Exploring the effects of SMEs' platform-based digital connectivity on firm performance – the moderating role of environmental turbulence

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Abstract

Purpose – Small- and medium-sized enterprises (SMEs) often operate in environments marked by high levels of turbulence. Such firms adopt digital technologies and platforms that provide access to external real-time information and establish digital connectivity between firms to remain competitive. This study aims to focus on SMEs' downstream and upstream platform-based digital connectivity (PDC).

Design/methodology/approach – This study examines the effects of PDC on SMEs' operational performance under conditions of environmental turbulence. The data was gathered from 192 SMEs operating in the manufacturing arena.

Findings – The results show that the adoption of PDC does not directly affect an SME's operational performance. However, in highly turbulent environments, PDC can improve operational performance. The results indicate that the performance effects of PDC vary according to the level and type of environmental turbulence.

Research limitations/implications – This research offers insights into the relationship between PDC among SMEs and operational performance and encourages future research examining other possible conditional effects that could explain the contradictory results found in previous research.

Originality/value – This study contributes to the knowledge of supply-chain digitalization among SMEs and its performance effects in varying environmental conditions. Further, this study contributes to the prior research by focusing on the interorganizational aspects of digitalization in SMEs.

Keywords Platform-based digital connectivity, Digitalization, Environmental turbulence, Small- and medium-sized enterprises

Paper type Research paper

1. Introduction

The digitalization of small- and medium-sized enterprises (SMEs) has recently attracted scholarly attention (Eller *et al.*, 2020; Matarazzo *et al.*, 2021; Scuotto *et al.*, 2021). The majority of the research exploring digital transformation has focused on large corporations (Cenamor *et al.*, 2019; Matarazzo *et al.*, 2021), and it is argued that SMEs lag behind larger companies in terms of the extent of digitalization (Eller *et al.*, 2020). Nevertheless, SMEs compete in highly dynamic environments and continuously search for ways to survive, grow and be competitive (Cenamor *et al.*, 2019; Lin and Lin, 2016; Martinelli and Tunisini, 2019). Digital technologies are developing and providing access to new ways to create value (de Gooyert, 2020). The emergence of new digital technologies signals that firms should seek to transform their business digitally (Verhoef *et al.*, 2021). Many SMEs are making more use of digital platforms to implement their business strategies in response to the pressures of competition (Li *et al.*, 2016).

Prior research has reviewed the advantages of information technology for company performance (Eller *et al.*, 2020; Suoniemi *et al.*, 2022; Yunis *et al.*, 2018), but there remains little research on the impact of digitalization on firm performance (Eller *et al.*, 2020; Ferreira *et al.*, 2018). Results on the impact of digital technologies on firm performance are conflicting. Some studies report that using digital technologies alone does not benefit performance (Cenamor *et al.*, 2019; Irani, 2010), and that a majority of projects adopting digital technology fail (Irani, 2010; Yunis *et al.*, 2018),). However, some studies report positive effects on firm performance (Eller *et al.*, 2020; Li *et al.*, 2020). Moreover, it is feasible that the relationship between digitalization and firm performance is nonlinear (Kohtamäki *et al.*, 2020). These contradictory results demonstrate the existence of the productivity paradox of information technology (IT) (Brynjolfsson and Hitt, 1998;

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King et al., 2020), which refers to the fact that massive investments in information systems (IT) do not always spur productivity improvements.

Digital technologies facilitate interactions between organizations, and digital platforms are an important source of competitive advantage in networked economies (Cenamor et al., 2019; Kazan et al., 2018). Digitalization enhances effective interaction between firms and has made organizational boundaries more flexible and permeable (Corsaro and D'Amico, 2022). Moreover, digital technologies facilitate processes that connect people and companies and enable monitoring, communication, exchange and feedback (Cherbib et al., 2021). Digital platforms and digital technologies are forms of digital connectivity available to firms. Digital connectivity, which includes information sharing, is considered one of the most important contributors to expediting the flow of goods, mitigating risks and minimizing uncertainty in supply chains. The forms of digital connectivity available to firms include digital platforms and other digital technologies (Engelseth and Wang, 2018; Lin et al., 2021b). This study focuses on platform-based digital connectivity (PDC), which refers to using digital technologies and processes in upstream and downstream supply chains to share information and convey knowledge. Prior research has argued that digital platforms are increasingly being created and implemented in various functions within supply chains (Lin et al., 2021a).

There is a call for research on how digitalization affects firm performance from the interorganizational perspective (Lin et al., 2021b; Martinelli and Tunisini, 2019), especially in varying environmental conditions (Li, 2022). We respond to this call by studying the PDC of firms in various environmental conditions. The results of the study demonstrate that PDC is not directly associated with operational performance; however, in a turbulent environment PDC produces operational benefits (Wang et al., 2020).

This paper aims to study the effects of PDC on firm performance under various conditions of environmental turbulence. Prior research has addressed environmental turbulence as an aggregate construct (Liao and Tu, 2008; Turulja and Bajgoric, 2019) or distinguished competitive, market and technological forms of turbulence (Jaworski and Kohli, 1993; Kohli and Jaworski, 1990; Wilden and Gudergan, 2015). Research on the moderating effect of environmental turbulence on the relationship between digitalization and performance is relatively scarce and mainly focused on the performance impact of digital technologies (Li et al., 2020), IT capabilities (Chen et al., 2014; Dubey et al., 2020; Rai and Tang, 2010), big data analytics (Wamba et al., 2020) and the integration of supply-chain information (Iyer et al., 2009). Extant knowledge of the moderating effect of environmental turbulence is somewhat contradictory and is influenced by the form of turbulence studied. We focus on the moderating effects of environmental turbulence between PDC and the operational performance of SMEs. Environmental turbulence is used as an aggregated construct, and the competitive, technological and market forms of turbulence are also addressed. This paper aims to study the effects of PDC on firm performance under different conditions of environmental turbulence.

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The study draws on supply chain digitalization literature to examine the moderating effect of environmental turbulence on PDC and SME performance. Research on the benefits of digitalization applicable to SMEs is relatively scarce (Cenamor et al., 2019; Matarazzo et al., 2021), which reinforces the need to extend the knowledge on the use of digital technologies and platforms in SMEs and the associated benefits. Accordingly, the research questions are as follows:

RQ1. To what extent does PDC affect operational performance?

RQ2. What is the effect of environmental turbulence on the relationship between PDC and operational performance?

