaterials
L	TP	x	No	No	e-sourcing	Not yet in use	Contract management system	IT services

Source(s): Table by authors

developed to a more advanced level before strategic or tactical phases. Operational purchasing is mainly conducted by ERP in the case organizations and these applications also contain supplier data (Table 3). There is data overlap between the master data from the ERP and SRM systems even if the master data do not contain all information necessary for PSM, including the preferred supplier status and classifications (JP). ERP should allow data integration to SRM or the supplier portal, and these should allow data transfer to the e-tendering system.

In the strategic and tactical PSM process phases, applications should extract data for other uses. Contracts are one example of documents that must be interoperable by multiple applications. Contract management systems store contracts (JP, KR and TP) or contract databases, which are simple databases or archives of contracts that may be distinct from other applications (KM, MV, RI and ER). This distinction creates barriers to digital transformation, since multiple separate applications are linked to contract management, including electronic signatures, purchasing systems and SRM. AI applications could reduce the human workload by screening lengthy documents and proposing documents that require attention (FC). The purchasing system could make notions to update contracts when conditions change if contracts are part of it (RV). Contracts have two or more participants by default, but the systems mentioned in the interviews do not support the participation of external actors (RI). Some purchasing systems allow contracts to be sent to suppliers for approval (JT), but making drafts together would be an advancement (RI). It is difficult to grasp how one application could provide all these solutions that are linked to contracts, and if applications stay fragmented in the future, data transfer between them is important. Therefore, contracts should be stored in an interoperable target database. An application could use this database as its source of data when interoperability is guaranteed by global governance and open standards. Similarly, applications must provide the data for further use.

As a logical consequence of these examples, we state that applications must allow the extraction of data for other uses to support digital transformation. First, data are extracted from target sources, such as applications or data sets (e.g., ERP, SRM and contract management). Then, the data are transformed into a format that can be used by different applications, cleaned and mapped. Next, the extracted data must be loaded into a common, interoperable target database. It must be interoperable, as other uses with various applications may be located elsewhere in the organization. The process steps for integrating data are extracting, transforming and loading (Mukherjee and Kar, 2017). On the basis of this analysis, we propose the following:

P3. Applications that support the digital transformation of the PSM process must allow data extraction, and these data could be transformed and loaded to a common, interoperable target database, data lake or similar.

PSM data owned and served by a cross-functional team

The organizational separation of operational and strategic purchasing is also visible in the digital infrastructure. Data transfer from strategic or tactical purchasing to operational purchasing and vice versa were considered risks (JL and TP). For example, the separation of operational and strategic purchasing is seen in the sourcing analysis process phase.

Sourcing analyses are considered promising for digital transformation in the near future (JN, RI and RV) because, by increasing data reliability, these could improve the development of sourcing strategies because of inputs of internal and external data (JP, KR, MV, JL, TP and RV). These internal and external data sets include financial data from previous contracts, potential supplier candidates and addressable spending data (JL, RV, TP and JT). Slow data transfer hampers access to real-time spending data (KR). Multiple systems are available, but the data sets downloaded from them are not necessarily correct. Errors occur with spending data during the input and output stages (KM). The main goal is to access correct data first and then the analysis can be conducted with an ordinary spreadsheet program (FC, JM, JL and TP). Thus, spending data should be owned and served by both operational and strategic PSM.

ERP systems do not serve all supplier data needs for a strategic PSM process, including sourcing analyses. The ERP data structure is used in the financial analysis rather than in meeting various PSM needs (KM). This leads to supplier data sets being located in some specific applications in the context of either strategic PSM or ERP. Many interviewees highlighted that they aim for a single, up-to-date supplier data entity but are far from achieving this. Resources are expended in building data sets, forcing managers to address more simple questions even if the data for more advanced analyses could have been available in the fragmented files.

An operational PSM process aims for process improvement and control over applications and their commensurability, which leads to ERP centricity. Yet the operational PSM process creates data that are cross-functionally important. These data cannot be left unused even if a process improvement requires stable applications, which should be sources of general-purpose data. These general-purpose data could be shared between functional domains or departments without a strict demand to use a specific application to access them.

In that way, data analytics and supplier measurement in strategic and tactical PSM could apply these data better. Even if the firm does not have global governance and open standards to ensure interoperability, the empirical analysis highlighted the need for common datasets that are available for operational and strategic PSM processes.

