Interorganisational Information Systems Maturity: The Effects Of Supply Chain Position

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Preface

This thesis is submitted for the master's degree in business administration at the Rotterdam School of Management. The described research was conducted between January and June 2016.

I am grateful for having this learning experience and feel enriched, enlightened and ready for the next challenge now that it's finished. I would like to thank Merieke Stevens for her enthusiastic courses and her huge positive energy towards this thesis project. My appreciation also goes out to Roelof Kuik for his wonderful attention to detail during his co-readership. Both of you helped to keep me energised to finish this thesis on a realistic planning.

There are no words to express the special thanks to my lovely girlfriend – and soon to be wife – Yvette. On October 7th, 2016 we are getting married and we will get to leave behind a period of 2 years where being together was no longer taken for granted. Our wedding also provides the opportunity to all of my family and friends to catch up on the time we have been missing out on. I thank all of you for your patience, help and love in the past two years.

I feel proud of the result that lies in front of you, please enjoy.

Danny Smit
Haarlem, May 16th, 2016

Executive Summary

Consumers demand accurate product availability information, but businesses are not always able to provide this information. Organisations can use interorganisational information systems (IOS) in order to improve the flow of information in the supply chain. Some organisations achieve higher maturity in IOS than other organisations. This study can add to the existing knowledge on IOS by identifying and strengthening the differences in maturity. Prior research (e.g. Plomp 2012) argues that for assessing IOS maturity research should not be limited to a technological dimension of IOS. Rather should research include an organisational dimension existing of arrangements and practices in IOS.

Frohlich and Westbrook (2001) made a distinction between the maturity of the demand- and the supply-side of an organisation and report that it would be helpful to see the effects of this demand- and supply-side in the whole supply chain as well. A request for a model that can assess the maturity of IOS with respect to the position of the organisation in the supply chain leads to the following research question:

How is the maturity of an organisation's interorganisational information system affected by the organisation's position in the supply chain?

The unit of analysis for this study is organisations and by 1. Evaluating the demand- and supply-side of organisations, 2. Evaluating the demand- and supply-side in the supply chain and 3. Selecting organisations that actually do business together this study can research supply chain IOS maturity scores along with measuring capabilities of individual organisations. An exploration of existing literature results in four more identified variables in addition to the organisations' position in the chain. Based on the exploration of literature the following hypotheses are proposed:

H1. The position on the supply side of the supply chain is negatively related to the IOS maturity in an organisation.

H2. The autonomy of an organisation is negatively related to the IOS maturity in an organisation.

H3. The complexity of an IOS in an organisation is negatively related to the IOS maturity in an organisation.

H4. The size of an organisation is positively related to the IOS maturity in an organisation.

H5. The importance of data synchronisation for an organisation is positively related to the IOS maturity in an organisation.

The research strategy used in this thesis is a survey. A large number of respondents allowed for statistical analysis wherein the variations in IOS maturity can be distinguished. A measurement protocol was built to provide a base for the questionnaire and a pilot interview and pre-tests were conducted to assess the validity and reliability of the approach. The sample was taken from a small population of the 'accessories' branch in the Consumer Electronics supply chain. A wholesale organisation provided the database with organisations and the access to the managers of these organisations.

The results of the statistical analysis are categorised by organisations of micro-, small- and medium/large size and in respect to the organisations position in the chain: retailer, wholesaler or supplier. There are several significant relations between IOS maturity and the importance of data synchronisation, the position in the chain and the size of the organisation. An example is the correlation coefficient of 0.55 at $P < 0.001$ for the importance of data synchronisation with IOS maturity and thus a strong relation is expected. In addition to this 'generic' effect, there are also effects on specific categories such as the medium/large suppliers that have the strongest relation with the level of IOS maturity. Applying these variables to multiple regression analysis shows that autonomy and complexity of IOS have no significant relation or influence on the explained variance for IOS maturity. The other three variables for position, size and data synchronisation together explain 0.502 of the adjusted R-squared for IOS maturity. These significant findings are coherent with the proposed hypotheses, except for the direction of the relation for position in the chain. The reasons for this opposite direction can be related to the history of suppliers with integrating interorganisational communication. While the exploration of literature proves that costs for IOS are often shifted to the supplier, this does not pose a problem and may also be observed as an opportunity to create competitive advantage.

