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INTEGRATING INDUSTRY CHARACTERISTICS IN INTER-ORGANIZATIONAL IS ADOPTION MODELS: A MIXED METHOD APPROACH

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Abstract

There are a number of benefits that can be achieved if information is shared automatically between partner organizations. While inter-organizational systems (IOS) are considered to be well adopted, a number of industries, amongst others the wood industry, lag far behind. This study aims to explain how industry characteristics can contribute to the explanation of this low adoption phenomenon. Based on eleven case studies and 204 survey responses, this mixed method study identifies five industry characteristics and their influence on adoption factors. The identified industry characteristics are organizational size, aged staff, low diffusion of IS, low government support, and heterogeneity in IT infrastructures. A theoretical model is developed integrating the industry characteristics and the Technology-Organization-Environment (TOE) framework constructs. This study demonstrates that partner pressure, relative advantage, regulatory environment, and technological readiness significantly influence the adoption of IOS. Thus, this research provides valuable insights and offers guidance for policymakers and practice on factors leading to an improved adoption. As well, we conduct a new research design to identify industry-specific actions to help improve the adoption of IOS.

Keywords: IOS, IT Adoption, Mixed Methods, Wood Industry

1 INTRODUCTION

In recent years, the use of wood has garnered increasing attention from public, economic, and political sectors. Heightened environmental awareness has led to rising popularity of wood as an ecological alternative for oil-based products. Wood processing companies are typically closely linked in order to deal with inter-organizational cascade utilization to take full advantage of by-products and reusable materials while minimizing waste in the supply chain (Daian & Ozarska 2009; Hogland & Stenis 2000). Accordingly, complementary cooperation between organizations accompanied by effective information processing is a central challenge for maximizing process efficiency. Inter-organizational systems[1] (IOS) – such as workflow systems, electronic data interchange (EDI), and supply chain systems – improve coordination and communication between partners, facilitate knowledge sharing, and increase innovation (Chi & Holsapple 2005). Despite the wide acknowledgement of these benefits gained through IOS in other industries (e.g., Zhu & Kraemer 2005) and the great need for information integration, particularly in the wood industry, there is still surprisingly low diffusion of IOS (Hewitt et al. 2011). A considerable number of studies have been published on IOS adoption during the last decades for a variety of different industries (Robey et al. 2008; Oliveira & Martins 2011). Findings from these studies cannot be directly translated as the wood industry is particularly different in terms of cross-organizational collaboration with a focus on regional networks, a patriarchic and owner-managed company structure (Mrosek et al. 2005), and a conservative attitude in terms of adopting new technologies (Arano & Spong 2012). Moreover, the body of industry-specific literature on IOS adoption in the wood industry is still rare. Most studies were conducted in the 1990s to early 2000s (Arano & Spong 2012); however, due to technological advancement, IOS today have a broader scope and offer more functionalities (Saraf et al. 2007). Therefore, more research is necessary to investigate how IOS adoption has evolved during recent years. Furthermore, IOS adoption studies with a branch-specific focus on the wood industry are often limited to surveys and statistical descriptions (Arano & Spong 2012; Henderson et al. 2004; Karuranga et al. 2006). Empirical research that draws on IT adoption models and more advanced research methods may provide a deeper understanding of the contributing factors of IOS adoption (Oliveira & Martins 2011). These gaps in the literature limit our understanding of IOS adoption in general and in the wood industry in particular. Therefore, we attempt to answer the following research question: What specific industry characteristics affect the adoption of IOS in the wood industry?

To address this question, we developed a two-stage research design, including a qualitative inquiry followed by a quantitative study, which draws on the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer 1990). In a first step, case study research including 12 interviews with professionals involved in the wood industry was conducted in order to examine how industry characteristics influence technological, organizational, and environmental adoption variables. In a second step, we demonstrated the influence of these factors on the actual adoption decision with a follow-up survey of 204 firms in the German wood industry. By including technological, organizational, and environmental decision variables as mediators, the mixed method approach enriches the understanding of how industry characteristics result in IOS adoption. The paper provides important contributions to research and practice. To the best of our knowledge, no branch-specific IOS adoption model exists for the wood industry. Hence, our study provides new insights into industry characteristics regarding the adoption of IOS in this emerging sector. Furthermore, our research adopts a mixed method approach, which is unique to the research stream of IOS adoption in the wood industry. By using this approach, we are able to provide a deeper understanding of factors affecting

[1] IOS is "built around information technology, i.e. around computer and communications technology that facilitates the creation, storage, transformation, and transmission of information. An IOS differs from an internal, distributed information system by allowing information to be sent across organizational boundaries." (Johnston and Vitale, 1988)

IOS adoption as well as test our results empirically. Furthermore, this study helps reduce the dearth of mixed method approaches (Venkatesh et al. 2013) in current IS research.

The remainder of this paper is organized as follows. First, we provide a brief overview of the current state of IOS in the wood industry, including adoption theories, existing systems in practice, and related adoption studies. The following part deals with the qualitative study of our approach and presents the industry characteristics that were derived from our interviews. Afterwards, we present results from our quantitative study. Finally, the paper closes with a discussion on theoretical and managerial implications, limitations, and further research.