The empirical part of the paper is based on a sample of 192 Finnish SMEs, and hierarchical regression analysis is conducted to address the research questions. The results of the study demonstrate that PDC is not directly associated with operational performance; however, under some environmental conditions, PDC produces operational benefits. This study contributes to the supply chain digitalization literature by showing that PDC does not in itself improve operational performance in SMEs. Further, we contribute to the literature by expanding knowledge on the effects of PDC and operational performance among SMEs. We also demonstrate that depending on the level of environmental turbulence and the type of turbulence, PDC can either improve or diminish operational performance. An additional contribution is therefore to demonstrate that the performance effects of PDC can vary markedly depending on the conditions.

The paper is structured as follows. Section 2 presents the theoretical background of the study and its research hypotheses. Then, the data and empirical methods are presented, and then the results are outlined in Section 3. We then discuss the findings and theoretical contributions in Section 4. Finally, managerial implications are discussed, and suggestions for future research are made in Section 5.

2. Theoretical background and hypotheses

Digital transformation has prompted several recent literature reviews (Hanelt et al., 2021; Nadkarni and Prügl, 2020;

Verhoef *et al.*, 2021), with the topic being defined as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication and connectivity technologies (Vial, 2019). Verhoef *et al.* (2021) distinguished three phases of digital transformation: digitization, digitalization and digital transformation. Digitization refers to the action of converting analog information into digital information (Verhoef *et al.*, 2021); digitalization is defined as the use of digital technologies (Srai and Lorentz, 2019), and digital transformation is seen as a larger change (Verhoef *et al.*, 2021), similar to the definition of Vial (2019). In this paper, we focus on the digitalization of interorganizational relationships, and thus, we build on digitalization literature.

Cross-boundary digital technologies drive changes that extend beyond internal process optimization as such technologies potentially trigger changes to business models, strategy, corporate culture and entire industry structures (Nadkarni and Prügl, 2020). Digitalization is changing how companies in a value chain interact with firms upstream or downstream in the supply chain, improving interorganizational interactions and improving data acquisition, warehousing and big data analytics (Porter and Heppelmann, 2014). Value creation is shifting from the value chain to value networks. Networks and ecosystems are, in turn, becoming more interconnected because of the growth of digital platforms (Nadkarni and Prügl, 2020). Digitalization fosters a greater number of network parties and process integration that again enables collaboration, information sharing and joint goals (Shashi *et al.*, 2020). Consequently, firms develop digital connectivity to access and share information with supply chain partners (Wong *et al.*, 2011a, 2011b).

This study defines PDC as the adoption of platform-based digital technologies and processes that enable firms to access, acquire and share knowledge and real-time information in the upstream and downstream supply chain. This view has some similarities with the so-called *self-thinking supply chain*. The notion holds supply chains are digitally connected through the cloud-based Internet of Things (IoT) architecture that enables real-time connectivity and deploying artificial intelligence to monitor supply chain performance (Calatayud *et al.*, 2019; Hallikas *et al.*, 2021). However, while self-thinking supply chains remain merely a vision, PDC among firms is already quite commonplace. Further, many digital technologies cannot be restricted to the boundaries of specific firms, instead involving a wider ecosystem or digital infrastructures that may be open (Hanelt *et al.*, 2021).

Implementing new digital technologies is always risky for SMEs (Moeuf *et al.*, 2018). Digitalization solely through the implementation of enterprise resource planning (ERP) systems has very high costs in relation to benefits and is not seen as a very productive digitalization strategy for SMEs (Koh and Saad, 2006). Accordingly, companies are increasingly investing in and introducing digital platforms to increase operational efficiency, establish interorganizational collaboration and improve customer satisfaction (Cenamor *et al.*, 2019; Hong *et al.*, 2021). Digital platforms are crucial in connected and data-rich businesses that utilize information sharing, collaboration and collective action (Costa *et al.*, 2020). Digital platforms provide SMEs with an affordable way to digitalize business compared to investing in complex IT systems (Cenamor *et al.*, 2019). Further, digital platforms are sources of external knowledge, which may be crucial for achieving competitive advantage via digital technologies (Ricci *et al.*, 2021).

2.1 Platform-based digital connectivity and small- and medium-sized enterprises performance

A major objective of digitalization in supply chains is to gather information about changes in the business environment, market customer behavior and the competitive situation (Hallikas *et al.*, 2021). Meeting that objective requires organizations identify, access and collect relevant data. Those data must then be combined, refined, analyzed and transformed into an actionable form to benefit from the digitalization of the supply chain (Hallikas *et al.*, 2021). In addition, firms adopting PDC should weigh the benefits of information sharing against the vulnerability to information leakage (Ried *et al.*, 2021).

Prior research identifies some positive effects of digitalization and firm performance. For instance, Barua *et al.* (2004) found that customer-side digitization is positively related to financial performance. Similarly, Eller *et al.* (2020) found that digitalization positively affects an SME's financial performance. Other research, in contrast, indicates that digitalization *per se* does not enhance a firm's performance. For example, Hallikas *et al.* (2021) found that using external market-related data did not directly affect supply chain performance but that external data could nurture digital procurement capability and thus indirectly affect supply chain performance. Similarly, Cenamor *et al.* (2019) demonstrated that the effect of platform capability on SME performance is indirect via network capability, meaning that acquiring a digital platform is not in itself sufficient to boost an SME's performance. In addition, Kohtamäki *et al.* (2020) argued that digitalization alone is insufficient to generate positive financial performance effects for manufacturing companies. Other studies show that information systems do not necessarily lead to improved operational efficiency and effectiveness (Irani, 2010). The implication is that PDC itself may not enhance SMEs' operational performance but can do so in combination with some other mechanism.

Research also suggests that digital technologies *per se* provide little value to an organization, but the application of digital technologies within a specific context can reveal new ways to create value (Vial, 2019). Moreover, implementing complex IT systems often involves costly investment in system integration and lengthy projects (Kohtamäki *et al.*, 2020). Cappa *et al.* (2021) found that cultivating big data can negatively affect firm performance, as the cost of data storage, management and analysis can outweigh the benefits. Similarly, for SMEs, the cost of implementing PDC may be greater than the monetary benefits of operational efficiency. That is because the early phases of digitalization projects can suffer from poor system integration that spurs overlapping processes and inefficiency. In addition, Wong *et al.* (2011a, 2011b) argued that connectivity via information integration might even be detrimental to the efficiency of interorganizational coordination and supply chain cost reduction.