There is a strong significant relation between the importance of data synchronisation and IOS maturity. It is likely that an organisation that highly values the importance of data synchronisation achieves higher IOS maturity scores. When organisations are already exchanging information with many of their partners, it becomes important to them. To prove that importance and IOS maturity are not parallels, a comparison of performance and importance should be made. When data synchronisation is important but barriers exist, such as a lack of financial resources and management commitment, IOS maturity can possibly fall short.

This study adds to existing literature by arguing that the position in the chain is a critical variable in assessing IOS maturity in organisations. The importance of data

synchronisation must be stressed because it shows a significant correlation to IOS maturity. As a result, future researchers should also be cautious when using autonomy or complexity to explain IOS maturity. Furthermore, it proves that studying IOS with organisations as a unit of analysis can have a significant contribution to assessing overall supply chain capabilities. Scoring organisations on their IOS maturity and assessing the result in relation to other organisations in the chain can help to improve chain performance in IOS.

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Chapter 1. Introduction

In this first chapter, an introduction to the topic and the contextual background is presented. This leads to the main research question of this study. Then the significance of this research and the research philosophy are defined. This study's structure is outlined at the end of this chapter.

1.1 Context of research

Consumers are getting used to receiving accurate availability information before making their purchase. They search the Internet looking for web shops that provide next day- or even same day delivery combined with competitive pricing. While some products are delivered from stock, others are sent directly from the wholesaler or manufacturer to the customer by drop shipment. To be able to provide these delivery services and provide the consumers with accurate availability information, the supply chain has to work together. This is where the interorganisational information systems (IOIS or IOS in short) come in. Every organisation continues working with their own custom information systems. Small modules are built into these systems that are able to extract information and send it to the supply chain partners. On the receiving end, another module picks up this information packet and translates it into something that their system can understand and use.

Providing real-time information can be challenging. This cannot be solved by a single organisation, but involves all organisations in the entire supply chain. To improve the information sharing and collaboration within the supply chain, it is necessary to be able to assess the current maturity score of interorganisational information systems in organisations. Knowing the current maturity score for partners can identify the weak spots in the supply chain. Either by motivating partners to perform better or to abandon such partners, accurate availability of products in the chain can be assured. The position in the chain: retailer, wholesaler or supplier is a critical variable in this research because the flow of information and collaboration can potentially be blocked by any one of these links in the chain.

1.2 Introduction to literature

Many prior studies have addressed interorganisational information systems including subsystems like supply chain management systems (SCM) and have reviewed their effects on organisation performance (e.g. Rai et al., 2006; Subramani, 2004; Saeed et al., 2005; Gunasekaran, 2001). While focussing on the technological dimension of IOS

in the individual organisation (e.g. e-commerce systems) these studies tend to overlook the organisational dimension that includes arrangements, relationships and collaboration with partners in the value chain. Enrichment of these study results can be achieved by changing the perspective from an individual organisation to the view on the whole supply chain. Instead of measuring the 'chain integration readiness' of an organisation, the actual benefits and limitations in the usage of interorganisational information systems can be assessed. Plomp (2010) also argues to include the organisational dimension and proposed an IOS maturity model. His empirical research consisted of scoring each supply chain based on a single interview for each supply chain. This approach can lead to inaccurate results. It is questionable whether a whole supply chain can be scored realistically with a single maturity level. Instead, this study performs quantitative research on organisations in a smaller 'accessories' branch from the consumer electronics (CE) supply chain.

All organisations in a supply chain can benefit from improved information sharing, by creating cost-reductions for example. These benefits can be achieved through improved purchasing and forecasting, by reducing transactions costs on invoicing and receiving goods but also by improved agility to respond to the changing market requirements (Gunasekaran et al., 2003; Zhang et al., 2005). With improved chain information and flexibility organisations should become demand-driven rather than forecast driven (Christopher, 2000). A potential drawback of this demand-driven approach is that more activities are likely to shift towards the supply side of the value chain (Carter, 1990; Clemens and Row, 1993) but also that the demand side of the value chain is required to arrange the market information for the rest of the chain.