2 FOUNDATIONS OF THE TOE FRAMEWORK AND STATUS QUO OF IOS IN THE WOOD INDUSTRY

A considerable number of studies have raised the question, which factors determine the diffusion of IOS. In this context, the technology-organization-environment framework is the most prominent framework for studying initial adoption decisions at the firm level (Oliveira & Martins 2011). It groups factors that influence the adoption decision into three distinct categories: individual characteristics of the technology, internal characteristics of the organization, and external characteristics of the environment (Tornatzky & Fleischer 1990). Several studies in the IS adoption literature have adopted and empirically supported the predictive power of the three dimensions of the TOE framework (Oliveira & Martins 2011).

Various influencing factors have been identified in the context of research on IOS adoption, including perceived benefits (Chwelos et al. 2001; Iacovou et al. 1995; Ramamurthy et al. 1999), network characteristics (Kauffman & Wang 1994; Kauffman et al. 2000), organizational readiness (Chwelos et al. 2001; Premkumar et al. 1997; Ramamurthy & Premkumar 1995), and innovation characteristics (Premkumar et al. 1994; Ramamurthy et al. 1999). In order to provide a deeper understanding of these factors and their influence on IOS adoption, various perspectives must first be taken into account to better grasp the theoretical background (Gregor & Johnston 2000). Research also highlights the importance of branch characteristics in this context. The influence of other stakeholders in the industry, governmental influence, and other branch-specific factors were found to play an important role in the adoption of IOS (Chau & Hui 2009; Kuan & Chau 2001; Chwelos et al. 2001; Kreuzer et al. 2014).

Kumar and van Dissel (1996) classify IOS into three types, based on the interdependencies between organizations, which were later expanded by Chi and Holsapple (2005). These types and corresponding examples in the wood industry are summarized in Table 1.

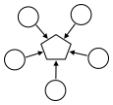
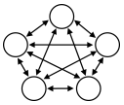
Characteristic	**IOS Type**		
	Pooled Information Resource IOS	Value/Supply-Chain IOS	Networked IOS
Configuration			
Examples of IOS in the wood industry	ELDAT, PapiNet, FHPDAT, Winforst Pro, StanForD, CoSeDat	INTEND WebLine, ArcGIS, GeoMail	IFIS

Table 1. IOS types and corresponding systems in the wood industry.

Pooled Information Resource IOS refer to IT systems that are shared among firms, such as common databases, networks, protocols, and standards. *ELDAT*, *PapiNet*, and *PHPDAT* represent some examples of communication standards that have been developed in the wood industry in recent years. These standards allow organizations to exchange contractual, invoice, and delivery data in order to improve processes, cooperation, and information sharing. *Value/Supply-Chain IOS* support customer-supplier relationships through, e.g., sales forecasting, RFID tracking, or workflow systems. For

instance, the logistics software *GeoMail* informs members of the wood supply chain about orders at any time through functions such as geo-tracking. These systems allow firms to reduce uncertainties, costs, and time cycles in the supply chain. Finally, *Networked IOS* facilitate collaboration in reciprocal relationships. Such systems, e.g., conferencing and decision support systems, typically share semi-structured and unstructured knowledge. The web-based system *IFIS* was developed specifically for organizations in the wood industry and supports, in addition to typical data exchange and supply chain functions, integrated communication and reporting functions to facilitate collaboration. In summary, existing information systems in the wood industry cover a wide range of IOS types and have the potential to help organizations gain competitive advantages in many ways.

Thus far, little attention has been paid to investigate IOS adoption with a branch-specific focus on the wood industry. Although many different IOS exist in this sector and these systems might lead to competitive advantages, studies indicate a low rate of IS diffusion (Arano & Spong 2012; Karuranga et al. 2006; Vlosky & Smith 2003). Previous research dealing with IS adaptation in the wood industry has indicated that nearly all publications reported a lack of IOS use in this sector (Hewitt et al. 2011). Furthermore, research has indicated the first factors that potentially influence IOS adoption in the wood industry. For instance, studies have investigated the perceived benefits of and barriers to IOS adoption. For example, Arano and Spong (2012) identify security of sensitive information, implementation costs, and the availability of technical resources as the top-three constraints to adoption in the American wood industry; other studies reported similar results (Henderson et al. 2004; Karuranga et al. 2006). Firm size in terms of sales and number of employees was also found to be positively correlated to IOS adoption rates (Dupuy & Vlosky 2000; Shook et al. 2002; Stennes et al. 2006). However, literature provided in this field is very descriptive in nature, concluding that it remains unclear which industry characteristics determine the adoption of IOS.

3 STUDY 1: INFLUENCE OF INDUSTRY CHARACTERISTICS ON TOE FACTORS

3.1 Research design

Previous research has suggested that the adoption and diffusion of IOS requires further understanding of the theoretical background (Gregor & Johnston 2000). Since neither the adoption of IOS nor the adoption behavior of information and communication technology in general has been examined sufficiently in this industry-specific context, a multiple qualitative case study approach was selected to provide critical information about the phenomenon. Applying the case study method has been widely recognized as being well suited to understand the interactions between information technology–related innovations and organizational contexts (Darke et al. 1998). Therefore, following the approach of Eisenhardt (1989), the purpose of this first qualitative phase is to acquire a deeper understanding of not only the circumstances affecting the adoption of IOS and effects arising from industry characteristics but also the nature of the phenomenon. Since case study research has often been criticized for a lack of rigor, we followed the steps suggested by Dubé and Paré (2003) and explicitly address validity and reliability concerns.