Further, it is stated that SMEs still do not consider data a source of added value and lack the resources to invest in and manage complex digital systems (Moeuf *et al.*, 2018). The productivity paradox suggests that IT initiatives can reduce productivity (King *et al.*, 2020). Cousins and Menguc (2006) also state that supply chain integration incurs costs and might not improve operational performance, sometimes even reducing it. Further, Barua *et al.* (2004) found that supplier-side digitization negatively affected financial performance. Das *et al.* (2006) report that collaboration with external partners can increase the cost of coordination and encourage inflexibility.

In conclusion, prior studies report contradictory results on the effect of different digitalization-related variables on firm performance. Digital platforms are viewed as a complex form of digitalization because they facilitate interactions between companies (Cenamor *et al.*, 2019). We, therefore, assume that digital platforms have similar effects on SMEs' performance to those reported for digitalization overall. We expect that PDC will have a negative direct effect on SME performance. We therefore hypothesize.

H1. Platform-based digital connectivity has a negative effect on operational performance in SMEs.

2.2 The moderating role of environmental turbulence

Environmental turbulence refers to the unpredictability or uncertainty firms face when predicting rapid changes in customer needs or technology development. The term encompasses competitive, market and technology turbulence (Jaworski and Kohli, 1993; Wang *et al.*, 2020). Environmental uncertainty encompasses changing customer demand, unpredictable competitor action and fluctuating sales volumes (Wong *et al.*, 2011a, 2011b). Competitive turbulence encompasses the competition in an industry (Huang and Tsai, 2014; Jaworski and Kohli, 1993). Market turbulence encompasses the rate and predictability of change in customer segments and customer preferences (Jaworski and Kohli, 1993; Wilden and Gudergan, 2015). Technological turbulence encompasses the rate of technological change in the industry (Huang and Tsai, 2014; Jaworski and Kohli, 1993; Wilden and Gudergan, 2015). Environmental turbulence is a key variable that affects a firm's competitive performance, strategies and capabilities (Rai and Tang, 2010). While prior studies have confirmed it moderates firm performance, the results are inconsistent.

Firms cannot rely solely on intra-organizational data in a dynamic business environment and must also access external information to predict changes and reduce uncertainty (Cherbib *et al.*, 2021; Li *et al.*, 2020; Wilden and Gudergan, 2015). Such external information can be valuable when combating environmental uncertainty (Wong *et al.*, 2011a, 2011b). Childerhouse *et al.* (2003) state that information flows should be transparent both upstream and downstream along the supply chain to counter environmental dynamism. The effects of digital-related variables on firm performance have been found to be strong in both stable and turbulent environments. Vijayasarathy (2010) found the use of technology has a strong effect on supply chain performance in a stable environment.

Further, Wong *et al.* (2011a, 2011b) found that the positive effect of information integration on supply chain cost performance strengthens when there is a low level of environmental uncertainty. Iyer *et al.* (2009) found that the relationships between IT-based business-to-business (B2B) integration and operational, financial and market performance are stronger in stable environments than in turbulent ones. In contrast, Li *et al.* (2020) found that digital technologies have a stronger effect on economic performance in highly dynamic environments than in more stable ones. Further, Wamba *et al.* (2020) demonstrate that environmental dynamism positively moderates the relationship between big data analytics and a firm's operational performance. In addition, Srinivasan and Swink (2018) find that the association between analytics capability and operational performance is stronger in high-volatility markets.

In summary, prior research has shown that the strength of the relationship between digital-related variables and firm performance varies depending on the extent of environmental turbulence. The need to identify opportunities in a turbulent environment often makes SMEs reliant on external partners to provide information on market changes (Alexiev *et al.*, 2016). Moreover, external pressure may force SMEs to adopt digital technologies to maintain their competitive position (Iacovou *et al.*, 1995; Li *et al.*, 2020). Therefore, the more turbulent the environment, the stronger the pressure on SMEs to leverage digital technologies to establish connectivity in their supply chain (Li *et al.*, 2020). Following this logic, we argue that SMEs can use PDC in turbulent environments to predict changes in the environment and, therefore, assume that the effect of PDC on operational performance will be stronger in situations of high environmental turbulence. As prior research has demonstrated that in turbulent environments, the use of digital technologies has a stronger effect on firm performance, and as we argue that SMEs operating in dynamic environments are more motivated to adopt digital technologies to remain competitive, we hypothesize:

H2. Environmental turbulence positively moderates the relationship between platform-based digital connectivity and a firm's operational performance.

We also acknowledge that the effect of environmental turbulence can differ depending on the type of turbulence (Wilden and Gudergan, 2015). First, with regard to *competitive turbulence*, a turbulent and uncertain environment challenges the identification of future probabilities and encourages a focus on real-time situation-specific new knowledge (Eisenhardt and Martin, 2000). That focus can cause issues with imitating competitors' strategies and encourage senior management to rely on their own decisions (Noda and Collis, 2001). In a more stable environment, firms' have more time to benchmark and identify the resources and capabilities that create value for the firm (Song *et al.*, 2005).

Business relationships often involve technological investments that unite partners (Easton and Araujo, 2003), and interorganizational investments in digitalization can benefit supply chain members. That is because PDC between firms can reduce the effect of competition and limit the willingness to switch partners and the opportunities to do so. If firms collaborate in highly competitive environments, they might choose between sharing information to gain access to the other firm's information and acquiring knowledge to mitigate competition (Alexiev *et al.*, 2016). In highly competitive environments, firms benefit from bold and proactive activity (Auh and Menguc, 2005). A competitive environment drives firms, and especially SMEs, to seek competitive advantage by adopting new technologies (Chan *et al.*, 2012; Daniel and Grimshaw, 2002).

Accordingly, we argue that when competitive turbulence is high, SMEs are more willing to adopt digital technologies and foster interorganizational integration to remain competitive. Presumably, the PDC built upstream and downstream is used more efficiently than in a stable environment, which enhances operational performance. Dong *et al.* (2009) confirmed that IT integration had a stronger effect on process improvement in more competitive environments than in stable ones. Further, in highly competitive environments, the potential knowledge gains from interorganizational collaboration can spur some level of information sharing but also information protection (Alexiev *et al.*, 2016). We assume that upstream and downstream PDC will be positively associated with operational performance. That hypothesis is based on the integrative effect of PDC that binds parties and operations, supports transparency and the use of data to analyze the current situation and formulate new knowledge and contributes new insights, which can be invaluable when rivalry is fierce.

H3. Competitive turbulence positively moderates the relationship between platform-based digital connectivity and a firm's operational performance.

