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# SHIFTING FROM JUSTIFICATION TO UNDERSTANDING: THE IMPACT OF ENVIRONMENTAL UNCERTAINTY ON THE VALUE OF IT-ENABLED COLLABORATION IN SUPPLY CHAINS

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*Completed Research*

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## Abstract

*After over two decades of IT value research, there is growing evidence that organizations benefit from investments in IT. Hence, it is time to shift from justifying IT value to understanding the conditions under which it occurs. Although the relevance of contextual factors for the impact of IT investments has been highlighted in several studies, the literature is still too limited to draw a clear representation. This study contributes to the nascent stream that incorporates contextual factors with regard to the impact of IT investments on performance outcomes. By drawing on organizational information processing theory, we develop a research model and propose that the relationship between IT-enabled collaboration and supply chain performance is moderated by several dimensions of environmental uncertainty, namely product complexity, technological uncertainty, demand uncertainty, and supply uncertainty. Based on an analysis of data gathered from 150 supply chain executives, the study sheds light on the salient question of the conditions under which IT creates value in the context of supply chains. The findings advance the knowledge frontier of IT value research by providing evidence that performance outcomes are contingent on various environmental conditions and offering an explanation for the mixed results observed in previous literature.*

*Keywords: IT value, IT-enabled collaboration, Supply chain performance, Environmental uncertainty.*

## 1 Introduction

During the past two decades, nothing has changed business operations like the emergence of the Internet and its related information and communication technologies have (Johnson and Whang, 2002; Sanders, 2007). This rapid growth of information technology (IT) and web-based information sharing has particularly influenced the field of supply chain management (SCM), which is founded on the collaboration among supply chain partners (Narasimhan and Jayaram, 1998; Sanders, 2007; Vaharia, 2002). As a result, IT-enabled collaboration across partnering organizations has become the backbone of supply chain business structures. It is seen as an essential enabler of SCM activities because it facilitates information sharing, thereby enhancing organizational flexibility and responsiveness while minimizing risk and inventory costs (Rajaguru and Matanda, 2013). Consequently, fostering supply chain collaboration via information and communication technologies has generated much excitement in both research and practice (Rai et al., 2006; Rosenzweig, 2009).

Therefore, academics have extensively examined the relationships between IT-related investments and organizational performance and, more recently, how multiple organizations can collectively leverage IT to co-create value from investments in IT (Grover and Kohli, 2012). Despite controversial empirical findings on the relationship between IT-related investments and economic outcomes, there is growing evidence that IT does create value under certain conditions in general (Masli et al., 2011; Melville et al., 2004; Staiger, 2004) and in terms of supply chain performance (SCP) in particular (Klein and Rai, 2009; Wang et al., 2013; Wu and Chuang, 2010).

However, if the value of a best practice, such as IT-enabled supply chain integration and collaboration, is supported by empirical evidence, research should shift from the justification of its value to the understanding of the contextual conditions under which it occurs (Sousa and Voss, 2008). Among other factors, environmental uncertainty (EU) has been emphasized as an important contextual factor that may affect the general effectiveness of a best practice (Souder, 1998; Venkatraman, 1989), particularly the relationship between supply chain integration and performance (Jean et al., 2008; Koufteros et al., 2005; Wong, Boon-Itt, et al., 2011).

Though the relevance of such contextual factors with regard to the impact of IT investments has been highlighted in several studies (e.g., Melville et al., 2004, 2007; Wade and Hulland, 2004), prior research has focused primarily on investigating the environmental conditions that drive or mediate information integration and IT-enabled collaboration rather than examining how these conditions moderate performance outcomes (Jean et al., 2008; Wong, Lai, et al., 2011). As a result, research on this topic remains scarce.

Of the literature that does exist, findings are rather limited. First, most studies that consider the moderating role of contextual factors focus solely on internal firm characteristics and neglect the influence of industry or macroeconomic factors, such as EU (Schryen, 2013). Second, evidence reported thus far is contradictory, as empirical results indicate that EU does not always moderate relationships between supply chain integration and performance. Furthermore, even if moderating effects exist, their direction varies (Wong, Boon-Itt, et al., 2011). Third, the variety of approaches in conceptualizing EU and performance prohibits a meaningful comparison of results or conclusions about the contingent effects. Fourth, and perhaps most importantly, there is a lack of conceptual foundations in information systems (IS) research that can provide a theoretical explanation for the varying moderating role of contextual factors with regard to the relationship between IT investments and performance outcomes (Jean et al., 2008).

In sum, the body of literature on the importance of various contextual factors for the relationship between IT-related investments and performance is still too small to draw any clear picture, particularly from an IS perspective (Jean et al., 2008; Schryen, 2010, 2013). Thus, by examining the conditions under which IT-enabled collaboration creates value in terms of SCP, this study contributes to the nascent stream of IT business value research, which incorporates contextual factors with regard to the impact of IT investments. In particular, the study aims to offer insights into the conditions under which IT creates value. Therefore, we developed and empirically tested a theoretical model to examine the contingent role of EU.

By doing so, this study differs from previous and related research endeavors in a number of aspects. As research on IT value has highlighted the need to examine how multiple organizations can leverage IT to co-create value (Kohli and Grover, 2008), we focus on SCP as a dependent variable rather than on individual firm performance. Moreover, to capture a broader scope, we operationalize SCP as a multi-dimensional construct, reflecting four different outcome dimensions. We concentrate on the sources of EU that have been regarded as most relevant in supply chain contexts. In addition, and in contrast to approaches applied in former studies (e.g., Wade and Hulland, 2004; Wong et al., 2011, 2012), we collapse the construct of EU into four dimensions, which enables us to adopt a more differentiated perspective. Furthermore, we draw upon the information processing view (Galbraith, 1973) as a conceptual foundation for our study because it offers valuable insights for research on IT value in the presence of EU. Lastly, we follow the very recent suggestion of Sabherwal and Jeyaraj (2015) for the design of studies on IT value and concentrate on a single relationship between an IT-based independent variable and a dependent variable to strengthen the focus our study.