According to Eisenhardt (1989), the a priori specification of constructs allows the shaping of an initial research design and enables a more accurate measurement of constructs. If these constructs prove to be important as the research progresses, one has a stronger theoretical grounding for the emergent theory (Eisenhardt 1989). Therefore, our interview guidelines are based on a predefined model that was derived from the TOE framework (Tornatzky & Fleischer 1990), as well as on the various perspectives of IOS adoption according to Gregor and Johnston (2000). The TOE framework has received considerable attention in IS research and has been applied to study technology adoption in various contexts. We chose the wood industry as a unit of analysis for this study and used typical case sampling in order to ensure representativeness and comparability (Teddlie & Yu 2007). In order to

account for the different viewpoints (Gregor & Johnston 2000) within the implementation of IOS, we collected data from interrelated perspectives: forestry organizations and manufacturing firms (organizational view); cluster organizations (industry view); and software providers, governmental organizations, and research institutes (environmental view). To obtain an in-depth understanding and to elicit the nature of IOS adoption and the context in which it occurs, we used semi-structured interviews as the central instrument for data collection. In addition, we followed Yin's (2009) approach and analyzed secondary data, such as freely available information (e.g., publications on the website of the organization or press releases) as well as internal documents in order to triangulate our findings. In total, 12 interviews covering 11 different organizations were conducted between March and July 2013. Within the last third of the interviews we found that new insights had become rare, and concluded that theoretical saturation had been reached. Table 2 provides an overview of all case sites.

ID	**Viewpoint**	**Perspective**	**Interview**		
			Interviewee	Duration	Method
#E1	Environmental	Software provider for woodpile communication	Marketing and sales manager	60 min.	Face-to-face (F2F)
#E2		Governmental organization	Senior manager	120 min.	F2F
#E3		Association for forest technology and forest work	Wood logistics and data manager	40 min.	Phone
#E4		Governmental association for wood timber industries	Cluster manager	30 min.	F2F
#I1	Industrial	Consolidation of local forestries	Senior manager	30 min.	Phone
#I2		Consolidation of local forestries	Senior manager	35 min.	Phone
#I3		Association for wood and timber trade	Cluster manager	30 min.	Phone
#I4		Consolidation of raw wood suppliers	Cluster manager	15 min.	Phone
#O1	Organizational	Trade and timber production	Sales manager	20 min.	F2F
#O2a		Manufacture of	Logistics manager	30 min.	F2F
#O2b		wood-based materials	IT manager	30 min.	F2F
#O3		Producer of wood-based materials for furniture and construction industry	Raw wood supply manager	35 min.	F2F

Table 2. Summary of case sites.

3.2 Results

Five major themes affecting the adoption of IOS in the wood industry emerged from the case studies: being composed of mainly small and medium-sized enterprises (SME) as well as having aged staff, low diffusion of IS, low government support, and heterogeneous IT infrastructure. The following section presents sample interview responses that illustrate these five themes. In addition, the themes reflecting the industry characteristics will be assigned to the corresponding dimensions of the TOE framework.

Mainly SMEs. The German wood industry is mainly characterized by SMEs. The results from our case studies reveal that organizational size is highly relevant to the adoption of IOS within this industry as SMEs face the challenge of insufficient financial and human resources. The manager of the association for wood timber industries (#E4) stated, *"As already said, in this case [the adoption of IOS] the company size as well as the financial potentials are vital."* We found very similar statements across the different viewpoints and organizations. For example, the statement of the logistics manager of one of the leading manufactures for wood-based materials (#O2a) reflects the organizational perspective: "*The firm size is a key driver for the adoption of new technologies in this industry."* The

main obstacle for the adoption of IOS with regard to organizational size seemed to be the lack of financial and human resources. According to the manager of a governmental organization (#E2), *"The structure of firms within the wood industry poses a challenge […]; SMEs often do not have the manpower or funding to support new technologies."* Further, the manager of a consolidation of regional local forestries acknowledged (#I1), "*The big players, such as [company name] and [company name], are doing their own thing because they have the staff and funding, but smaller firms usually do not have the necessary financial background to take part in such [IOS adoption] investments."* The interviewee of a provider for industry-specific software (#E1) agreed, stating, *"The point is that this industry is unable to invest in research and development, due to its structure. Many organizations cannot afford the staff for maintenance and operation."* The results from our case studies suggest that the industry structure in terms of organizational size seems to be a major challenge for the adoption of IOS. Interviewees from the different perspectives indicate that due to a lack of both human and financial resources, organizations in the wood industry hesitate to adopt IOS or invest in information and communication technologies in general. The relative importance of size as a predictor for organizational innovativeness has often been described in IS and organizational research literature and can be seen as a proxy variable for both technological readiness as well as the ability of an organization to blend IT and managerial skills (Hsu et al. 2006). This restrain cannot be handled by all organizations and is reflected in managerial obstacles.