Technological turbulence encompasses the level of technological change in production, process and service technologies (Iyer, 2011; Kohli *et al.*, 1993). The assumption is that technological uncertainty will prompt frequent changes in product design and innovation (Mishra *et al.*, 2007), and firms will acquire a competitive advantage through technological innovation (Jaworski and Kohli, 1993). Further, an environment marked by high levels of technological turbulence drives partners to deploy IT in support of collaborative efforts to make supply chain operations more predictable (Iyer, 2011). The role of fast information sharing grows in a highly turbulent environment (Trkman and McCormack, 2009), and PDC can be viewed as an avenue that enables information sharing in response to the requirements imposed by rapid changes.

Previous research has demonstrated both a decline in performance when technological turbulence is high (Segarra and Callejón, 2002) and technological turbulence facilitating better performance (Efrat and Shoham, 2012). Technological turbulence forces firms to keep up with and adapt to technological trends (Martin *et al.*, 2020). In addition, technological turbulence fosters collaboration with downstream partners (Iyer, 2011). We expect that a technologically turbulent environment would encourage SMEs to familiarize themselves with PDC and be willing to incorporate it into their operations. We therefore expect SMEs operating in environments with a high level of technological turbulence to be more engaged with PDC and more capable of using it; thus, the relationship between PDC and operational performance should be stronger.

H4. Technological turbulence positively moderates the relationship between PDC and a firm's operational performance.

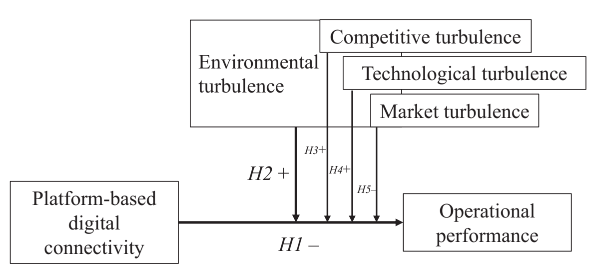
2.2.1 Market turbulence

Organizations operating in less turbulent markets are less likely to modify their products or services (Jaworski and Kohli, 1993; Kohli and Jaworski, 1990). In contrast, firms operating in highly turbulent markets may have long-standing customers with frequently changing preferences alongside new customers with different requirements (Hanvanich *et al.*, 2006). A broad customer base may also require an SME to install a range of IT systems to interact with the customers in real time. The systems or platforms may vary, creating an issue with system compatibility and hindering information exchange, which would reduce operational efficiency (Bayraktar *et al.*, 2009). An IT-enabled integration can ensure information flows across organizational boundaries in real time, which could thus extend a firm's capability to respond to fluctuations in the volume and type of products the market demands (Rai and Tang, 2010). A case study by Welker *et al.* (2008) showed that complex business conditions encourage partners to share information through direct contacts such as phone calls and meetings, limiting the role of information and communication technology. That finding suggests that companies may be reluctant to invest in building PDC in turbulent markets.

A turbulent market environment may also lead to firms struggling to accommodate diverse customer demands, which weakens operational performance despite the interaction and information offered by PDC. Although SMEs firms may be able to obtain individualized customer data (Schniederjans *et al.*, 2020), their usually limited resources present challenges around exploiting those data. Further, if companies focus only on the needs of customers, the performance effect would be negative because market demands and customer preferences are constantly changing in dynamic environments (Oh *et al.*, 2012). In addition, SMEs may be powerless in the face of large customers' changing needs because they are forced to accept the buyers' norms instead of securing their own interests (Quayle, 2003). This imbalance can lead to SMEs focusing on activities that do not improve performance.

Moreover, Arora *et al.* (2016) argued that turbulent markets reduce interfirm collaboration because firms fear information and knowledge sharing. Most SMEs tend guard information on their supply chains (Chan *et al.*, 2012), so we anticipate that in uncertain market conditions, SMEs may defer building and fully using PDC (Figure 1). Accordingly, we hypothesize:

Figure 1 The hypothesized model



H5. Market turbulence negatively moderates the relationship between PDC and operational performance.

The hypothesized model of the study is illustrated in Figure 1.

3. Method

3.1 Data collection and sample

The data were collected from SMEs operating in the manufacturing sector. In total, 1,136 manufacturing companies meeting a criterion of an annual turnover of €1.5–50m were selected from the Orbis database at the end of 2019. Their CEOs were then invited to participate in the study via an internet-based survey constructed using the Webropol survey tool. In total, 21 of 720 companies completed the survey following an e-mail invitation. We sought to increase the response level by contacting 414 companies by telephone, and 323 then agreed to accept the survey, of which 172 eventually completed it, and 87 declined to participate. A total of 193 responses were received, including one duplicate submission. Therefore, the final sample comprises 192 SMEs, equating to a response rate of 17%, which can be considered adequate (Malhotra, 2010). The non-response bias was tested by comparing the turnover between non-respondents and respondents using a *t*-test. There were no differences between the groups t (1109) = −0.477, p = 0.634; hence, the sample appears representative of the selected population.

Of the key respondents, 83% were CEOs, 4% were CFOs and 13% were in other management positions. The companies in the final sample are mainly small firms, in that 73% have fewer than 50 employees and 69% have a turnover of less than €10m. Among the sample, 59% of the companies operate in the metal manufacturing industry. The remaining 41% operate mostly in electric or electronic machinery, chemicals, petroleum, rubber, plastic, food or transport manufacturing industries.

3.2 Measures

PDC was measured through a novel instrument based on 20 items that interrogated the firms' digital connectivity. The measurement instrument was developed by three academics based on prior research on platform-based connectivity and tested by two practitioners – an IT professional and consultant and a CEO of a manufacturing SME. The items measure the PDC of a firm in both directions: upstream (suppliers) and downstream (customers) along the supply chain. All the PDC items were measured on a seven-point scale anchored with *not at all* (1) and *very much* (7). As the PDC measurement instrument is a novel one, we conducted several tests to assess the validity and reliability of the scale. First, we conducted an exploratory factor analysis that identified four factors. We named the dimensions of PDC to reflect the factors and thus categorized PDC into *digital supply chain transparency* (6 items), *digital product data* (2 items), *digitally enabled order-delivery process* (4 items) and *digital customer/supplier involvement* (6 items). The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.85, which exceeds the threshold value of 0.5. Further, the results of Bartlett's test of sphericity (2171,17, p = 0.000) also indicated that the data were suitable for factor analysis.