The remainder of this paper is structured as follows. In the next section we provide a background on organization information processing theory (OIPT) and elaborate upon our conceptualization of IT-enabled collaboration. We then present our theoretical framework and derive hypotheses. Afterwards, we outline the design and procedure of the empirical investigation. We then reflect upon the implications of this study, concluding with limitations and suggestions for future research.

# 2 Theoretical Background

In this section we first discuss OIPT as a conceptual foundation for our study and define the relevant contextual factors with regard to EU in supply chains. We then highlight and clarify the role of IT-enabled collaboration as an information processing capability.

## 2.1 Organizational information processing theory

The information processing view of the firm argues that organizations need quality information to cope with uncertainty and improve their decision making. It posits that resolving uncertainty, defined as a lack of information, is the central task in organizational design, highlighting the strategic importance of information processing for interorganizational activities in supply chains (Galbraith, 1973). This notion of OIPT is consistent with contingency theory, which suggests that performance depends on the alignment between an organization’s structure and its environmental conditions (Sillince, 2005). However, while contingency theory only posits the need for alignment, OIPT extends this perspective by providing a theoretical reason explaining why such alignment is valuable in improving performance. In particular, OIPT emphasizes the importance of aligning information processing capabilities with information processing needs, which arise from uncertainties, in order to reach performance gains (Grover and Saeed, 2007; Premkumar et al., 2005; Wong et al., 2015).

Information processing theorists have proposed various sources and types of uncertainty that can vary across and within different organizations (Gattiker and Goodhue, 2004; Wong et al., 2015). However, we focus on EU because it has been regarded as an inherent condition of interorganizational interaction in supply chains (Miller, 1987; Wong, Boon-Itt, et al., 2011). Previous research has identified two major dimensions of EU, namely complexity and dynamism (Duncan, 1972; Miller and Friesen, 1982). While complexity captures the number of factors and their interactions relevant to decision making, dynamism involves the relative rate of change for those factors as well as the ability to predict these changes. In accordance with previous literature, we use product complexity to represent the first dimension and technological uncertainty, demand uncertainty, and supply uncertainty to capture the dimension of dynamism (Premkumar et al., 2005). These factors reflect the dimensions of EU and have been regarded as being most relevant to supply chain contexts and the information processing needs of organizations (Bensaou and Anderson, 1999; Bensaou and Venkatraman, 1996; Chen and Paulraj, 2004; Davis, 1993; Fynes et al., 2004; Heide and John, 1990; Premkumar et al., 2005).

*Technological uncertainty* is defined as the extent of technological changes evident within an industry (Chen and Paulraj, 2004). It refers to the technical level of future product and process changes as well as the inability to accurately forecast the technical or design requirements for the product (Fynes et al., 2004; Premkumar et al., 2005). *Demand uncertainty* reflects changes in demand for the processed product and the inability to accurately predict these fluctuations, which may result in forecast errors (Premkumar et al., 2005; Walker and Weber, 1987). These forecast errors are influenced by unknown or unpredictable variations in both the quantity and timing of demand that is experienced in a supply chain (Fynes et al., 2004). *Supply uncertainty* is similar to demand uncertainty, in that it is also related to the unpredictability of quantity and timing (Fynes et al., 2004). However, in contrast to demand uncertainty, it represents the dynamisms in supply in terms of availability, stability, and consistency in quality that influence timeliness and inspection requirements (Chen and Paulraj, 2004; Premkumar et al., 2005). *Product complexity* also contributes to uncertainty in supply chains (Premkumar et al., 2005) and is defined as the degree of customizability, intricacy, and variety (Sancha et al., 2014). It also refers to the nature of the product in terms of the diversity of inputs as well as the adjustments required from suppliers (Wong, Lai, et al., 2011).

According to OIPT, organizations typically have two strategies for coping with EU and the resulting increased information needs: First, developing buffers in order to reduce the effect of uncertainty (increase slack) and, second, increasing adaptability by implementing structural mechanisms, which provide real-time, accurate, and relevant information to reduce uncertainty (Grover and Saeed, 2007). An example of the latter is the implementation of advanced information processing capabilities through integrated IS. These IS enhance the flow of information and facilitate collaboration among organizations within the supply chain (Huang et al., 2014; Premkumar et al., 2005; Wang et al., 2013), which is reflected in our conceptualization of IT-enabled collaboration described below.

## 2.2 IT-enabled collaboration as an information processing capability

Based on the resource-based view, IT value researchers argue that IT resources per se – such as software, hardware, and IT personnel – do not lead to value, because they are imitable and mobile. Instead, firms should develop unique capabilities for implementing and using IT resources in combination with other organizational resources. By doing so, these IT capabilities are rendered organizationally embedded and not easy transferable, thereby leading to business value (Bharadwaj, 2000; Ray et al., 2005; Wade and Hulland, 2004). Extended to interorganizational relationships, IT capabilities refer to the use of interorganizational IS (IOS) in combination with other resources to perform interorganizational business activities and processes (Rai et al., 2006). Information processing capability describes the ability to gather, interpret, and synthesize information properly in order to deal with uncertainties (Huang et al., 2014; Tushman and Nadler, 1978). This capability can be enabled by IT, as integrated IOS allow for the exchange of high quality information, more efficient information processing, and enhanced absorptive capacity (Malhotra et al., 2005; Roberts and Grover, 2012).