1.3 General research objective

To be able to improve the IOS maturity level in the future, the differences in IOS maturity between groups of organisations need to be assessed. For example Frohlich and Westbrook (2001) made a distinction between the maturity of the demand- and the supply-side of an organisation and report that it would be helpful to see the effects of this demand- and supply-side in the whole supply chain as well. A request for a model that can assess the maturity of IOS with respect to the position of the organisation in the supply chain leads to the following research question:

How is the maturity of an organisation's interorganisational information system affected by the organisation's position in the supply chain?

The goal of this study is to contribute to the knowledge of IOS maturity in interorganisational information systems within an organisation by testing the hypotheses related to this question. By focussing on the organisational- and technological dimension this study builds on existing maturity models and extends it with a new independent variable. The unit of analysis for this study is organisations and by:

1. Evaluating both the demand- and supply-side of individual organisations,
2. Evaluating organisations on both the demand- and supply-side of the supply chain
3. Selecting respondents that actually do business together within their supply chain

this study can research the supply chain IOS maturity scores along with measuring capabilities of individual organisations.

1.4 Significance of this study

The theoretical relevance of this study is achieved by building upon suggestions from prior research. Both Frohlich and Westbrook (2001) and Guinipero, Hooker, Joseph-Matthews and Brudwig (2008) state that future research in supply chain management should focus on understanding the nature of multiple links in supply chain management beyond dyadic and inter-firm relationships. Since research on IOS maturity is scarce it may be possible to strengthen Plomp's (2012) model for measuring IOS maturity. This study has practical relevance by providing a point of reference for current IOS maturity in the consumer electronics. Organisations are then able to compare their performance with others and improve decision-making on future development for their information systems.

1.5 Research philosophy

This research is written from a critical realism philosophy. It is considered as a post-positivism form that transcends traditional positivistic thinking with the recognition that observation has error and is fallible (Trochim, 2006). It rejects incommensurability and allows for different perspectives to exist. However, it still believes that there is an independent reality that can be measured and studied. To do so empirical analytical tools can be used to create knowledge that can understand and control phenomena.

When studying a supply chain and the organisations that interact in this chain, Morgan (1997) is considered for his view on organisations as if they were organisms. Each organism is a living system that depends on the satisfaction of needs in an

environment bigger than themselves. The changing needs of the outside world require satisfaction and therefore, adaption by the organisms might be necessary.

The mind-set used in this study also follows Ronald Coase (1937) in his transaction cost theory of the firm. The relation of the firm to the market in terms of transaction costs is critical when assessing interactions within a supply chain. Klein (1983) adds that the transaction costs occurring within the firm should also be considered as market relationships and that both intra-firm and interfirm transactions are considered as transaction costs. The transaction costs perspective allows improved assessment of all transactions involved in the chain to aim for chain-wide operational excellence.

1.6 Structure

This first chapter provided an introduction to our subject and research question. Chapter two consists of an exploration of the literature to identify all current knowledge on the maturity of IOS and to explore what variables might affect the maturity of IOS. Hypotheses are formulated about the expected relations and a conceptual model is proposed. In Chapter three the methodology of this research is explained and a measurement protocol is built in order to collect valid data. The results of the data analysis are reported in Chapter four. Chapter five discusses the findings in relation the research question and hypotheses, followed by limitations of this study and suggestions for further research.

Chapter 2. Exploration

In this chapter, the exploration of literature is reported. The definitions and prior research of the different variables are addressed. The discussed variables result in the conceptual model that is used in this study.