Factor analysis was conducted with Oblimin rotation, and the four-factor solution explained 68% of the variance. Two items were dropped owing to low loadings. Next, the validity and reliability of those dimensions were assessed. Although the digital supply chain transparency dimension showed quite poor average variance extracted (AVE) values (<0.5), the composite reliability (CR) and Cronbach's alpha values exceed the threshold values of 0.7. Research has accepted AVE values greater than 0.4 as adequate (Fornell and Larcker, 1981; Malhotra, 2010). We also assessed the discriminant validity of the measures through maximum shared variance (MSV) and average shared variance (ASV) values. The key criteria for assessing discriminant validity were that MSV was less than AVE and ASV was less than AVE (Hair *et al.*, 2014). We concluded that the PDC constructs did not suggest any issues with discriminant validity (Table 1). We also concluded that all the dimensions of PDC showed satisfactory validity and reliability. The relevant results are digital supply chain transparency (AVE = 0.43, CR = 0.82, α = 0.82), digital product data (AVE = 0.59, CR = 0.74, α = 0.74), digitally enabled order-delivery process (AVE = 0.58, CR = 0.85, α = 0.84) and digital customer/supplier involvement (AVE = 0.64, CR = 0.91, α = 0.92).

The environmental turbulence scale featured three dimensions: market turbulence, competitive turbulence and technological turbulence. The measurement scale is one validated in prior studies (Jaworski and Kohli, 1993; Wilden and Gudergan, 2015). Technological turbulence measures the speed and frequency of technological change, market turbulence is based on assessing the changes in customer preferences, and competitive turbulence measures the general degree of competition (Wilden and Gudergan, 2015). Each of the three dimensions was measured by three items with a seven-point scale anchored with *totally disagree* (1) and *totally agree* (7). The assessment of the validity and reliability of the market turbulence scale revealed some issues relating to one item loading poorly, which adversely affected the AVE and CR values (AVE = 0.29, CR = 0.50, α = 0.48). Therefore, we

Table 1 Reliability and validity

Construct	CA	CR	AVE	MSV	ASV
Platform-based digital connectivity					
Digital supply chain transparency	0.82	0.82	0.43	0.42	0.31
Digital product data	0.74	0.74	0.59	0.27	0.27
Digitally enabled order-delivery process	0.84	0.85	0.58	0.41	0.27
Digital customer/supplier involvement	0.92	0.91	0.64	0.53	0.30
Turbulence					
Competitive turbulence	0.7	0.75	0.52	0.01	0.26
Market turbulence	0.5	0.48	0.29	0.50	0.26
Technological turbulence	0.84	0.85	0.65	0.50	0.26
Operational performance					
Delivery performance	0.84	0.82	0.53	0.02	0.17
Production costs	0.84	0.85	0.58	0.21	0.11
Product quality	0.87	0.88	0.78	0.48	0.14

Notes: CA = Cronbach's alpha; CR = Composite reliability; AVE = Average variance extracted; MSV = Maximum shared variance; ASV = Average shared variance decided the market turbulence construct should be dropped as its inclusion could jeopardize the interpretation of the results. The market turbulence construct also had some issues with discriminant validity (Table 1), whereas technological and competitive turbulence did not. The technological turbulence (AVE = 0.65, CR = 0.85, $\alpha = 0.84$) and competitive turbulence scales (AVE = 0.52, CR = 0.75, $\alpha = 0.70$) showed satisfactory reliability and validity.

The operational performance measurement instrument was adapted from prior research (Ward and Duray, 2000; Wong *et al.*, 2011a, 2011b). Operational performance was measured through three dimensions: delivery performance (4 items), production costs (4 items) and product quality (2 items). Each of these dimensions was measured on a seven-point scale anchored with *totally disagree* (1) and *totally agree* (7). Delivery performance (AVE = 0.53, CR = 0.82, $\alpha = 0.84$), production costs (AVE = 0.58, CR = 0.85, $\alpha = 0.84$) and product quality (AVE = 0.78, CR = 0.88, $\alpha = 0.87$) demonstrated acceptable levels of validity and reliability. The operational performance constructs did not have any discriminant validity issues (Table 1). To ensure the validity of the operational performance measurement, we tested the relationship between the three-dimensional operational performance measure and objective performance indicators derived from the financial database. We found that our three-dimensional operational performance measure positively correlated with the EBIDTA margin of each company (0.15, $p < 0.05$), indicating the reliability of the subjective performance measure used.

We also used company age, size and industry as *control variables*. Company age is a continuous variable. Company size was measured through turnover and dummy coded as 0 (turnover less than EUR 10 m) or 1 (turnover over EUR 10 m). The industry was dummy coded such that the metal industry was coded as 1 and other manufacturing as 0.

3.3 Test of measures

A confirmatory factor analysis was conducted using Stata 15.1 software to ensure the measurement model demonstrated sufficient validity. All items loaded significantly on their latent variables ($p < 0.000$), and the loadings ranged from 0.25 to 0.95. Although one item had a low loading (0.25), we decided to retain it in the measurement model, as it was part of a previously validated scale. All other loadings were acceptable. Although the loadings of two items fell below the 0.5 minimum loading recommended by Hair *et al.* (2014), they met the minimum criterion of 0.4 applied in other research (Kohtamäki and Partanen, 2016). The loadings and items are presented in Appendix. The fit indices indicate that the data fit the model well (χ^2/df = 1.69; CFI = 0.91; TLI = 0.90; SRMR = 0.08; RMSEA = 0.06). These tests indicate that the measurement model is acceptable.

We used various tests to control for common method variance (Podsakoff *et al.*, 2003). First, we compared the research model to a single-factor model (Podsakoff *et al.*, 2003). The research model exhibits a significantly better model fit (χ^2/df = 1.69; CFI = 0.91; TLI = 0.90; SRMR = 0.08; RMSEA = 0.06) than the single-factor model (χ^2/df = 4.71; CFI = 0.41; TLI = 0.37; SRMR = 0.14; RMSEA = 0.14). The results suggest that common method variance is low. Second, we used the marker variable approach, which is suggested as an appropriate method for controlling the effects of common method variance (Podsakoff *et al.*, 2003). The technique incorporates a theoretically unrelated *marker variable* in the analysis; however, researchers rarely include unrelated constructs in their surveys and tend to use a variable with a weak correlation with the main study variables (Richardson *et al.*, 2009). We chose a marker variable that was measured on a similar scale as the main study variables and thus was more likely to reflect the same method variance. We chose flexibility (consisting of three items) as our marker variable. It has a weak correlation with the turbulence and connectivity variables and is measurable on the same scale. It can therefore be assumed to have the same method variance effect as the other study variables. The common method variance analysis results show that the inclusion of the marker variable did not seriously affect the results because the relationships remained steady with and without the marker. Therefore, the tests indicate that common method variance is controlled for in the analysis and poses no threat to the interpretation of the study's results.