In this study, we investigated an interorganizational information processing capability that has garnered much attention in research: IT-enabled collaboration. This capability is defined as business-to-business activities – such as information, decision, resource, and process sharing – that are facilitated by IT (Johnson and Whang, 2002). Literature has examined IT-enabled collaboration both on a general level as well as more specifically. Various studies have investigated particular tools, such as supply chain collaboration systems (Hadaya and Cassivi, 2012), and dimensions, e.g., IT-enabled integration (Rai et al., 2006) and information sharing (Barua et al., 2004). We chose IT-enabled collaboration to investigate the role of uncertainties in value co-creation for several reasons: First, as a generic and comprehensive capability, it encompasses a majority of IT-enabled business-to-business activities. Second, previous studies have shown that IT-enabled collaboration influences firm and SCP both directly (Ko et al., 2009; Rosenzweig, 2009) and indirectly through intermediate factors, such as interorganizational learning (Choi and Ko, 2012). Third, it has already been introduced as a suitable capability for investigating the role of contextual factors (Chan et al., 2012; Chong et al., 2009; Rosenzweig, 2009).

# 3 Research Model and Hypotheses

In accordance with previous research and OIPT, the study's research model (Figure 1) is based on the following theoretical underpinnings. The first basis is the assumption that IT-enabled collaboration as an information processing capability facilitates interorganizational information sharing and integration with supply chain partners, thus enhancing performance (Choi and Ko, 2012; Malhotra et al., 2005; Wang et al., 2006). Second, as OIPT argues that high uncertainty increases information processing needs, which must be matched by expanding information processing capabilities (Galbraith, 1973), the model assumes that the relationship between IT-enabled collaboration and SCP is moderated by the degree of EU.

Drawing on the moderation perspective of fit (Venkatraman, 1989), in the following sections we develop the theoretical model that guides our study and derive our hypotheses in order to explain the moderating effects of EU on the proposed relationship between IT-enabled collaboration and SCP.

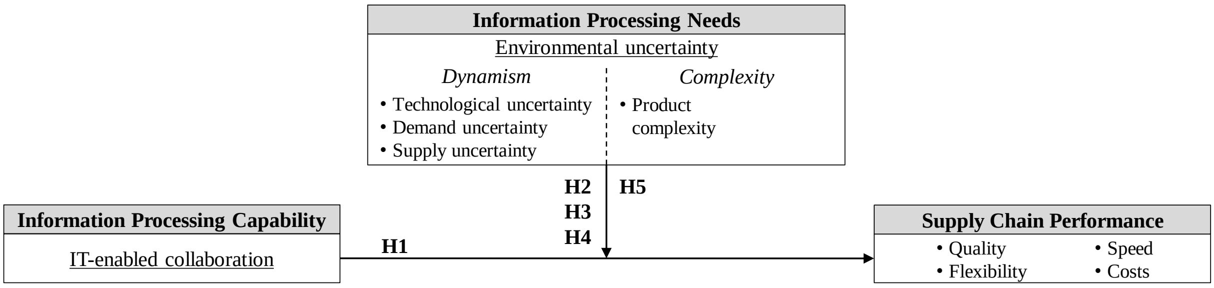


*Figure 1. Research model.*

## 3.1 Linking IT-enabled collaboration and supply chain performance

According to the prevailing literature, IT-enabled collaboration that leverages interorganizational IS leads to value through both a better exchange of information and communication as well as an improved coordination with partners along the supply chain. The standardized exchange of information and communication among partnering organizations with compatible IS (Koufteros et al., 2005) reduces technical barriers and facilitates seamless information flows. This IT-enabled collaboration enables organizations to deal with large amounts of data (Barua et al., 2004; Wong et al., 2015), resulting in improved visibility of information within the supply chain (Barua et al., 2004; Choi and Ko, 2012; Roberts and Grover, 2012; Wong et al., 2015). Going beyond the improved flow of information, this boundary-spanning mechanism also establishes a common platform for coordinating operations among partners in a supply chain that require inputs and developmental efforts from various partners (Galbraith, 1973), such as production planning, product design and development, or distribution network design. These joint organizational efforts reduce the chance for organizations to make conflicting decisions (Premkumar, 2000; Wong et al., 2015). Hence, IT-enabled collaboration empowers organizations within a supply chain to work together more efficiently and effectively than their less integrated counterparts (Rosenzweig, 2009) in terms of cost reductions, process speed and quality improvements, as well as increased flexibility (Johnson and Whang, 2002; Rosenzweig, 2009; Wang et al., 2013). As a result, organizations engaged in IT-enabled collaboration are able to enhance both operational SCP in the short run as well as strategic benefits in the long run (Choi and Ko, 2012; Mukhopadhyay and Kekre, 2002). Therefore, and in accordance with prevailing research, we submit the following hypothesis:

*Hypothesis 1: IT-enabled collaboration is positively related to supply chain performance.*

## 3.2 IT-enabled collaboration and supply chain performance in context

Now, the salient question arises of whether the proposed positive relationship in Hypothesis 1 is influenced by certain contextual factors. In this study we therefore consider the various dimensions of EU to moderate the specific relationship between IT-enabled collaboration and SCP. Accordingly, the focus of this study lies on the strength of the moderation effect. Thus, the aim is to examine the impact of EU on the proposed relationship (Hypothesis 1), but we do not particularly focus on the joint effect of IT-enabled collaboration and EU on performance outcomes, drawing instead on the moderation perspective of fit (Venkatraman, 1989).

According to OIPT, there is a need to improve information processing capabilities under high uncertainty (Galbraith, 1973). Indeed, EU demands organizations to acquire and process additional, rich information (Koufteros et al., 2005; Wong, Boon-Itt, et al., 2011), which requires that external integrative mechanisms be used to collect information (Galbraith, 1973), coordinate and monitor the business activities of partnering organizations (Miller, 1992), and facilitate flexible responses as well as rapid decision making (Sitkin and Sutcliffe, 1994; Wong, Boon-Itt, et al., 2011). Therefore, we argue that the proposed positive relationship between IT-enabled collaboration and SCP is strengthened under high levels of EU, as the fit between information needs and information processing capability results in improved performance (Premkumar et al., 2005). In the following, we reflect on this general assumption and discuss the moderating effect for each dimension of EU considered in greater detail.