Aged staff. In addition to the industry structure, our analysis revealed that the internal age distribution of staff is also a relevant industry-specific characteristic that influences the decision to adopt IOS. The relatively high average age of staff within organizations in the wood industry seems to be a major inhibitor for technology adoption. The manager of the association for forest technology and forest work (#E3) framed the situation: *"Information technologies can help to enhance communication and coordination. However, it will take a number of years until this view is widely accepted. It will happen when the patriarch retires and the grandchildren prevail, particularly in the wood industry, where many firms are family owned, and owners have grown up in a different time."* The manager of a cooperation of local forestries (#I2) confirms this environmental perspective: "*The majority of our members and customers are between 50 and 60 years old. Thus, the awareness of those opportunities [of IOS] is not given."* We also found support for this industry characteristic within the organizational perspective. For example, a manager responsible for RFID (#O2b) stated, *"That is a question of the alternation of generations […]; we have aged employees that are not open to information technology." However, the succeeding generation is aware of the necessity of IT."* Further, his colleague (#O2a) acknowledges, *"That is the way it is with many firms in the wood industry, particularly in those in which the old man is the boss. They are always saying how they used to do things."* Across all three perspectives, our case studies suggest that aged staff is a crucial factor regarding the adoption of IOS in the wood industry. The analysis revealed that this industry-specific characteristic appears to be the main reason for not adopting innovations. Since many organizations are SMEs and/or family owned, the decision-making process is often delegated to a single person. However, these decision makers seem to be afraid to adopt new technologies in general and IOS in particular due to their lack of expertise, which results in management obstacles. Furthermore, there is a lack of awareness that the adoption of IOS offers advantages.

Low diffusion of IS. In addition to aged staff, or as a result of it, the diffusion of IS in general is a major concern regarding the adoption of IOS in the wood industry. Our case studies revealed that the majority of organizations still rely heavily on traditional communication media, such as fax or telephone. The marketing director of a software provider (#E1) framed the situation: "*The existence of organizational IT infrastructure is closely related to the adoption of IOS […]. However, […] there is not much appreciation for information technology in this branch […]. Even less complex technologies, such as websites and e-mail, are not often used or maintained. […] Communication via letter mail is quite common."* The manager of the association for wood and timber (#I3) agreed, stating, "*Only 10 percent of our members have an e-mail address, and as a result we are using fax."* Further, he acknowledged, *"Most organizations do not have a website, and if one exists, it is not maintained or updated regularly."* We also find evidence for this industry-specific characteristic from the

organizational point of view. For example, the logistics manager of a manufacturer of wood-based materials (#O2a) stated, *"There are still many firms that do not reply to e-mails, because they never read them."* The low diffusion of IS is not only limited to the area of communication but also applies for the execution of internal processes that are often paper based and only marginally supported by information technology. For example, the interviewee of the software provider (#E1) stated, *"The multiple collection of data is a major problem: […] data are often written down on paper, transcribed, and reentered; […] receipts are gathered in a box […]; and internal IT is often non-existent.*" Further, the manager of the association for wood and timber trade acknowledged, *"Many organizational processes are still paper based; for example, invoices are often handwritten."* Our case studies revealed that the diffusion of IS is a relevant factor for the adoption of IOS within the wood industry. IS has not become widespread in this industry and organizations still rely heavily on traditional communication and paper-based processes, which results in both management obstacles and low technological readiness. Moreover, due to the missing experience, the awareness of the potential advantages of IS is diminished, resulting in a lack of partner pressure. However, partner pressure seems to be an important aspect regarding the diffusion of innovations in the wood industry. As the interviewee from the software provider (#E1) mentioned, *"Most firms do not adopt a new technology because it is right and important; they do it because everyone else does it […] It is not the idea of modernization that is decisive but rather the pressure from others."*

Low government support. A lack of government support has been regarded as a major concern for the diffusion of innovations in the wood industry. According to the results of our case studies, government support is crucial within this industry. We found evidence for this from both organizational and industry perspectives. For example, from an organizational point of view, a sales manager (#O1) noted, *"The government still plays a leading role. What they do is usually also adopted by the privately owned forestries."* Further, the statement of the manager of the cooperative of local forestries (#I1) reflects the industry perspective: *"If the state invests money and signs a basic agreement for something, then it will be used. […] That is very common in this industry; the government has a pioneering role."* Although it is widely acknowledged that the government has great influence over the organizations in the wood industry, government support is regarded minimal and difficult to acquire. For example, the manager of a manufacturer of wood-based materials (#O2b) commented, *"It is a lot of work to get subsidies. If you want funding […] you have to invest 200 man hours."* The manager of a consolidation of local forestries observed, *"Historically, forest and wood management has meant bureaucracy."* Moreover, the termination of government-financed projects for research and development, such as the *Holzabsatzfond*, has been a major point of criticism across all perspectives. A manager responsible for logistics and data management (#E3) described the situation: *"The abolition [of the Holzabsatzfond] was a setback as it was a central financial platform. They [Holzabsatfonds] did an excellent job […] by financing IT-related projects and studies. Now a common basis is completely missing."* Besides the reduction of funding, missing communication channels and the low consideration of the branch by government sides are also criticized. As the manager of the association for wood and timber trade (#E3) remarked, *"Compared to other industries, such as automotive, chemical, or even the agricultural sector, we do not have a powerful lobby […]. As a result communication is weak and attention is low.*" The results reveal that government support is an important factor for organizations within the wood industry. However, organizations are facing a lack of both regulatory as well as financial support.