P4. Operational and strategic PSM require a common data lake or a similar space to combine PSM data, which positively influences the digital transformation of the PSM process.

Mechanisms by which digitalization creates value for the PSM process

Supplier measurement. Sourcing analyses and supplier selection PSM process phases underscore supplier measurement as a mechanism that creates value for the process. Our analysis revealed that supplier measurement is hindered by data issues, but there are multiple programs that do specific measurement-related tasks. If firms would like to progress in supplier measurement, they need to adopt applications that allow data extraction to other uses elsewhere in the firm.

Supplier data tend to scatter around applications even if the same up-to-date supplier data available everywhere in the organization would increase transparency and data quality (KM, JL and KR). A shortage of supplier data in a structured form limits supplier measurement possibilities to price-centric decisions (JN and RI). Comparisons are often performed manually with spreadsheets (MV). AI could be used to screen supplier websites and import data to the buyer's system (JL). A single supplier database consisting of internal and external data is needed for supplier measurement.

Supplier portals in which suppliers could fill in their information and from which one or more buyers could transfer data to their systems are promising tools for the future (KR and JL). The supplier's input could initially be screened with RPA to ensure that all information is present (JL). Supplier portals would increase suppliers' workloads if they were built between a supplier and a buyer (KR). However, if there are more standards for supplier data transfer, the same supplier data could be available for multiple firms (RI and JM). A third party could audit the information accuracy in this type of service (JM). Credit reports and insufficient tax obligations provided by third parties are examples of digital transformation based on data standards that systems can capture without human intervention (JN and RV).

Process development. Process development is another mechanism that offers improvement when digital transformation is in progress. A digital transformation aimed at process development often entails connecting multiple PSM process phases and removing barriers to data transfer between these phases. In the tactical phase, the role of supplier approvals and purchasing systems is crucial. For instance, if a firm has a purchasing system that directs and manages purchasing activities, such as supplier selection, negotiation and contracting, the sourcing strategy should be implemented in this system (JT). In this way, key performance indicators that support the sourcing strategy are known and visible during later phases after strategy development.

Process development also includes process control, including supplier selection and reduction of maverick buying. Supplier compliance, financial performance and other approvals are part of the process development in which digital systems are necessary during supplier selection (JT). Approvals may be inadequate, especially regarding indirect purchases, which are at risk of being left out of purchase orders (ER). Indirect purchases do not necessarily go through ERP, causing missing data about them (FC) and a lack of data transfer to finance and direct sourcing (ER). Digital transformation could formalize the indirect purchasing process (ER) and internal control (JT). The purchasing system should somehow obtain insights about all purchases even if they are made in a wrong way and support the objective to make correct purchase orders (KR).

The PSM process has a weak point in moving from the end of the tactical phase to the beginning of the operational phase, because different teams in varying locations are usually responsible for this. For example, data transfer of the intended meaning of the contract to actual purchases would improve the process (JL and ER). An approval earlier in the process could replace later approvals in operative PSM if digital systems allow. Before contracting, expenditure and project approvals should be obtained and could be transferred through the process without additional approvals if the systems are reliable (ER). Similarly, integration of the operational purchasing system and inventory levels before creating a purchase order could lower costs when unnecessary purchases decrease (MV). Production planning and operational purchasing units require continuous dialogue, which could be facilitated by digital channels (JT and KR). If the system can properly identify needs and can forecast the demand and devise a plan accordingly; orders would not be based on historical data but on actual needs when automated purchases could increase (FC, JM, JL, RI). Nevertheless, problems with data quality hinder automated purchases (FC) even if they are increasingly used for regular or routine purchases (JL, KR, RI and RV).

During operational purchasing, process improvements require applications or systems to add control to match the invoice quantity and amount to the purchase order (JT, JL) or packing documents (JN). However, these are late steps from the perspective of control because problems with purchase orders that are noticed at this stage have already occurred (ER). All the examples in this section underscore two main mechanisms by which digital transformation enhances the performance of the PSM function. Thus, our final proposition suggests the following:

P5. Supplier measurement and process development are the main mechanisms by which digital transformation improves the performance of the PSM function.