**Technological uncertainty**, or the rate of technological change, substantially influences governance structures of transactions between organizations (Heide and John, 1990; Walker and Weber, 1987). Frequent improvements or changes in product functionalities, manufacturing processes, and shifts in the design of components create significant information needs for partnering organizations (Premkumar et al., 2005), as they often rely on emerging technologies that require clarification and assistance during diffusion (Fynes et al., 2004). As a result, organizations are expected to process information more frequently with partners in the supply chain in order to enhance knowledge about new technologies and capabilities (Premkumar et al., 2005). Hence, when technology is changing rapidly, organizations must be able to collaborate more flexibly and share information more quickly than when technology is more predictable (Fynes et al., 2004). Accordingly, IT-enabled collaboration is expected to be more valuable for SCP when technological uncertainty is high. Therefore, we propose a second hypothesis:

*Hypothesis 2: Technological uncertainty strengthens the relationship between IT-enabled collaboration and supply chain performance.*

**Demand uncertainty** creates adaptation problems between organizations within a supply chain and significantly increases requirements for coordination mechanisms (Grover and Saeed, 2007; Heide, 1994; Walker and Weber, 1984). Under conditions of high demand uncertainty, organizations must monitor forecasts continuously and are forced to perform adjustments accordingly in order to predict fluctuations and effectively respond to deviations (Walker and Weber, 1987). As a result, organizations require timely information and tighter information linkages with partnering organizations to communicate the frequent changes (Premkumar et al., 2005). In contrast, forecast errors and deviations from estimates are likely to be fewer for organizations operating under stable demand, where customer needs and preferences do not change frequently, resulting in less benefit from mutual adjustment processes (Fynes et al., 2004). As the primary strategy for reducing demand uncertainty is the timely availability of relevant information (Grover and Saeed, 2007), organizations operating in volatile demand environments are more likely to benefit from expanded information processing capabilities that provide structured and near-real-time information to supply chain partners (Premkumar et al., 2005). Accordingly, we argue that IT-enabled collaboration has a greater contribution to SCP when demand uncertainty is high.

*Hypothesis 3: Demand uncertainty strengthens the relationship between IT-enabled collaboration and supply chain performance.*

**Supply uncertainty** is similar to demand uncertainty in that it relates to the unpredictability of the quantity and timing of supply. Significant dynamism in supply can generate risk in supply chain processes (Cannon and Perreault, 1999; Premkumar et al., 2005), such as manufacturing downtime, quality and yield problems, order-entry errors, forecast inaccuracies, or logistical malfunctioning (Fynes et al., 2004; Walker and Weber, 1987). Therefore, under such conditions, organizations require more information for flexible and timely decision making (Premkumar et al., 2005). The exchange of information along the supply chain as well as close collaboration and coordination via electronic linkages with partnering organizations have been found to be highly effective in reducing the risk of supplier failure and supply uncertainties (Lee, 2002). Hence, as with demand uncertainty, organizations operating in volatile supply environments are likely to benefit more from IT-enabled information processing capabilities than those operating in stable supply environments (Fynes et al., 2004). Therefore, we propose the following hypothesis:

*Hypothesis 4: Supply uncertainty strengthens the relationship between IT-enabled collaboration and supply chain performance.*

**Product complexities**, which reflect the final factor of EU, are said to contribute to uncertainty in a transaction (Malone et al., 1987; Premkumar et al., 2005). A complex and customized product without standard specification requires greater interaction and information sharing with partnering organizations as well as joint actions in the design and manufacturing process (Premkumar et al., 2005). As a result, complex products typically call for the exchange of rich, product-related information across multiple functional areas of supply chain partners (Novak and Eppinger, 2001; Rosenzweig, 2009). In the presence of these factors, close and collaborative relationships are needed and organizations prefer tightly integrated supply chains to facilitate the flow of information via electronic linkages (Bensaou and Anderson, 1999; Brown and Eisenhardt, 1995; Wong, Lai, et al., 2011). In contrast, when products are low in complexity, the value of IT-enabled collaborative relationships is likely to be diminished for SCP outcomes, as minimal information exchange is required (Wong, Lai, et al., 2011). In such a case, interorganizational coordination within the supply chain can instead be accomplished by simple procedures and preplanning. Accordingly, we propose a fifth hypothesis:

*Hypothesis 5: Product complexity strengthens the relationship between IT-enabled collaboration and supply chain performance.*

# 4 Research Design

## 4.1 Measurement of constructs

All scales for both the dependent and independent variables were adopted from validated measures used in prior and corresponding research and were translated into German. The results were independently cross-checked by two researchers and discrepancies were discussed until a common understanding was reached. An overview of all measurement instruments including both items and original authors can be found the Appendix. Previous research has suggested that SCP is a multidimensional construct; therefore, to capture its broad scope, SCP is modeled as a second-order construct reflecting four first-order dimensions, namely quality, speed, cost, and flexibility (Chen et al., 2013; Hult et al., 2006). The operationalization of the independent variables also follows the original scales from corresponding research and are as follows: IT-enabled collaboration, product complexity, technological uncertainty, supply uncertainty, and demand uncertainty. In accordance with prior literature, all independent variables were modeled as reflective constructs and items were measured using a seven-point Likert scale, except for one: the product complexity construct is suggested to be measured with a single-item scale that ranges from the manufacture of standardized products to customized products (Rosenzweig, 2009; Saeed et al., 2005). The scale for IT-enabled collaboration was adapted from Chan et al. (2012). In line with previous research, we measured this capability by the actual use of IOS in major domains of supply chain collaboration (Rai et al., 2012; Subramani, 2004). Furthermore, as firm size plays a critical role in the use and integration of interorganizational IS in supply chains (Zhu and Kraemer, 2005) – larger firms tend to enjoy scale efficiencies and are equipped with more resources (Wong, Lai, et al., 2011) – we included this measure as a control variable in terms of the number of employees.