2.1 Interorganisational Information Systems

Interorganisational information systems (IOS) have been an active subject since 1982 when Barret and Konsynski defined IOS as "shared information systems that cross organisational boundaries and benefit all participants". Today technical possibilities are extending exponentially and Internet-based platforms are used to facilitate buyer-supplier collaboration. Traditionally IOS was used as a definition for technical solutions that link multiple organisations (e.g. Barrett & Konsynski, 1982; Meier & Sprague, 1991; Swatman & Swatman, 1992) but Reimers, Johnston & Klein (2014) propose that IOS is rather a constellation of practices in a framework that they call IOS boundary structures. IOS indeed proves to be more than just an IT dimension as it also accommodates organisational arrangements such as virtual organisations and value networks. Therefore, when IOS is used in this study it is not limited to logistics and operations, but it refers to social chains and larger scale interorganisational processes for creating value (Grijpink, 2010).

Supply chain management (SCM) can be seen as a subset of activities in IOS. Simchi- Levi et al. (2000) define SCM as a set of approaches utilised to effectively integrate suppliers, manufacturers, warehouses and stores so merchandise is produced and delivered in the right quantity, at the right location and at the right time to minimise costs and satisfy service level requirements. SCM is considered a subset because IOS also involves sharing strategic information or facilitation of collaboration on, for example, product development. Another type of information system is the enterprise resource planning (ERP) system, which basically integrates all different disciplines in an organisation such as sales, purchasing and accounting into a single local information system. SCM systems or Extended Resource Planning (XRP) systems (Kalakota and Robinson, 2001) can then use this information to communicate it to the external recipients like customers and suppliers. IOS then functions as a necessary infrastructure to combine all technical components, practices and arrangements for the use of interorganisational collaboration.

IOS does not require organisations to use exactly the same information system. Instead, all organisations are able to use their own custom IT systems and they create modules that can export- and import information in a standardised format, for example, Electronic Data Interchange (EDI). These EDI formatted files allow trading partners to exchange information electronically between separate computer applications (Swatman & Swatman, 1992). This long-established EDI format is very persistent and replacing it by newer and supposedly superior – Extensible Markup Language (XML) based systems have appeared to be extremely difficult (Wareham et al., 2005).

2.2 Collaboration

The stream of literature related to the importance of information sharing shows a continuously growing stream (e.g. Sahin and Robinson, 2002; Cousins *et al.*, 2006). Instead of just sharing information, collaboration should be seen as a higher-level goal because by working together organisations can achieve more than lowering operational costs. There are three organisational levels where collaboration benefits can be defined. On the operational level, this consists of organisations sharing order information (Klein and Rai, 2009) and demand or sales data (Patnayakuni *et al.*, 2006) to reduce order information distortion and reduce stock levels (Yu *et al.*, 2010). On the tactical level quarterly forecasts, plans and trends are shared (Bowersox *et al.*, 2000; Yigitbasioglu, 2010; Ramanathan, 2012). Based on this information organisations can improve resource planning and improve reliability to downstream partners (Kembro & Selviaridis, 2015). On the highest level, strategic information sharing can be found where organisations share one-year forecasts, marketing strategies and sales promotions (Mentzer *et al.*, 2001) to allow planning of future growth for the alliance (Mohr and Spekman, 1994).

2.3 Maturity of IOS

Measuring the level of IOS maturity can only be achieved through clearly stated indicators. Based on a review of journals, books and conferences, Plomp (2010) proposes a framework that consists of a technological- and organisational dimension and equally divides each dimension into four levels. The necessity for using technological- and organisational dimensions is argued by recent business-IT alignment theories and its validation (Chan and Reich, 2007).

2.3.1 Technological dimension

The levels for scoring the technological dimension are based on definitions by Folinas et al (2004) and CBS Statistics Netherlands (2006). All levels have an explicit

technological component and as the level rises more external linkages are being made. When a higher level is achieved it can be assumed that the technology automatically obsoletes the prior level.

Levels of the Technological dimension

" 1. No chain automation. There is no interorganisational technology. This means that at the level of the single organisation there is no use of ICT at all, there is island automation, or there are even many internal linkages (e.g. an enterprise resource planning (ERP) system). Whichever is the case, there are no digital connections to the outside world.

2. E-business. At this level ICT is used to cross the borders of the organisation. Connections are made between for example the stock system of a retailer and the order system of a supplier. This is also called eXtended ERP (XRP), indicating that the internal information system extends outside the organisation itself (Kalakota and Robinson, 2001). In this phase, the focus lies on transactional processes.