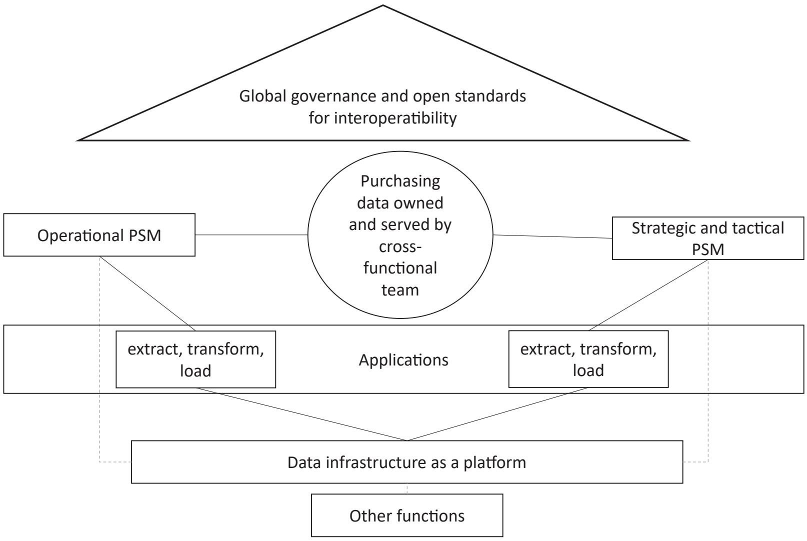
Discussion

Implications for theory

Considerable progress has been made in understanding the digital transformation of the purchasing and supply management (PSM) function (Lorentz *et al.*, 2021; Seyedghorban *et al.*, 2020; Srai and Lorentz, 2019). However, advanced technologies have not fulfilled their promises for PSM processes, and the scope of transformation has remained ambiguous for researchers and practitioners (Herold *et al.*, 2022). A unified digital infrastructure that allows boundaryless data transfer and digital integration was previously identified as one factor (Herold *et al.*, 2022; Seyedghorban *et al.*, 2020) but not suggested as a scope of transformation until now. By proposing what kind of redesign of internal structures could positively influence digital transformation, we contribute to the research stream of digital integration and maturity in the PSM function (Herold *et al.*, 2022; Seyedghorban *et al.*, 2020).

The central contribution of this study lies in the data infrastructure, which is the primary intervention for the digital transformation of PSM processes. The data infrastructure needs firm-wide global governance and open standards that allow interoperable, generic data sets that are located on platforms (Propositions 1 and 2). Applications must be adjusted to work with these generic data sets, and applications should also serve as sources of data to integrate them for further use beyond organizational boundaries (Propositions 3 and 4). Transforming the data infrastructure is the primary intervention because it will enable performance improvements in supplier measurement due to integrated, generic supplier data (Proposition 5). Process development is another mechanism by which digital transformation improves the performance of the PSM function (Proposition 5). The data architecture particularly influences the digital transformation of strategic and tactical PSM processes. However, operational PSM and its process developments have been based on an integrated set of applications that transfer data directly between applications. That is why digital transformation in the data infrastructure requires operational PSM and its applications to serve more as a source of generic data sets, even if its own digital transformation focuses on integrating applications. The digital transformation that emerges from the data infrastructure in the context of the PSM process is summarized in Figure 2. Some concepts in the figure have been borrowed from the data architecture literature (Machado *et al.*, 2021) and practitioners (Zhamak, 2020). Next, we discuss each proposition and reflect on it in light of previous research.

Proposition 1. *Data infrastructure as a platform positively influences the digital transformation of PSM processes.* Without data integration, the data architecture always satisfies needs other



Source(s): Figure by authors

Figure 2.
Digital transformation for PSM processes

than those of supply management. When the digital infrastructure moves toward data integration, the maturity of PSM digitalization increases (Seyedghorban *et al.*, 2020). The data infrastructure should provide data on a self-service basis and allow purchasing professional tools to access it. Our findings indicate that strategic and tactical PSM would especially benefit interventions that create generic PSM data, for instance, generic supplier data sets for supplier measurement. Similarly, the external data of customers and suppliers would benefit from data integration (Handfield *et al.*, 2019). Fragmented data sources and incomplete data have been reported to impede AI solutions in PSM (Wehrle *et al.*, 2022), but a common data platform could remove boundaries (Öhman *et al.*, 2021; Seyedghorban *et al.*, 2020). Internal data integration, such as spend data platforms, might enhance coordination and control (Lorentz *et al.*, 2021). An adequate data architecture generates synergies for PSM processes when there is well-curated data from multiple sources (Legenvre *et al.*, 2020).