## 4.2 Sample and non-responses

To test the theoretical model, data was collected between July and September 2015 from organizations in the German wood industry, which is Europe’s second largest in terms of production value. Furthermore, the wood industry is one of the most significant sectors in Germany, accounting for the largest share of employees and the second largest annual turnover. The wood industry was chosen as the unit of analysis for three interrelated reasons: First, this industry exhibits a low to medium rate of IS diffusion in general (Arano and Spong, 2012; Karuranga et al., 2005; Vlosky and Smith, 2003). Therefore, compared to more mature industries, we expect to see a higher degree of variance in IT-enabled collaboration. Second, despite the relatively limited diffusion of IS, previous studies have demonstrated the importance of technological integration through IS for the wood industry (Trang et al., 2014; Zander, Trang, Mandrella, et al., 2015). Third, the processing and utilization of renewable resources, such as wood, is typically characterized by a high level of complexity and EU regarding quantity, quality, and the time of availability (Narodoslawsky et al., 2008; Zander, Trang and Kolbe, 2015). Thus, both the internal and external contextual factors considered in this study are highly relevant in this industry context. Given the low diffusion of IS and its potential benefits – particularly against the background of the existing EU – we argue that the wood industry is a suitable starting point for analyzing the conditions under which IT-enabled collaboration contributes to better SCP.

Respondents were gathered from the *Fordaq* database using an online survey method. *Fordaq* is a sector-specific network that provides a business database with contact information, specialized in the forestry and wood cluster and. Personalized survey invitations were distributed among organizations involved in woodworking, wood processing, wood building, or the timber trade. A total of 203 questionnaires were returned, leading to an overall response rate of just below 10%. However, of these cases, 53 were excluded due to quality criteria, such as missing values or implausibility of firm characteristics and IT usage behaviors. Hence, a final sample of 150 complete cases that fulfilled all quality criteria remained. The sample characteristics are summarized in Table 1.

| **Industry sub-sector** | | **Respondent's title** | |
|---|---|---|---|
| Woodworking industry | 32.9% | CEO | 38.8% |
| Wood processing industry | 28.8% | Senior IT manager | 12.7% |
| Wood building industry | 13.0% | Senior manager | 48.5% |
| Timber trade | 16.4% | *Purchasing & supply* | 10.6% |
| Other | 8.9% | *Production & logistics* | 24.4% |
| **Number of employees** | | *Marketing & sales* | 13.5% |
| Small (<50) | 50.6% | | |
| Medium (50–250) | 32.7% | | |
| Large (>250) | 16.7% | | *N = 150* |

*Table 1. Sample characteristics.*

Low response rates are typical for this kind of web-based survey (Preston and Karahanna, 2009); however, they bear the risk of non-response. To account for this threat, we used two common measures: First, the sample characteristics are similar to those of the basic population, indicating that our sample is fairly representative. Second, we checked for mean differences between the construct items in the first and the second halves of the sample (Armstrong and Overton, 1977); the results of the t-tests revealed no significant differences ($p < .10$). Both indicate that non-responses are not a major threat for this study.

# 5 Data Analysis and Results

To test the proposed model and hypotheses, we used a structural equation modeling (SEM) approach. We decided to apply the partial least squares method (PLS) for two reasons: First, it has fewer demands for sample size and excels at prediction. Second, a normal distribution is not required (Ringle et al., 2012). The analysis was supported primarily using the software SmartPLS 2.0. In addition, SPSS Statistics 21 was used for tests that are unavailable within the SmartPLS package. The data analysis follows the widely adopted two-step analytic approach for SEM (Anderson and Gerbing, 1988). First, the quality of the measurement model should be assessed to ensure validity and reliability. Then, the structural model can be analyzed.

## 5.1 Measurement model assessment

According to Chin (1998), the sample size should exceed 10 times the number of indicators for the scale with the largest number of indicators. In addition, the sample size must be greater than 10 times the number of paths directed to any latent variable in the model. Our sample size, which includes 150 cases, meets both criteria.

A single informant assessed both the independent and dependent variables in our study. As a result, common method variance (CMV) poses a potential threat to the validity of the results (Podsakoff and MacKenzie, 2003). Therefore, following the approach of Podsakoff and MacKenzie (2003), we checked for CMV with Harman's single factor test and ran an exploratory factor analysis. The results reveal that no single factor emerges from the data and that a general factor does not account for the majority of the covariance among the measures. Hence, CMV is not a major concern for this study.

| Construct | FL | AVE | CR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. IT-enabled collab. | .788–.863 | 0.876 | .935 | **.936** | | | | | | | | |
| 2. Product complexity | n/a | n/a | n/a | .746 | **n/a** | | | | | | | |
| 3. Tech. uncertainty | .870–.933 | 0.820 | .870 | .836 | .859 | **.906** | | | | | | |
| 4. Demand uncertainty | .875–.940 | 0.837 | .863 | .826 | .851 | .750 | **.915** | | | | | |
| 5. Supply uncertainty | .887–.931 | 0.828 | .951 | .811 | .832 | .859 | .785 | **.910** | | | | |
| 6. Quality | .877–.894 | 0.790 | .938 | .557 | .233 | .382 | .375 | .398 | **.889** | | | |
| 7. Cost | .807–.861 | 0.795 | .723 | .442 | .086 | .266 | .291 | .255 | .831 | **.892** | | |
| 8. Speed | .840–.876 | 0.751 | .938 | .303 | -.049 | .114 | .134 | .116 | .696 | .860 | **.867** | |
| 9. Flexibility | .844–.901 | 0.913 | .939 | .387 | .016 | .180 | .204 | .190 | .784 | .886 | .817 | **.955** |