3. E-collaboration. A type of ICT that serves collaboration between multiple parties in the chain. Standards and standardisation of product databases and descriptions are relevant here. E-collaboration comprises tactical processes.

4. Open, n-tier sourcing. A level that differs from the preceding level because the technology is available and used by all ("n") parties within and between value chains. Data comes from multiple locations through open standards and architectures (Van Beers and Bouwman, 2007)." (Plomp, 2012)

2.3.2 Organisational dimension

The second dimension focuses on the organisational aspects of collaboration. An 'organisational' dimension is used as a broad concept and should in this context be seen as collaborating on products, projects or along the value chain by multiple parties to collectively deliver value (Closs, Swink & Nair, 2005). An example is personalised or tailor-made products such as photo books or customised phone cases. Based on previous research (e.g. Skjoett-Larsen, 2003 and Schoenfeldt, 2008) on the organisational dimension, the following levels can be distinguished:

Levels of the Organisational dimension

" 1. No chain collaboration. There are no interorganisational relationships. Note that this says nothing about the internal organisation, which may be fully integrated or consist of separate parts.

2. *Bilateral collaboration. In this case there is collaboration with another organisation, which can be in the same line of work (e.g. a retailer working together with another retailer), but is more often a connected link of the value chain (e.g. a retailer working together with its supplier). Think about the sharing of information such as turnover per product (which are the best-selling products?) and stock information (when do which items need to be replenished?).*
3. *Multilateral collaboration. This is in fact the same as the previous level, but with multiple parties. It can be in the form of collaborative planning, forecasting, and replenishment (CPFR) – the joint management of resources in the chain based on supply and demand information. A similar notion is collaborative commerce, where information in the chain is shared and even activities like product design are performed jointly (Turban et al., 2004).*
4. *Extended chain collaboration. At this level there is collaboration between multiple parties across multiple links within and between value chains. One of the many possibilities is a retailer who passes the product requirements of a consumer directly on to the producer. Another example is a consultative body for discussing problems or making arrangements that concern all actors in the chain. The interaction is truly many-to-many and "n-tier", including the customers and suppliers of all chain organisations." (Plomp, 2012)*

2.4 Maturity and performance

Within the organisational dimension, one could also think of behaviour that may provide barriers for maturity in IOS. Research by Kembro and Selviaridis (2015) argues that there are three key barriers to extending information sharing beyond dyadic relationships: 1. Demand information disaggregation; 2. Risk of information misinterpretation; and 3. Risk of making production and distribution decisions based on incomplete information. Cheng et al. (2008) have a different view on barriers for maturity in IOS, based on a more social perspective "Lack of trust, difficulty in fostering commitment, the persistence of separate organisations in independence, the complexity of joint projects, and the different cultures to be coordinated are common and obvious barriers". When an increase in performance on IOS maturity is desirable, these obstacles need to be overcome.

More maturity in IOS does not always lead to improved business performance when the balance as in the business-IT alignment theory by Henderson and Venkataraman (1993) is considered. When IOS maturity is split into a technological and organisational component it should always be in balance with each other and in balance

with other operational- and business processes. For example, when the internal processes are not properly linked in an ERP system, organisations are not able to achieve high maturity on the technological dimension. Even though the external communication is achieved, the available information to be synchronised is insufficient. Organisations that achieve a reasonable level of business-IT alignment are more likely to improve their competitive advantage by achieving higher IOS maturity. Daugherty (2006) argues that collaborative organisations are certainly more successful than isolated organisations. IOS maturity helps to facilitate and thus improve this collaboration.

2.5 Position in the supply chain

Assessing the IOS maturity benefits from the supplier side shows that more collaboration between organisations is likely to bring extra costs and activities to these suppliers (Subramani, 2004). Osegowitsch and Madhok (2003) claim that customers concentrate more on their own core competencies and rely on their suppliers for information solutions that can be integrated into their own processes. When the information from the supplier is missing in an interorganisational information system, this leads to major error in providing accurate availability information to customers.