Heterogeneity of IT infrastructure. The last theme that emerged from the case studies is the heterogeneity of existing IT infrastructure in the wood industry. All interviewees across the different perspectives agreed that standardization is an important factor for the industry. The responses indicate that standards are unsophisticated and insufficiently widespread and that the heterogeneity of existing IT infrastructure is a major problem for the adoption of IOS. A manager responsible for wood logistics and data management (#E3) outlined the relevance of standards for the wood industry: *"We need a common platform that connects different information systems […] in order to exchange data between one partner and another […]. Such platforms are becoming increasingly important since our sector is characterized through many interfaces and involved partners, which have to be connected in order to*

exchange information […]. Therefore, we need standards." The manager of the association for wood and timber trade (#I3) proposed, *"It would be very desirable if we could establish standard solutions for all parties involved."* We found similar statements from nearly all interviewees across the different perspectives. However, due to the heterogeneity of the IT environment in the wood industry, standards are rare; the standards that do exist have not become widespread, despite the awareness of the need. For example, the interviewee from the association for forest technology and forest work (#E3) observed, *"Individual solutions on a regional basis are very common in this industry; this is a typical problem […]. Therefore, we have to work with many isolated applications."* The logistics manager of a manufacturer of wood-based materials (#O2a) acknowledged this trend from the organizational perspective: *"Due the fragmented industry structure, each organization has its own standard […] and we have not made any progress."* Furthermore, a manager for raw wood (#O3) noted, *"All our IT solutions are customer-specific […]. There has been a claim for more standardization. However, we never made it."* The marketing manager of a software provider (#E1) commented further, *"Standardization within this industry is a big drama."* Other examples can be found across all perspectives. This lack of standards seems to be a major problem regarding the diffusion of IOS in the wood industry. As the manager of a producer of wood-based materials (#O3) stated, *"We are very skeptical [regarding existing standards]. Even the good approaches have failed […]. If one standard would be enforced, IOS would clearly have better chances […]. However, at the moment that's not the case; everything is too dispersed, and there is no advantage."*

The five themes that emerged from our case studies reflect the special characteristics of the wood industry and can be linked to existing constructs of the TOE framework. Combing these two perspectives enables both a strong grounding for the emergent theory as well as an accurate measurement of constructs. Table 3 summarizes the assignment of the identified industry characteristics to the associated explanatory TOE variables.

TOE Dimension	**Construct**	**Industry Characteristic**				
		Mainly SME	Aged staff	Low diffusion of IS	Low government support	Heterogeneity of IT infrastructure
Technology	Relative advantage		●	●		●
Organization	Technological readiness	●		●		
	Management obstacles	●	●	●	●	
Environment	Partner pressure			●		
	Regulatory environment				●	

Table 3. Industry characteristics and associated TOE variables.

Based on the results of our case studies, we theorize that five major factors affect the extent of IOS adoption in the wood industry. *First*, the process of innovation diffusion starts with an evaluation of potential organizational benefits (Rogers 1995). Relative advantage is associated with increasing internal efficiency and also affects and enables business opportunities that potentially offer competitive advantages (Iacovou et al. 1995). Correspondingly, relative advantage positively influences IOS adoption. *Second*, technological readiness comprises both physical assets that facilitate IOS, such as technology infrastructure, and IT human resources that contribute to the development, such as IT professionals (Mata et al. 1995). Accordingly, firms with greater technology readiness are better positioned to adopt IOS. *Third*, managerial obstacles are defined as the lack of managerial skills for managing organizational adaptations to accommodate new technologies (Zhu, Kraemer, et al. 2006). Some organizations are unable to manage the blending of managerial and IT skills in order to assimilate information technology (Chatterjee et al. 2002). Therefore, it can be proposed that managerial obstacles are barriers to IOS adoption. *Fourth*, partner pressure can be seen as the external

pressure from a business partner to adopt a certain technology. This construct is affected by the status of the business partner and by the potential of the partner to influence an organization's decision-making process (Iacovou et al. 1995). Therefore, it can be argued that partner pressure positively influences IOS adoption. *Fifth*, the regulatory environment has been recognized as a critical factor influencing innovation diffusion (Zhu et al. 2003). The government can affect innovation diffusion by altering payoffs and other measures or by changing the regulatory climate (Williamson 1983). Accordingly, governments can encourage IOS assimilation through supportive regulations and policies.

4 STUDY 2: INFLUENCE OF TOE FACTORS ON IOS ADOPTION

Following the qualitative analysis in the first study of industry characteristics affecting the adoption of IOS, Study 2 involved a quantitative field study that examined the empirical and statistical relationships between the factors that were regarded as relevant and IOS adoption. The theoretical linkages and research hypotheses are illustrated in Figure 1.