Proposition 2. *Global governance and open standards for interoperability positively influence the digital transformation of PSM processes.* The data infrastructure should not include domain-specific concepts, keeping it domain-agnostic and preserving autonomy to create and maintain insights from data (Machado *et al.*, 2021). Data integration is enabled by interoperability, which is not reachable without global governance and open standards in a firm. Global governance and open standards are reflected in Seyedghorban *et al.*'s (2020) work when they discuss streamlining the boundary structure of the procurement function and removing data boundaries. Similarly, Arcidiacono *et al.* (2022) determined that compatibility planning between existing and novel technologies is necessary to enable big data analytics. Thus, interoperability also applies to the application level. When purchasing has a strategic role, the boundaries of the applications must be solved, and databases must be accessible to various, continuously developing applications (by importing and exporting data). Therefore, the data repository must be designed for general purposes, not for applications. If interoperability does not fully exist, firms apply RPA to enable data transfer between different information systems (Lorentz *et al.*, 2021), but this is a quick fix for a permanent need for interoperability. Lorentz *et al.* (2021) discussed a harmonization process involving a decrease in the number of systems to overcome problems of siloed systems to improve digital transformation. Our findings also suggest that interoperable systems are required for interfaces between firms, and this is in line with the previous findings of Legenvre *et al.* (2020).

Proposition 3. *Applications that support the digital transformation of PSM processes must allow data extraction, and these data could be transformed and loaded to a common, interoperable target database, data lake, or similar.* Digital transformation requires cross-functional coordination (Allal-Chérif *et al.*, 2021; Seyedghorban *et al.*, 2020) and data transfer between applications across organizational boundaries. Given the multidimensionality of purchasing-related data (internal and external data), one large application aimed at providing operational and analytical data has never fulfilled all needs. That is why applications must support data integration, which is a less discussed insight in the literature. As digital transformation requires integration that cannot be compromised, this might mean that the best tool for a specific task must be rejected in favor of an application that enables data integration (Gust *et al.*, 2017). A format that provides interoperability depends on the rules issued by IT governance (the triangle in Figure 2). This finding resonates with previous work: Legenvre *et al.* (2020) highlighted the immense need for a firm to integrate IoT technologies and related applications within its digital infrastructure to benefit from big data in PSM.

Proposition 4. *Operational and strategic PSM require a common data lake or a similar space to combine PSM data, which positively influences the digital transformation of PSM processes.* The organizational separation of operational and strategic purchasing is also visible in the digital infrastructure and our empirical results showed that data transfer between these functions was a challenge. The digital infrastructure in operational purchasing (ERPs) is highly interdependent on other fundamental systems that reduce its adaptability to other

PSM needs. In contrast, tactical PSM processes must build on data whose structure and representation do not directly respond to their needs. Second, external data about suppliers (created or obtained by strategic and tactical PSM processes) is difficult to combine with internal data created through operative PSM. Consequently, a single data set consisting of all supplier-related data or other procurement data is extremely challenging to create, hindering supplier measurement and sourcing analyses. Process steps, such as sourcing analyses and supplier selection, are data driven and could be improved by data integration. Thus, operational, strategic and tactical PSM processes require a common data lake or a similar space to combine PSM data (circle in Figure 2). This is in line with Öhman *et al.*'s (2021) finding that data analytics in PSM represents an increasingly cross-functional initiative, and that the construction of data sets should be user-driven. This means that strategic and tactical PSM processes should be seen as users of operational PSM data.

Proposition 5. Supplier measurement and process development are the main mechanisms by which digital transformation improves the performance of the PSM function. Process development is one of the most important benefits of digital transformation (Lorentz *et al.*, 2021). Our findings show that a process improvement mechanism is based on an interdependent set of applications that use and produce operational data. These applications control and formalize procedures and, to some extent, automatization, consistent with previous findings (Lorentz *et al.*, 2021; Srai and Lorentz, 2019). Supplier measurement is based on stand-alone applications that are specific and use multiple data sources. These applications do not necessarily need to be directly integrated into other applications, but into general-purpose data sets that are accessible. In addition, the mechanism of supplier measurement creates interesting outcomes for additional process steps and other functions, highlighting the role of sharing insightful information at the firm level (Seyedghorban *et al.*, 2020). This study provides the novel insight that the mechanism of process development demands interdependent applications (direct application integration), whereas supplier measurement demands general-purpose data provided by the data infrastructure as a platform (data integration). These demands are different, suggesting that purchasing applications could be understood from the perspective of process improvement or supplier measurement, and combining these two mechanisms in the same applications might limit the advancement of supplier measurement because of the interdependencies of process improvement–centric applications.