4. Analysis and results

The hypotheses were tested using moderated regression analysis employing Stata 15.1 software. Table 2 shows the correlations between constructs, means and standard deviations.

The highest correlation between independent variables is 0.32 (Table 2), and the variance inflation factor (VIF) analysis shows that values for all constructs remain well below the threshold value of 10 (Hair *et al.*, 2014), as the highest VIF value is 1.12. The results indicate that multicollinearity is not an issue in the research model.

We tested the research hypotheses through hierarchical regression analysis, the results are presented in Table 3. First, we tested the relationships between PDC and operational performance and the moderating effects of environmental turbulence. We ran a model including only the company age and industry control variables (Model 1), which were not found to have any effect on operational performance. Next, we added the direct effects of PDC and environmental turbulence to the model (Model 2). Environmental turbulence was found to have a positive relationship with operational performance ($\beta = 0.22$, $p < 0.001$). The moderation effect of environmental turbulence was added to the third model (Model 3), which is our main research model. The model shows that PDC is not directly associated with operational performance ($\beta = -0.03$, n.s.): *H1* is therefore unsupported. The model also provides evidence of the moderating role of environmental turbulence on the relationship between PDC and operational performance ($\beta = 0.21$, $p < 0.001$), which indicates that the relationship between PDC and operational performance varies according to the environmental conditions. The results demonstrate that in highly turbulent environments, PDC improves operational performance, while in the case of low turbulence, PDC reduces a firm's operational performance. Therefore, *H2* is supported.

The moderation model explains 15% of the variance in the SMEs' operational performance, which is realistic, as operational performance comprises multiple effectual factors. We examined only the effects of PDC and environmental turbulence on performance. Figure 2 demonstrates the

Table 2 Correlations, means and standard deviations

Variable	Mean	SD	1	2	3	4	4a	4b	4c	4d	5	6
1. Company age	26.94	16.05										
2. Company size (1 = over 10 m€)	0.32	0.47	0.09									
3. Industry (1 = metal industry)	0.59	0.49	−0.17*	−0.03								
4. Platform-based digital connectivity	2.62	1.09	0.00	0.07	−0.03							
4a. Digital supply chain transparency	2.44	1.18	0.00	0.10	−0.04							
4b. Digital product data	2.27	1.44	0.02	0.05	−0.02		0.47***					
4c. Digitally enabled order-delivery process	3.60	1.60	−0.02	0.13	−0.06		0.55***	0.37***				
4d. Digital customer/supplier involvement	2.86	1.40	−0.00	−0.07	0.03		0.61***	0.48***	0.56***			
5. Competitive turbulence	4.60	1.15	0.01	0.07	−0.18*	0.06	−0.01	0.02	0.16*	0.09		
6. Technological turbulence	3.54	1.32	−0.10	−0.01	0.07	0.32***	0.24***	0.26***	0.24***	0.24***	0.09	
7. Operational performance	4.78	0.89	−0.05	0.05	−0.07	−0.00	0.2	−0.04	0.01	0.04	0.25***	0.16*

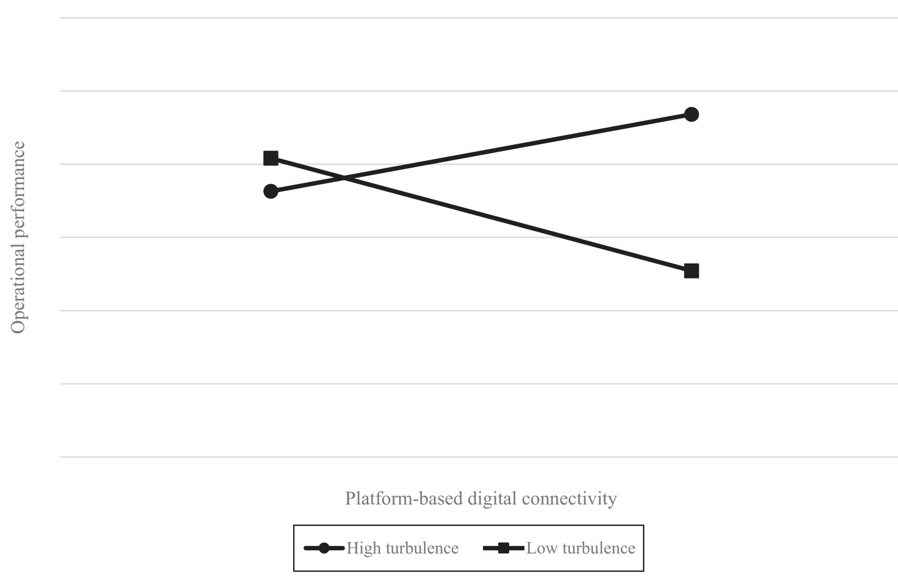
Notes: $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, $^{***}p \leq 0.001$

Table 3 Results of the hierarchical regression analyses

Dependent variable: Operational performance	Model 1	Model 2	Model 3
Control variables			
Company age	−0.00	−0.00	−0.00
Industry: metal manufacturing	−0.15	−0.12	−0.12
Company size: over 10 m€	0.11	0.11	0.07
Main effects			
Platform-based digital connectivity (PDC)		−0.07	−0.03
Environmental turbulence		0.22***	0.21**
Moderation effects			
PDC × environmental turbulence			0.21***
ΔR^2	0.01	0.04	0.06
R^2	0.01	0.05	0.15
Adjusted R^2	0.00	0.04	0.12
F	0.78	5.44	5.51

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Figure 2 The moderating effect of environmental turbulence on the relationship between PDC and operational performance



moderating effect of environmental turbulence on the relationship between PDC and operational performance.

To extend our understanding of the moderating effects of environmental turbulence on the relationship between PDC and operational performance, we tested the different turbulence types separately (Table 4).

The analysis indicates that the effects of competitive turbulence on operational performance were positively associated with operational performance ($\beta = 0.17$, $p < 0.01$) and to positively moderate the relationship between PDC and operational performance ($\beta = 0.23$, $p < 0.001$). Accordingly, *H3* is supported. These results (Figure 3) show that PDC improves an SME's operational performance when competitive turbulence is high, while in environments where competitive turbulence is low, PDC reduces that operational performance.

Technological turbulence proves to be positively associated with operational performance ($\beta = 0.16$, $p < 0.05$), but it does not moderate the relationship between PDC and operational performance; thus, *H4* is not supported. Market turbulence could not be tested because of the measure's reliability issues; therefore, *H5* could not be tested.

5. Discussion

This study builds on the supply chain digitalization literature to examine the moderating role of environmental turbulence in the relationship between PDC and operational performance in SMEs. Both scholars and practitioners recognize the importance of PDC to SMEs.