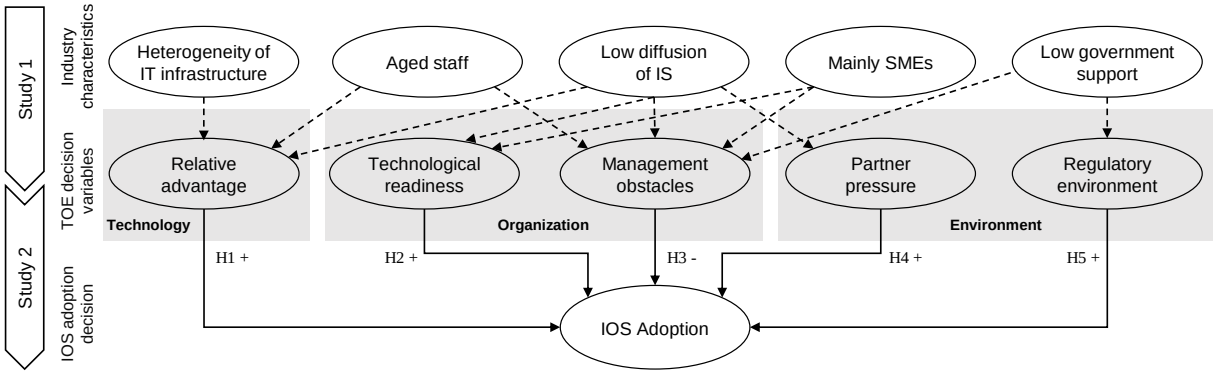


Figure 1. Research model.

4.1 Research design

In order to test the theoretical model, data was collected from the German wood industry between November 2013 and February 2014. The questionnaire was distributed among organizations involved in woodworking, wood processing, wood building, or the timber trade. The underlying database builds upon the *Internationale Holzbörse* (IHB), which is a specialized network in the forestry and wood cluster that provides a business database with contacts. 204 complete cases that fulfilled all quality criteria were collected. Cases were excluded due to missing values and implausibility of firm characteristics or IT usage behaviors. SMEs accounted for the largest share within our sample: 86 % have less than 50 employees, 9.8 % have between 50 and 250 employees, and 4.2 % are large-scale organizations with more than 250 employees. Respondents were mainly CEOs, CIOs, or senior IT managers. Further, the different industry sectors are equally represented: woodworking (28 %), wood processing (30.6 %), wood building (22.6 %), and timber trade (18.8 %).

All scales for both dependent and independent variables were adopted from validated measures used in prior research on e-business, which can be seen as a manifestation of IOS along the value chain (Zhu, Kraemer, et al. 2006). The scales were translated into German and two researchers independently crosschecked the results. An overview of all measurement instruments including both items (in English) and original authors can be found in the Appendix. The measurement of IOS adoption is based on the value chain model (Porter 1985) and indicates whether an organization had used IOS for each value chain activity as an aggregated value (1 item). The operationalization of the independent variables also follows original scales of corresponding research and are as follows: relative advantage

(4 items), organizational readiness (3 items), regulatory environment (3 items), technological readiness (3 items), and partner pressure (3 items). In accordance with prior research, all independent variables are modelled as reflective constructs.

4.2 Data analysis and results

In order to test the theoretical model, a structural equation modelling (SEM) approach was used. 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, normal distribution is not required (Ringle et al. 2012). Our analysis was supported using the software SmartPLS 2.0 (Ringle et al. 2005). In addition, SPSS Statistics was used for tests that are unavailable within the SmartPLS package. The data analysis follows the widely adopted two-step approach for SEM (Anderson & Gerbing 1988). First, in order to ensure validity and reliability, the quality of the measurement model was assessed; subsequently, the structural model was analyzed.

4.2.1 Measurement model assessment

According to Chin (1998), the sample should exceed 10 times the number of indicators for the scale with the largest number of indicators, and sample size must be higher than 10 times the largest number of paths directed to any construct in the model. Our sample size, which includes 204 cases, meets both criteria. In order to account for the threat of non-response, we checked for mean differences of the construct items of the first and the last half of the sample (Armstrong & Overton 1977). The results of the t-tests revealed no significant differences ($p < .10$) between both time periods, indicating that non-response bias is not a concern for this study. A single informant assessed both independent and dependent variables. Thus, common method variance (CMV) poses a potential threat to the validity of the results (Podsakoff & MacKenzie 2003). Following the approach of Podsakoff and MacKenzie (2003), an exploratory factor analysis was conducted. No single factor emerged from the data, and a general factor does not account for the majority of the covariance among the measures. Hence, common method bias is not a major concern for this study.

Construct	FL	CR	AVE	ADO	RA	TR	MO	PP	RE
IOS adoption (ADO)	n/a	n/a	n/a	**n/a**					
Relative advantage (RA)	.691-.913	.875	.702	.467	**.838**				
Technological readiness (TR)	.776-.839	.844	.643	.275	.055	**.802**			
Management obstacles (MO)	.833-.988	.909	.835	.052	-.006	.130	**.914**		
Partner pressure (PP)	.701-.808	.785	.550	.305	-.175	-.209	.141	**.741**	
Regulatory environment (RE)	.733-.843	.768	.624	.160	.002	.007	.160	-.171	**.790**

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 4. CA, CR, AVE, and inter-construct correlations.