*FL: Factor loadings; AVE: average variance extracted; CR: composite reliability; Bolded numbers: square root of AVE; Note: FL, AVE, and CR cannot be computed for formative or single item measures.*

*Table 2. FL, CR, AVE, and inter-construct correlations.*

To assess the fit of the proposed hypotheses and empirical data, the measurement model was tested for content, convergent, and discriminant validity. We assured content validity by using established theories and existing scales from related research. Three measures were evaluated to offer evidence of convergent validity: individual item reliability, composite construct reliability (CR), and average variance extracted (AVE). Due to low factor loadings, one item each from IT-enabled collaboration and quality scale were dropped (see Appendix). Afterwards, as depicted in Table 2, all items loaded on their assigned construct at .70 or above, which indicates an acceptable limit of item reliability (Gefen and Straub, 2005). The CR ranges between .723 and .951, which is also above the acceptable limit of .70 (Hulland, 1999). Furthermore, the AVEs for all constructs exceed the minimum threshold of .50 (Bhattacherjee and Premkumar, 2004). The AVE is also used to evaluate discriminant validity (Chin, 1998; Fornell and Larcker, 1981); as the AVE for each construct is greater than the variance shared with other constructs (square root of AVEs on the diagonal in Table 2), the distinctiveness of constructs – and thus discriminant validity – can be confirmed. Finally, we checked the cross-loadings. As expected, all items display higher loadings on their assigned constructs than on any other construct within the model (Chin, 1998). Hence, our analysis suggests that our model is both acceptable and reliable.

## 5.2 Structural model assessment

To evaluate the structural model and test our hypotheses, we used a bootstrapping re-sampling procedure (5000 samples) to compute inference statistics, as is the preferred method when the sample size is greater than 100 (Kock, 2011). The central criterion for the assessment of the PLS structural model is the explained variance of the endogenous variable. With an explained variance of .560, this value lies at a satisfactory level. However, the explained variance is typically highly dependent on the research context (Hair et al., 2011). Therefore, we also computed the Stone-Geisser $Q^2$ coefficient with a blindfolding procedure to determine the predictive relevance of the structural model. With a value of .393, this measure clearly exceeds the minimum threshold of 0 (Hair et al., 2011).

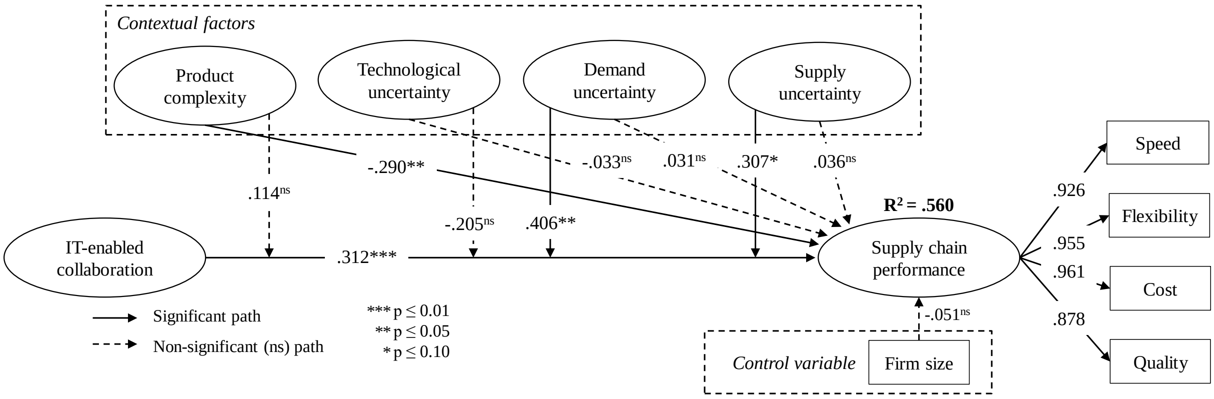


*Figure 2. PLS results of the structural model.*

The estimates of the path coefficients as well as the significance levels of the bootstrapping procedure for both direct and moderating effects are presented in Figure 2. The structural model indicates that IT-enabled collaboration positively and significantly (b = .312; $p \leq .01$) influences SCP, providing strong support for Hypothesis 1. With regard to the contextual factors considered in our model, which were proposed to influence the relationship between IT-enabled collaboration and SCP, the results offer support for two of the four remaining hypotheses. The analysis demonstrates that both demand uncertainty (b = .406; $p \leq .05$) and supply uncertainty (b = .307; $p \leq .10$) positively influence this relationship, offering support for Hypothesis 3 and 4. However, we found no empirical support for Hypothesis 5, as the level of product complexity was revealed not to influence the relationship between IT-enabled collaboration and SCP. That is, the interaction effect of IT-enabled collaboration and product complexity in SCP is not statistically significant (b = .114; $p \geq .10$). Turning to technological uncertainties, the results also do not support Hypothesis 2: The level of technological uncertainty does not moderate the relationship between IT-enabled collaboration and SCP. In contrast to our theoretical assumption, the results display a negative effect (b = -.205). However, this relation cannot be shown to be empirically significant ($p \geq .10$). Lastly, we found no significant effect of the control variable (b = -.051; $p \geq .10$).