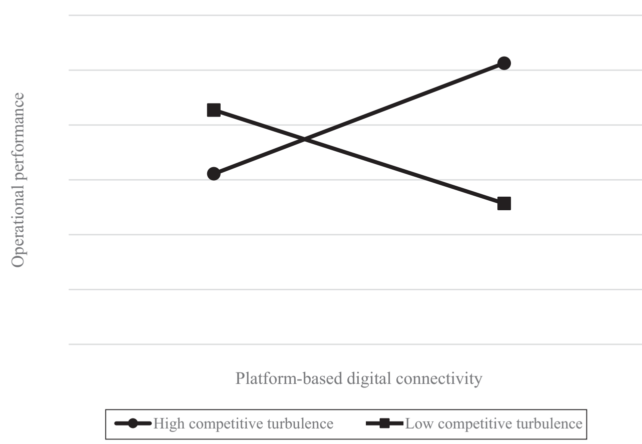
Our results demonstrate that the relationship between PDC and SMEs' operational performance is moderated by environmental turbulence. This study contributes to the literature on supply chain digitalization in several ways. First, we found that PDC alone does not directly affect operational performance, which demonstrates that the implementation of digital technology is no guarantee of operational efficiency. This finding confirms the existence of the IT productivity paradox, where manufacturing companies struggle to capture value flowing from digitalization (Kohtamäki *et al.*, 2020). Previous studies have recognized that electronic supply chain processes influence operational performance (Chae *et al.*, 2014; Hallikas *et al.*, 2021); however, it has also been argued that the relationship between digitalization and performance is nonlinear (Kohtamäki *et al.*, 2020) or that the relationship may be mediated by a number of intermediate variables (Wamba *et al.*, 2017). Our study shows that the relationship between PDC and performance varies depending on the prevailing environmental conditions. Prior studies have demonstrated that digitalization may have a positive effect (Barua *et al.*, 2004; Eller *et al.*, 2020), a negative effect (Cappa *et al.*, 2021) or no direct effect (Hallikas *et al.*, 2021) on performance. Our results show that PDC in and of itself does not affect operational performance; however, when the moderating effect of environmental turbulence is factored in, PDC may benefit firms in various ways. Hence, this study offers valuable information about the impact of digitalization on firm performance from the interorganizational perspective (Lin *et al.*, 2021b; Martinelli and Tunisini, 2019). In addition, this study contributes to the prior research by offering one possible explanation for the diverse results of studies of digitalization on firm performance. Environmental turbulence positively moderates the relationship between PDC and SMEs' operational performance, meaning that in a turbulent environment, the effects of PDC on operational performance are positive.

Table 4 Results of the moderation effects of different types of environmental turbulence on the relationship between PDC and operational performance

Dependent variable: Operational performance	Model 1	Model 2
Control variables		
Company age	−0.00	−0.00
Industry: metal manufacturing	−0.19	−0.04
Company size: over 10 m€	0.12	0.02
Main effects		
PDC	−0.06	0.04
Technological turbulence	0.16*	
Competitor turbulence		0.17**
Moderation effects		
PDC × technological turbulence	0.10	
PDC × competitor turbulence		0.23***
R^2	0.05	0.16
Adjusted R^2	0.02	0.13
F	1.76	5.96

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Figure 3 The moderating effect of competitive turbulence on the relationship between PDC and operational performance



In contrast, increasing PDC undermines operational performance in stable environments, which signals that the costs of digitalization may outweigh the gains; a finding in line with that of Cousins and Menguc (2006). This outcome is logical, as an SME operating in a turbulent environment must acquire and assimilate external information to maintain competitiveness. Deploying PDC provides access to tools to enhance information sharing, often in real time, which results in improved operational performance. Similarly, Corsaro and D'Amico (2022) acknowledge that digitalization can foster interaction between firms.

The current study, therefore, contributes to the literature by demonstrating that the performance effects of PDC can be divergent under differing conditions. Moreover, the results suggest that the conflicting results of prior studies on the effects of digitalization on performance might relate to conditional effects. The current research offers empirically tested insights into the effect of the environmental conditions affecting a firm, as has been called for in prior research (Li, 2022).

Second, we demonstrate how different forms of environmental turbulence have different moderation effects. In environments marked by high competitive turbulence, PDC strongly enhances operational performance, a finding aligned with that in a recent theoretical paper by Knudsen *et al.* (2021). That study states that in velocity environments, hyper-competition will be normal, and therefore digitalization makes data and networks sources of competitive advantage. Prior studies report technological turbulence exerts positive moderation effects on the relationship between digital-related variables and performance (Efrat and Shoham, 2012; Iyer, 2011). Our results indicate that technological turbulence does not affect the relationship between PDC and operational performance. That may be because SMEs collaborate with larger companies, which may determine the technologies and platforms used, and therefore SMEs may only have to adapt to those requirements.

Third, we focus on digitalization and digital transformation among SMEs because prior research indicates a research gap (Cenamor *et al.*, 2019; Matarazzo *et al.*, 2021; Tortora *et al.*, 2021). The liability of smallness may discourage SMEs from investing in and using digital connectivity (Cenamor *et al.*, 2019) because they may not have the necessary resources, skills, commitment and proper understanding of digital opportunities (Matarazzo *et al.*, 2021). Our results demonstrate that some SMEs that have built PDC downstream and upstream along the supply chain can enhance their operational performance; however, the turbulence of the operating environment can mean others experience reduced operational performance. Previous studies of digitalization among SMEs mainly focused on digital platforms (Cenamor *et al.*, 2019; Li *et al.*, 2020) or the adoption of digital technology (Yunis *et al.*, 2018). We studied PDC among SMEs, which includes both the use of digital technologies and platforms. Therefore, we extend the knowledge of SME digitalization and its performance effects.

5.1 Managerial implications

The results highlight that adopting digital technologies, platforms or tools is not a guaranteed route to competitive advantage, operational efficiency or success. Digitalization-related capabilities must be developed to use the opportunities presented by various tools and techniques. When adopting digital platforms and building digital connectivity between firms, managers should consider the skills required to use those tools.

In addition, while some level of information sharing allied with supply chain transparency can provide external information that might be a source of competitive advantage, clear rules on information sharing with external partners must be in place. Nevertheless, PDC can enhance SMEs' operational performance, especially in turbulent business environments.