In order to assess the fit of the hypotheses and empirical data, the measurement model was tested for content, convergent, and discriminant validity. Three measures were evaluated for each reflective construct in order to ensure convergent validity: individual item reliability, composite construct reliability (CR), and average variance extracted (AVE). Due to low factor loadings, one item from each management obstacles, regulatory environment, and relative advantage scale were dropped (see Appendix). Afterwards, as depicted in Table 4, all except one item loaded on its own construct at .70 or above, which indicates an acceptable limit of item reliability (Gefen & Straub 2005). The CR ranges between .768 and .909, which is also above the acceptable limit of .70 (Hulland 1999). Further, all AVEs exceed the lower bound of .50 (Bhattacherjee & Premkumar 2004). In order to access this quality measure, the Fornell-Larcker criterion was used (Fornell & Larcker 1981). As the AVE of each construct is greater than the variance shared with other constructs (see square root of AVEs on the diagonal in Table 4), discriminant validity is confirmed. Finally, we also checked the cross-loadings.

As expected, all items display higher loadings on their assigned construct than on other constructs within the model (Chin 1998). Thus, the analysis suggests that our model is both acceptable and reliable.

4.2.2 Structural model assessment

In order to evaluate the structural model, we applied a bootstrapping procedure (5000 samples). The central criterion for the assessment of the PLS structural model is the explained variance of the endogenous variable, which typically depends on the research context (Hair et al. 2011). With an explained variance of .351, the endogenous variable (IOS adoption) lies at a satisfactory level for IT adoption studies on organizational level (Chan et al. 2012; Zhu, Kraemer, et al. 2006). We also computed the Stone-Geisser Q^2 coefficient with a blindfolding procedure in order to determine the predictive relevance of the structural model. With a value of .276, this measure lies clearly above the minimum threshold of 0 (Hair et al. 2011).

Hypothesis	Explanatory Variable	Path Coefficient (b)	Support for Hypothesis
H1	Relative advantage	.417***	Supported
H2	Technological readiness	.201***	Supported
H3	Management obstacles	.029	Not supported
H4	Partner pressure	.221***	Supported
H5	Regulatory environment	.200***	Supported

Significance levels: ***p<.01, **p<.05, *p<.10

Table 5. Path coefficients and bootstrapping results of the structural model.

Table 5 presents the estimates of the PLS analysis as well as the significance levels of the bootstrapping procedure. The structural model offers support for most of our hypotheses. The adoption of IOS is significantly influenced by partner pressure (H4, b = .221), relative advantage (H1, b = .417), the regulatory environment (H5, b = .200), and technological readiness (H2, b =. 201). All coefficients were revealed to be significant on a $p < 0.1$ level. However, we did not find support for the hypothesis related to management obstacles (H3). In contrast to our theoretical model the results show a positive relation. However, this relation cannot be shown to be empirically significant.

5 DISCUSSION AND CONCLUSION

The wood industry lags far behind other industries when it comes to the adoption of new technologies in general and inter-organizational IS in particular (Hewitt et al. 2011). Based on 11 case studies and data gathered from 204 organizations for statistical analysis, our study set out to explain the low degree of IOS adoption in the wood industry in order to identify potentials for effectively encouraging the diffusion of inter-organizational IS. By combining qualitative and quantitative methods, this research offers both insights into the circumstances affecting the adoption of IOS, and effects arising from industry characteristics as well as empirically validated factors that influence adoption decisions. We argue that the low diffusion has its roots in the specific characteristics of the wood industry and that effective actions to promote IOS should be designed along the unique characteristics of the wood industry.

Our results support the basic structure of the theoretical model and suggest that there are four main factors affecting the extent of IOS adoption. We can demonstrate that partner pressure, relative advantage, the regulatory environment, and technological readiness have significant influence on the adoption of IOS, which is in line with previous research in other industry contexts. Interestingly, the

statistical analysis reveals that the perceived relative advantage seems to be the main driving factor for organizations to adopt IOS (b = .417). This is surprising, as small and medium-sized organizations, which account for the largest share by far within our sample, are said to adopt new technologies without having recognized the need to do so (Iacovou et al. 1995), which has also been indicated by the cases studies. In addition, previous research suggests that SMEs are particularly susceptible to impositions by larger partners. Accordingly, we would have expected a higher influence of partner pressure, which, compared to the factor of relative advantage, is relatively low (b = .221). One reason for this might be the industry's lack of large-scale enterprises, which would be able to put higher pressure on trading partners (Iacovou et al. 1995). Furthermore, the analysis revealed that management obstacles appear to be unimportant for the adoption decision. This is surprising for two reasons: First, in prevailing research, management obstacles have been regarded as highly relevant with regard to technology adoption. For example, Chan et al. (2012) demonstrate that management obstacles have a significant negative influence on the organization's decision to adopt e-collaboration, particularly in small- and medium-sized enterprises. Second, this result is in contrast to the findings from our case studies, in which the majority of industry characteristics were found to intensify management obstacles.