# 6 Discussion

## 6.1 Summary of findings

The results of the analysis regarding the relationship between IT-enabled collaboration and performance (H1) support our expectation and highlight the value of developing information processing capabilities for partnering organizations within a supply chain. Based upon survey data gathered from 150 supply chain executives and senior managers, the empirical analysis suggests that IT-enabled collaboration is key for achieving greater SCP in terms of speed, flexibility, cost, and quality. These findings are largely consistent with prior research on IT value co-creation (e.g., Chen et al., 2013; Lee et al., 2014; Rajaguru and Matanda, 2013). However, by drawing on the OIPT, our analysis goes one step further and examines how this relationship is influenced by several contextual factors arising from different dimensions of EU. In particular, we observe that both demand uncertainty (H3) and supply uncertainty (H4) strengthen the relationship between IT-enabled collaboration and SCP. Hence, consistent with our argumentation and the information processing view of the firm, organizations operating in environments with volatile supply and demand benefit particularly from IT-enabled information processing capabilities, as they enable organizations to respond to changing conditions in a flexible and timely manner. These findings are generally in line with previous research on the contextual role of volatile supply and demand (e.g., Fynes et al., 2004). However, the results are also in contrast to findings from related research on the contingent effects of EU. For example, both Koufteros et al. (2005) as well as Wong et al. (2011) report insignificant moderating effects of EU. Furthermore, Wong et al. (2012) find that the positive association between information integration and performance is strengthened when the firm experiences a low level of EU. However, the comparability of results from the studies mentioned above is limited because they only consider EU as a unidimensional construct.

In terms of technological uncertainty, the empirical analysis does not offer support for Hypothesis 2. Instead, the results suggest a negative moderating effect of technological uncertainty on the relationship between IT-enabled collaboration and SCP. However, this relation cannot be shown to be empirically significant. In fact, there is conflicting empirical evidence regarding the effects of technological uncertainty on organizations' integration decisions (Walker and Weber, 1987). According to Fynes et al. (2004) and Krause (1999), a possible explanation is that organizations prefer to keep technology in-house, where it represents a competitive advantage. This is particularly true for the wood industry, where the sharing of information and knowledge is often restricted to non-core and non-sensitive activities (Zander, Trang and Kolbe, 2015). Furthermore, small organizations, which account for the largest share in our sample, tend to be less innovative than their larger counterparts, resulting in lower levels of technological change and uncertainty in general (Wagner and Hansen, 2005).

Finally, the analysis demonstrates that the relationship between IT-enabled collaboration and SCP is not significantly influenced by the level of product complexity and thus offers no support for Hypothesis 5. Simultaneously, the results indicate that product complexity significantly and negatively impacts SCP, emphasizing the relevance of this factor. However, these results are consistent with findings from previous research. According to Rosenzweig (2009), a potential explanation for this is that under certain conditions, IT-enabled collaboration can be beneficial across varying degrees of product complexity: For complex products, it enables the exchange of rich, product-related information and facilitates the flow of information via electronic linkages. In contrast, when products are low in complexity and subject to high volumes, properly executed IT-enabled collaboration can still be worthwhile, as it allows for close collaboration with key customers and the optimization of product flows across the supply chain.

## 6.2 Implications and contributions

The study incorporates contextual factors with regard to the impact of IT investments on performance outcomes and sets out to offer insights on the question regarding the conditions under which IT creates value in the context of supply chains. By drawing on the information processing view of the firm, our study findings offer valuable contributions and implications to both research and practice.

The first theoretical contribution concerns the conceptualization of constructs. The study demonstrates that EU should not be seen as a single, unidimensional construct reflecting various dimensions simultaneously; instead, our results indicate that these dimensions are empirically distinct from one another. Unlike previous studies that conceptualize EU as a unidimensional construct, our approach allows for comprehensive model development and a deeper understanding of the moderating role of the various dimensions of EU. Moreover, this approach may have the potential to resolve the contradicting results from previous research. Second, the study is one of the few in research on IT value that draws on the OIPT and applies the moderation perspective of fit in terms of moderated regression analysis to examine the role of contextual factors. Despite some divergences, our results support the basic structure of the theoretical model, highlighting both the applicability as well as the merits of OIPT as a theoretical lens for research on IT value in general and research on IT value co-creation in particular. Third, by drawing on OIPT and considering different dimensions of EU as inherent conditions of interaction in supply chains, the study directly responds to calls for both more theory-driven empirical research on supply chain management (Chen et al., 2013) and investigating the role of contextual factors with regard to the relationship between IT-related investments and performance (Schryen, 2013).

Although this study focuses on a specific industrial sector, our results are largely consistent with theory and may to some extent be generalizable to other sectors, as environmental uncertainty is an important factor in supply chains across various domains. Hence, in terms of practical implications, this study provides important recommendations for supply chain executives and IT managers. First, the findings highlight that developing efficient information processing capabilities is crucial for mitigating uncertainty in supply chains. In particular, organizations should consider investing in information processing capabilities when operating under volatile conditions of demand and supply. Second, as a result of the former, our findings demonstrate that contextual factors are highly related to performance outcomes of IT-enabled collaboration. Therefore, managers should carefully reflect upon the conditions of their business environments before investing in the development and implementation of IT-related capabilities. Third, practitioners can profit from our study, as it equips managers with both theoretical background and empirical evidence relating to why investments in IT may not necessarily reap the expected performance outcomes. Lastly, our study provides a useful tool for measuring contextual factors, which managers can apply to diagnose the conditions of their business environment.