Further, it is important that SMEs investing in digitalization to build PDC between firms do not lose sight of their strategies and goals and establish an organizational culture capable of identifying and exploiting opportunities presented by digitalization. Moreover, building a positive attitude to digital tools is a necessary component of the digital transformation process. When competition is fierce in the SME business environment, strategies incorporating PDC may be beneficial.

Overall, managers should carefully examine the business environment in which they operate and be aware that if it is one of high environmental turbulence, access to external knowledge and information may accelerate performance enhancements. In addition, the type of environmental turbulence present should be identified because that can affect the impact of PDC. In environments with a high level of competitive turbulence, PDC may enhance operational performance. In that case, establishing and maintaining PDC upstream and downstream along the supply chain can be a source of competitive advantage and boost operational performance.

Furthermore, PDC can benefit SMEs in the long term. Therefore, managers should be aware that even if PDC is not currently an attractive option for the firm, it could become one in the future. Moreover, SMEs operating in turbulent environments may benefit from proactively seeking opportunities to maintain and improve the firm's competitiveness. Those opportunities can be presented by nurturing PDC. As the changes in the business environment can also affect business models and processes, it is important that managers acknowledge the level of digitalization and direction of their business environment and aim to match and preferably exceed, competitor efforts.

5.2 Limitations and future research

This study is affected by several limitations. The data were collected between the end of 2019 and the beginning of 2020 and therefore do not reflect the effects of the COVID-19 pandemic on SME digitalization. The COVID-19 pandemic may have forced many SMEs to make a digitalization stripe, which would offer avenues for future research. In addition, SMEs may have started developing digitalization-related capabilities that will foster PDC and positively affect performance. Therefore, future research could examine the capabilities that mediate between digitalization and performance. Moreover, we studied only the conditional effects of environmental turbulence. Future research might investigate other conditional effects that explain the contradictory results of prior studies on the relationship between digitalization and performance.

Another limitation of the study is that its sample was drawn only from manufacturing SMEs. Future studies might extend the purview to the service sector or other industries. In addition, our empirical context is Finland, which limits the generalizability of the results. Accordingly, future research might benefit from analyzing cross-country differences and similarities related to digital connectivity in SMEs.

In addition, the market turbulence measure was affected by poor reliability, and therefore the effects of market turbulence could not be empirically studied. Future research should also be aware that the market turbulence measure may need some modifications if it is to be reliable.

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Appendix

Table A1 Measurement constructs and items

Constructs and items	Mean	SD	Loading
Platform-based digital connectivity			
Digital supply chain transparency (α: 0.82; CR: 0.82; AVE:0.43)			
Assess the following statements about the transparency of information from your company's perspective			
To what extent do your customers share digitally (through portal or collaboration platform) information on demand forecasting?	2.93	1.85	0.52
To what extent do you share information on demand forecasting digitally with your suppliers (through a portal or collaboration platform)?	2.40	1.62	0.78
To what extent do you have a view of the capacity or warehouse situation of your suppliers (through portal or collaboration platform)	2.21	1.37	0.59
To what extent do you open your capacity or warehouse situation to your customers (through portal or collaboration platform?)	2.16	1.58	0.61
To what extent do you let your customer follow the progress of their order-delivery process digitally?	2.50	1.76	0.69
To what extent do your suppliers let you digitally follow the progress of your order-delivery process?	2.43	1.52	0.71
Digital customer/supplier involvement (α: 0.92; CR: 0.91; AVE:0.64)			
To what extent do you use digital collaboration platforms to interact in the following business processes			
With customers on issues related to the development of your own product	3.01	1.76	0.74
With suppliers on issues related to the development of your own product	2.76	1.57	0.74
With customers on issues related to the development of activities	3.02	1.71	0.82
With suppliers on issues related to the development of activities	2.65	1.55	0.85
With suppliers on training or advice related to their products	2.83	1.64	0.84
In training or advising customers	2.92	1.72	0.80
Digitally enabled order-delivery process (α: 0.84; CR: 0.85; AVE:0.58)			
To what extent does your firm automatically exchange information on enterprise resource planning?			
Regarding order information from customers	3.65	2.16	0.79
Regarding order information to be sent to suppliers	3.17	1.91	0.75
To what extent do you use digital collaboration platforms to interact with the following business processes?			
With customers on issues related to the order-delivery process	4.13	1.95	0.74
With suppliers on issues related to the order-delivery process	3.44	1.76	0.77
Digital product data (α: 0.74; CR: 0.74; AVE:0.59)			
To what extent does your company take advantage of the (big) data from the products?			
In your customer relationships (our products produce a continuous stream of data operated by the customer, which is utilized in service performance to the customer)	2.30	1.67	0.78
In your supplier relations (machine and equipment suppliers receive a continuous data flow from the devices we operate, and they perform data-based service activities for us).	2.24	1.54	0.76
Environmental turbulence			
Technological turbulence (α: 0.84; CR: 0.85; AVE:0.65)			
The technology in our industry is changing rapidly	3.52	1.55	0.76
A large number of new product ideas have been made possible through technological breakthroughs in our industry	3.44	1.51	0.86
The technological changes in this industry are frequent	3.65	1.46	0.79

(*continued*)

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Table A1

Constructs and items	Mean	SD	Loading
vMarket turbulence (α: 0.48; CR: 0.50; AVE:0.29)			
In our kind of business, customers' product preferences change quite a bit over time	3.40	1.30	0.78
We are witnessing demand for our products and services from customers who have never bought them before	2.40	1.35	0.43
It is very difficult to predict any changes in this marketplace	3.99	1.38	0.25
Competitor turbulence (α: 0.70; CR: 0.75; AVE:0.52)			
Competition in our industry is cutthroat	4.86	1.46	0.91
Price competition is a hallmark of our industry	5.38	1.34	0.75
One hears of a new competitive move almost every day	3.55	1.54	0.40
Operational performance			
Delivery performance (α:0.84; CR: 0.82; AVE:0.53)			
Delivery products quickly or on short lead-times	4.90	1.44	0.65
Provide on-time delivery to our customers	5.22	1.37	0.78
Provide reliable delivery to our customers	5.28	1.36	0.79
Reduce customer order taking time	4.46	1.35	0.68
Production costs (α:0.84; CR: 0.85; AVE:0.58)			
Produce products with low costs	4.03	1.45	0.80
Produce products with low inventory costs	3.99	1.38	0.66
Produce products with low overhead costs	3.94	1.36	0.78
Offer price as low or lower than our competitors	4.14	1.28	0.80
Product quality (α:0.87; CR: 0.88; AVE:0.78)			
High-performance products that meet customer needs	5.26	1.31	0.95
Produce consistent quality products with low defects	5.46	1.18	0.81

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