This study was conducted with the aim of identifying factors that predict the adoption of IOS in the wood industry. Based upon qualitative and quantitative data, we were able to empirically investigate industry characteristics that influence adoption decisions. Thus, this research provides valuable insights and offers guidance for policymaking and practice. Our results show that specific industry characteristics are highly relevant for the decision-making process and therefore must be considered when putting measures in place. In order to respond adequately to industry characteristics, measures should focus on underlying specifics and the resulting needs and requirements rather than acting on general levels. For example, the statistical analysis suggests that relative advantage is an important predictor for IOS adoption. At the same time, however, the results from case studies reveal that organizations of the wood industry are rather unaware of these potential benefits, due to their lack of expertise. Therefore, selective measures, such as information events or selective marketing campaigns, could enhance awareness and should be designed along industry characteristics. Since the industry is mainly characterized by SMEs, organizations and pioneers that can develop and enforce industry-wide standards by leveraging pressure are rare. Governmental encouragement might compensate for this constraint. However, case studies reveal that a lack of government support is a major issue in the industry. For example, nearly all interviewees criticized the cutting of financial aid for research and development. In summary, decision makers should pay close attention to the specific context in which they are involved. Internal and external contingencies are particularly relevant and should be identified and addressed by policymakers in order to facilitate the successful adoption and diffusion of IOS.

This study also provides important contributions to research. First, by explicitly considering industry characteristics from different perspectives and multiple viewpoints, this study directly responses to calls from previous research on IOS adoption (Gregor & Johnston 2000). Thus, this research claims to extend and deepens existing research. Second, the data underlines the relevance of investigating industry-specific characteristics. However, previous research on IS adoption has drawn surprisingly little from the major strength of combining quantitative and qualitative research methods and, in general, there is a dearth of research in IS that employs a mixed method approach (Venkatesh et al. 2013). Thus, this study contributes to the body of knowledge by offering insights on how industry characteristics can shape research on IS adoption, particularly in industry-specific contexts. Further, we hope that our research design can inspire future IS research to employ mixed method approaches in order to develop richer insights into various other phenomena of interest, which cannot be fully understood using only quantitative or qualitative methods.

When interpreting the results, several limitations must be considered. First of all, this study was designed to investigate factors that influence the adoption and diffusion of IOS in the German wood industry. Although our findings might also be applicable to other contexts, we do not argue for generalizability as cultural differences (Zhu, Dong, et al. 2006) and industry specifics (Theodosiou &

Katsikea 2012) are influencing IS adoption behavior. Thus, future research should conduct empirical studies in a broader range of countries and/or industries to validate the findings and examine differences and similarities. Further, we used the TOE framework for theoretical guidance because it offers a broad range of contextual factors that fit with our research approach. However, future research should integrate other theoretical lenses in order to add predicting variables and examine supplementary relationships. While this study concentrates only on direct relationships, future studies should also consider moderating effects and mutual relationships. Despite these limitations, this study can be seen as a step towards a more integrated perspective on IS adoption research in general, and IOS adoption in particular.

Appendix

Construct	Scale
IOS adoption (Zhu, Kraemer, et al. 2006)	Check the box describing applications of e-business in your value chain processes: Advertising and marketing, Making sales online, After-sales customer service and support, Exchanging operational data with upstream suppliers, Making purchases online, Exchanging operational data with downstream business partners and customers, Electronically integrating business processes with business partners (e.g., real-time transaction of orders, collaborative forecasting, integrated channel management, etc.).
Relative advantage (Zhu, Kraemer, et al. 2006)	Please indicate how significant each of the following potential benefits was rated when your organization was considering using e-business for value chain business activities: 1. To reduce costs*, 2. To expand the market for existing products/services, 3. To enter new businesses or markets, 4. To improve coordination with customers and suppliers
Technological readiness (Chan et al. 2012; Zhu, Kraemer, et al. 2006)	1. Approximately how many personal computers are currently in use in your organization? 2. Approximately how many IT professionals are located in your organization? 3. Please check the box describing technologies used in your organization (Use of e-mail, Use of websites accessible by public, Use of Intranet, Use of Extranet, Use of electronic data interchange (EDI), Use of electronic funds transfer (EFT), Use of a call center).
Managerial obstacles (Huynh et al. 2012; Zhu, Kraemer, et al. 2006)	Please rate how significant the following obstacles are to your organization's ability to use e-business (7-point Likert scale): 1. Making needed organizational changes for e-business implementation, 2. Integrating e-business into the overall strategy and business process, 3. Lacking staff with e-business expertise*.
Regulatory environment (Huynh et al. 2012; Zhu, Kraemer, et al. 2006)	1. The use of the Internet for business was driven by incentives provided by the government, 2. The use of the Internet was required by government procurement, 3. Business laws support e-business*.
Partner pressure (Huynh et al. 2012)	1. Our business partners demand us to use e-business, 2. Our business partners are able to process businesses via the Internet, 3. Our suppliers and/or business partners force us to implement e-business.

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

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