Implications for practice

Process development and supplier measurement are the main mechanisms by which digital transformation improves the performance of the PSM function. Companies appear to be developing very strong digitalization infrastructures through ERP systems, in principle, focusing more on supporting the process development. These process developments are based on an integrated set of applications that transfer data directly between applications. But given the pace of renewal of applications (e.g., big data analytics), especially in strategic and tactical PSM, attempts to fully integrate all fragmented applications with direct interfaces will always fall behind. That is why direct interfaces between applications should not be within the main scope of transformation in strategic and tactical PSM. Instead, our findings indicate that strategic and tactical PSM would benefit interventions that create generic PSM data. Thus, our findings propose data infrastructure as a scope of digital transformation when strategic, data-driven benefits (e.g., supplier measurement) are sought. However, process development is based on integration among applications. Thus, technological roadmaps for PSM processes should consider application/technology integration to induce process development and the data infrastructure to induce strategic analyses.

The solutions to infrastructure challenges should strive for cross-functional data sets and data integration should be emphasized. The PSM data should be owned and served by a cross-functional team that possesses operational, strategic and tactical PSM process understanding. Practitioners should integrate these data on a general-purpose, accessible platform. Global governance and open standards provide interoperability, and applications must serve as data sources. Data infrastructure is not a function for PSM to decide, but the PSM must ensure access to the data. Similarly, the PSM function is a source of data that others may need, which leads to cross-functional planning of data representation (Öhman *et al.*, 2021). Incompatible applications are not worthy of investment. Operational ERP systems should function better as data sources to make greater use of data in areas such as supplier performance evaluation. The design and maintenance of lasting data structures create the basis for promoting transformation on which data-intensive services and applications for supplier measurement and process improvement can be built.

Conclusions, limitations and future research

In this study, we explored the interventions of and mechanisms for digital transformation of the PSM process. Our research findings underscore that the data infrastructure is the main intervention for the digital transformation of PSM processes. Data infrastructure as a platform removes boundaries between systems, generates synergy for processes and enhances coordination and control of PSM function. Digital transformation requires the intervention of open standards that allow interdependent applications to focus on process improvement in maintaining the formalization and control of PSM processes. Comprehensive data governance and open standards enable interoperability across the different functions of a firm and between the interfaces of other organizations. The generic data sets can serve PSM decision-makers by enabling them to improve supplier measurement. PSM process data should be owned and served by a cross-functional team that considers operational, strategic and tactical purchasing needs. The PSM function deserves the latest technological advancements to reach its strategic and value-adding role in process development. Therefore, we hope that research on digital transformation continues to grow.

This exploratory study has several limitations. We considered a relatively small sample of 12 Finnish firms. Almost all these firms organized their operational PSM through ERP systems, but our implications might be less relevant, especially for smaller firms that do not have ERPs. Similarly, other context-related factors, such as the location or business sector, may impact the findings. Therefore, one should be cautious about generalizing these results to a broader set of firms. Thus, in this exploratory study, we formulated testable propositions for future research. Another limitation of this study is that as the interview data was gathered from large enterprises, the findings are not applicable to PSM processes in small enterprises. Similarly, the data did not include many service businesses, but included businesses that manufactured or produced goods. In future research, digital transformation in these small enterprises could be investigated, especially in terms of PSM processes and different sectors. Moreover, technology- and application-centric discussions are important for digital transformation, and more detailed research is required. Discussions of analytics (Handfield *et al.*, 2019) or IoT in the purchasing context (Legenvre *et al.*, 2020) are examples of fruitful research directions in parallel with the integration of systems.