Supplier networks are characterised by a large number of supplier organisations working with a dominant network leader. These network leaders seem to benefit unevenly and skewed in the expense of supplier organisations by shifting activities and costs to them (Carter, 1990; Clemens and Row, 1993). Improvements like forms of delivery integration or collaboration includes product postponement and mass customisation in the supply chain (Lee and Tang, 1998; Pagh and Cooper, 1998; Van Hoek et al., 1998). When costs and activities shift towards the suppliers it may be beneficial to use this as a competitive strategy. Frohlich and Westbrook (2001) show that organisations with an outward facing supply chain strategy are achieving better performance. The organisations that achieve bigger arcs of integration perform better than organisations that follow more inward facing strategies.

One way for the supplier to benefit is by preventing the bullwhip effect (Lee et al., 2004) by having more accurate sales- en inventory information from the retail channels. Vendor Managed Inventory (VMI) is a clear example how suppliers are able to make better sales predictions and thus create cost reductions by lowering inventory levels or raising levels to prevent stock out costs (e.g. Aviv and Federgruen, 1998; Parker, 1996, Schenck and McInerny, 1998).

As indicated earlier, Frohlich and Westbrook (2001) argue that a distinction between demand- and supply-side in the whole supply chain would be helpful. Customers rely on their suppliers for information solutions that can be integrated into their own processes, but it is likely that activities and costs are shifted towards the supplier. For this reason, the relation of position in the chain is likely to be negative. The primary hypothesis for this research is:

H1. The position at the supply side of the supply chain is negatively related to the IOS maturity in an organisation.

2.6 Determinants of IOS

To identify independent variables that can influence the organisational- and technological dimensions of maturity this study follows the same approach as Plomp (2012). The discussed determinants are based on a literature review by Robey et al. (2008) on research articles published between 1990 and 2003. Although he reviewed determinants for the adoption of IOS it is expected that the determinants apply to the maturity of IOS as well. The adoption or initiation of an information system always precedes achieving maturity in an information system. Furthermore, Kurnia, Ali and Johnston (2008) argue that IOS maturity can be rephrased to 'IOS adoption maturity' because there are continuous cycles of increasing levels of adoption and collaboration in the process of becoming more mature. The identified determinants related to IOS adoption that fit IOS maturity are the autonomy of the organisations, the complexity of IOS solutions, the size of the organisation and the importance of data synchronisation. Prior research by Plomp (2012) shows two other possible determinants for IOS maturity: ability to communicate or collaborate and the level of trust in the value chain. However, these determinants were proven of insignificant relation to the maturity of IOS. Trust and the ability to communicate are determinants on the social side of IOS where this research focuses on business- and tangible resource based determinants. Therefore, these determinants are not discussed in this research.

2.6.1 Autonomy of the organisation

When discussing the level of autonomy in an organisation in this study, it refers to the freedom of an organisation to make its own decisions on the use and allocation of its own internal resources without necessarily following expectations or demand from linkage partners in the chain (Child, 1972; Hambrick & Finkelstein, 1987). When learning from the chain is unnecessary or the organisation has major advantages or uniqueness in its products, this leads to autonomy and thereby dominance in the chain.

This dominant player does not wish to lose its favourable position and bargaining power in a supplier-buyer relationship (Seidmann and Sundararajan, 1998; Christopher and Juttner, 2000). Other players can fear to become overly dependent on dominant players and consequently, wish to remain more autonomous. Organisations that have a certain level of autonomy in the chain do not suffer from the lack of information from others. Munkvold (2005) adds that challenges in adoption of e-collaboration increase when the level of autonomy of the organisation rises. As a result, the second hypothesis in this research is the following;

H2. The autonomy of an organisation is negatively related to the IOS maturity in an organisation.