### 6.3 Limitations and future research

We acknowledge that there are several limitations of the study, which can be remedied by extending our work in a number of directions. First, although our findings offer support for our theoretical assumptions, a portion of the variance remains unexplained, as is the case for most empirical studies. Therefore, future research might consider incorporating further determinants and moderating factors. For example, despite EU being a key factor affecting the performance of operations, it is not the only contingency factor. There are also likely to be means of mitigating uncertainties in supply chains other than IT-enabled collaboration. Second, while we argue that the wood industry is a suitable starting point for analyzing contextual factors, this specific context makes it harder to generalize, as the strength of factors may vary due to industry-specific requirements and processes. Although the survey of a single industry has its advantages, future studies should investigate industries with different characteristics in order to improve generalizability. Third, the unit of analysis of this study is the supply chain of an organization and its primary products, allowing for the consideration of supply chain–wide patterns. However, it would be worthwhile to examine the role of contextual factors and their influence on IT value at different stages of a supply chain in order to clarify the role of varying operational procedures. Fourth, this study does not consider that the different dimensions of EU might influence each other. For example, product complexity is often associated with high levels of demand uncertainty (Rosenzweig, 2009). Although the analysis supports our conceptualization of constructs and suggests that the various dimensions of EU are empirically distinct from one another, the inter-construct correlations indicate that these dimensions are interrelated, which might have influenced our results. Therefore, future research should proceed by examining these interactions and their influence on the relationships between IT investments and performance in greater detail. For example, considering and analyzing EU as a multidimensional hierarchical construct could enhance our understanding of how the different dimensions of EU are related to one another as well as how and under what circumstances this affects the relationship between IT investments and performance outcomes. Fifth, we used a single informant approach and captured self-reported perceptions of the dependent and independent variables. Although this is common in IS research (e.g., Saraf et al., 2007), the findings are nonetheless susceptible to the effects of CMV. While the results from Harman’s single-factor test suggest that CMV is not significantly present in our data, we encourage future research to collect objective performance indicators and data from multiple sources and informants across the supply chain. Lastly, there is a threat in using measures of IT capabilities and IT success collected at a single point in time, as effects may be time shifted. Therefore, future studies should take the opportunity to substantiate findings using longitudinal data.

## 7 Conclusion

Our study advances the knowledge frontier of IT value research and contributes to the nascent stream that incorporates contextual factors with regard to the impact of IT investments on performance outcomes. By drawing on OIPT, the study sheds light on the salient question of the conditions under which IT creates value in the context of supply chains and offers an explanation for the mixed results in previous literature. Based on our empirical findings, we provide academics and managers with insights into the contextual role of EU and provide guidance for both research and practice.

# Appendix

| Construct | Scale |
|---|---|
| **IT-enabled Collaboration** (Chan et al., 2012) | (Please rate how frequently you use the following IT tools in your supply chain): 1. Direct procurement tools. 2. Replenishment tools. 3. Projected shortages tool. 4. Delivery and tracking tool. 5. Design tool 6. Supply chain planning forecasting tool. 7. Capacity planning tool 8. Business strategy tool.* |
| **Product Complexity** (Rosenzweig, 2009) | (Please select one category below that best describes the degree of customization for the primary products manufactured in your organization) 1. Mostly standard products with no options. 2. Mostly standard products with standard options. 3. Mostly standard products modified to customer specifications. 4. Mostly standard products with options modified to customer specifications. 5. Mostly customized products manufactured to customer specifications. |
| **Technological Uncertainty** (Fink et al., 2007) (Chen and Paulraj, 2004) | 1. There is a high probability of product improvements in the next two years. 2. We are often able to predict the nature of product improvements. 3. There have been many changes in the product over the past five years 4. Our industry is characterized by rapidly changing technology. 5. If we don't keep up with changes in technology, it will be difficult for us to remain competitive. 6. The rate of process obsolescence is high in our industry. 7. The production technology changes frequently and sufficiently. |
| **Supply Uncertainty** (Chen and Paulraj, 2004) | 1. The suppliers consistently meet our requirements. 2. The suppliers produce materials with consistent quality. 3. We have extensive inspections of incoming critical materials from suppliers. 4. We have a high rejection rate of incoming critical materials from suppliers. |
| **Demand Uncertainty** (Chen and Paulraj, 2004) | 1. Our master production schedule has a high percentage of variation in demand. 2. Our demand fluctuates drastically from week to week. 3. Our supply requirements vary drastically from week to week. 4. We keep weeks of inventory of the critical material to meet the changing demand. 5. The volume and/or composition of demand are difficult to predict. |
| **Supply Chain Performance** (Hult et al., 2006) (Chen et al., 2013) | **Quality:** 1. The quality of the order fulfillment process is getting better every time. 2. We have recently seen an improvement in the quality of the order fulfillment process.* 3. We are satisfied with the quality of the order fulfillment process. 4. Based on our knowledge of the order fulfillment process, we think it is of high quality. 5. The quality of the order fulfillment process could not be much better than it is today. **Speed:** 1. The length of the order fulfillment process is getting shorter every time. 2. We have recently seen an improvement in the cycle time of the order fulfillment process. 3. We are satisfied with the speed of the order fulfillment process. 4. Based on our knowledge of the order fulfillment process, we think it is short and efficient. 5. The length of the order fulfillment process could not be much shorter than it is today. **Cost:** 1. The cost associated with the order fulfillment process is getting better every time. 2. We have recently seen an improvement in the cost associated with the order fulfillment process. 3. We are satisfied with the cost associated with the order fulfillment process. 4. Based on our knowledge of the order fulfillment process, we think it is cost efficient. 5. The cost associated with the order fulfillment process could not be much better than it is today. **Flexibility:** 1. The flexibility of the order fulfillment process is getting better every time. 2. We have recently seen an improvement in the flexibility of the order fulfillment process. 3. We are satisfied with the flexibility of the order fulfillment process. 4. Based on our knowledge of the order fulfillment process, we think it is flexible. 5. The flexibility of the order fulfillment process could not be much better than it is today. |

*Note: * Item has been removed due to low factor loadings.*

*Table 3. Measurement scales.*

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