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Supplementary File

	First-order codes	Description	Example of evidence
Supplier measurement	Supplier measurement requires data	A situation when supplier measurement is linked with internal or external data	"When we get data from database, we could build key performance indicators" (MK)
	Supplier data needed for discussions with supplier	A situation when data brings benefit to a buyer when discussing with supplier	"Reports about suppliers creates right focus to discuss how they could develop further their quality, time and cost management" (JN)
	Measuring instruments	Tools and techniques for supplier measurement	"We follow our suppliers' CO_2 emissions and total recordable incidents (TRIs)-index" (JL)
Process development	Approvals	Formal approvals of management to continue purchasing process	"We have a spend approval before the process can go on" (ER)

Table A1.
A coding scheme

(*continued*)

	First-order codes	Description	Example of evidence
	Maverick buying	Making purchases without following the intended purchasing process or choosing suppliers that are accepted by the firm	"When we do not have a system, someone just order by phone and invoices arrive that are not known by us" (KR)
	Process control	Guiding of the purchasing process from the start to end and ensuring the control	"Our system of purchasing and supply management holistically quides the process and include internal controls" (JT)
	Supplier selection control	Ensuring the validity of supplier or preferred status	"When we started to use software, our managers could see additional information when selecting a supplier" (KM)
	Process development	Aim to improve the purchasing process (e.g., transparency)	"Enterprise resource planning solutions are just tools but there must be rules how process goes on" (RV)
Data	Internal data	Data retrieved from inside of the firm or through operations	"We receive information from ERP but we wish to have more data there" (MV)
	External data	Data acquired beyond the firm boundaries	"We collected data from stakeholders to understand possibility of market changes" (JT)
	Supplier data	Internal or external supplier related data	"What kind of suppliers we have. We don't have yet great tools for supplier data management" (JP)
	Data quality	Accuracy, consistency, reliability, and up-to-datedness of data	"Reliability of data is a major factor to slow down adoption of novel solutions" (JT)
Automation	Automated data screening	Data could be checked by automation	"Registration of supplier to a portal could be checked automatically now and then" (JP)
	Automated tenders	Automation of requests for quotation and bids handling	"I see potential in automation of tenders as much as possible for routine purchases" (JM)
	Automated operational purchasing	Automation of purchasing orders	"If we always make the same order frequently, it could be automated instead of manual work" (JL)
Applications	Applications for internal data integration	Any application that creates internal data sets from scattered data	"We gather supplier, invoice and order information to BI-tool" (JN)
	Enterprise resource planning (ERP)	Enterprise resource planning (ERP)	"Operational purchasing goes through ERP" (FC)
	E-sourcing applications	Digital tools for sourcing activities	"We have a e-sourcing system to conduct process electronically" (TP)
	Product data management (PDM)	Product data management (PDM) software that include, e.g. product design data	"We have PDM that means we aim to limit our repertoire of products" (RI)
	Robotic process automation (RPA)	Robotic process automation (RPA)	"RPA will be used to routine tasks" (JL)
	Spend analysis with a program	Software applied to spend analysis	"We have Sievo software for spend analysis" (KR)

(*continued*)

Table A1.

	First-order codes	Description	Example of evidence
	Supplier relationship management (SRM)	Supplier relationship management (SRM)	"We have SRM module, but it is not yet in use" (TP)
	Supplier related applications	Other supplier-related applications that do not belong to other code categories	"Co-development hubs with a supplier" (JM)
Data analytics	Sourcing analyses	Collecting and analyzing procurement data	"There must be reliable internal data for sourcing analysis" (JT)
	Data analytics to market data	Analytics to market data	"Digitalization helps to follow market data but people makes analyses" (RV)
	Digitalization and knowledge based management are dependent on each others	Analytics require data and let knowledge based management	"When decision making requires evaluation, digitalization produces the information needed" (RV)
Digital infrastructure	Structure of digital infrastructure	The basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function" (Tilson *et al.*, 2010, p. 748)	"Our digital environment consist of multiple tools instead of entities" (KM) "No more connections between one system to another but rather API interfaces to help construct system architecture " (RI)
	Separation of operational and strategic purchasing	Operational and strategic purchasing are often distinct functions in terms of digital solutions	"I would like to see development of process when we move from strategic to operational side.it is a window of vulnerability" (JL)
	Point-to-many solutions to enable interfaces between companies	Data transfer that allows a buyer to communicate with several suppliers through one established connection to a network	"Point-to-many in which buyer builds one connection to a network. In that network there could be hundreds or thousands of suppliers, which allows data transfer through the network. Then there are no built connections to one-by-one" (JL)

Table A1.

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