2.6.2 Complexity of IOS solutions

Ensuring that technical compatibility with partners is possible beforehand is crucial for a successful IOS integration (Mottaghian, 2004). When creating an interorganisational collaboration with a single partner or when the transactions are limited to shipping orders and invoicing then IOS integration may be relatively easy (Rajaguru & Matanda, 2013). When expanding to multiple partners and more diverse transactions, the complexity can increase by a rising number, and heterogeneity of, used hardware, software, protocols and practices in information solutions (Klein & Rai, 2009). The design approach of legacy information systems often does not prepare for adding complex functionality in the future (BCS/RAE, 2004), such as adding custom interorganisational communication. To allow systems to be more flexible in the future design approaches like architectures, modularity or standards are used to reduce this complexity (e.g. Baldwin and Clark, 2000).

In small and medium enterprises 'Enterprise resource planning' (ERP) systems are often used to integrate business processes. Research by Hendricks, Singhal and Straman (2007) shows that especially these ERP systems are a limitation to allowing interorganisational information exchange and collaboration. These systems have been designed and implemented to serve an intra-organisational purpose, and custom functionality was often added over the course of several years. Changing these systems to face outwards require a (costly) redesign to accommodate these collaboration features. This leads to the third hypothesis of the current study;

H3. The complexity of an IOS in an organisation is negatively related to the IOS maturity in an organisation.

2.6.3 Size of the organisation

Rajaguru & Matanda (2011) claim that the benefits for SCM activities can vary significantly between small and large organisations. Larger organisations are likely to be more capable of adopting innovations because of larger financial resources and scale advantages, but they also perform better in the integration- and use of IOS (Cox, Mowatt, & Prevezer, 2003; Zhu & Kraemer, 2005). In small- and medium enterprises a single employee is often dedicated to system maintenance and development while in large organisations teams of specialist have the responsibility to improve collaboration through the information system. Large organisations are also more likely to have transactions that better suit the interorganisational dimension (Geri and Ahituv, 2008). Furthermore, Teo et al. (2009) argues the size of the organisation has a significant positive effect on the adoption of e-procurement. Based on the expected positive effects for larger organisations, the fourth hypothesis is proposed:

H4. The size of an organisation is positively related to the IOS maturity in an organisation.

2.6.4 Importance of data synchronisation

With data synchronisation, this study refers to the digital exchange of information between two or more organisations. The organisations synchronise their data records from one system to another. The importance of data synchronisation can manifest in two ways: it can be a requirement for executing day to day activities and it can be in a form of perceived importance by the management of the organisation.

Organisations that keep products in stock require stock information for in time replenishment to ensure product availability. An example is organisations that participate in VMI that require sales information to be exchanged to arrange in time replenishment (Vigtil, 2007). The importance of data synchronisation in day-to-day activities are also proven by an established competitive advantage with this information (Mentzer et al., 2001) by for example reducing the logistics costs and enhancing the value delivered to the customer (e.g. Brewer and Speh, 2000; Cooper *et al*., 1997). The degree of importance for digital data synchronisation ultimately depends on the number of stock keeping units (SKUs). When the number of SKUs is low, the information exchange can also be executed manually by telephone or fax (Waller, 1999) and when security stocks are high, the update frequency becomes less important.

Importance can also be a perceptual measure where the level of importance that management assigns to data synchronisation is based on the possible gain in benefits or competitive advantage. The perceived importance can be limited by barriers for

implementation including an unwillingness to promote another organisation for the good of the supply chain, resistance from employees, lack of tangible- and intangible resources and deficiency of management comfort (e.g. Mentzer et al., 2000). Higginson and Alam (1997) argue that commitment to SCM by top management is a key component to successful implementation. This commitment also requires trust by confidently relying on an exchange partner (Moorman et al., 1993) and to increase the importance placed on information exchange in each relationship between organisations (Geyskens et al., 1998). Research by Moberg, Cutler, Gross and Speh (2002) shows that commitment is more important than trust for fostering strategic information exchange. The mentioned barriers should eventually be outweighed by the possible benefits to allow higher levels of perceived importance by the management.

The requirement for data synchronisation and the perceived importance of data synchronisation for achieving IOS maturity leads to the fifth and final hypothesis;

H5. The importance of data synchronisation for an organisation is positively related to the IOS maturity in an organisation.

2.7 Conceptual model

These hypotheses lead to the following conceptual model for this study

Conceptual model

Independent variable ***Dependent variable***

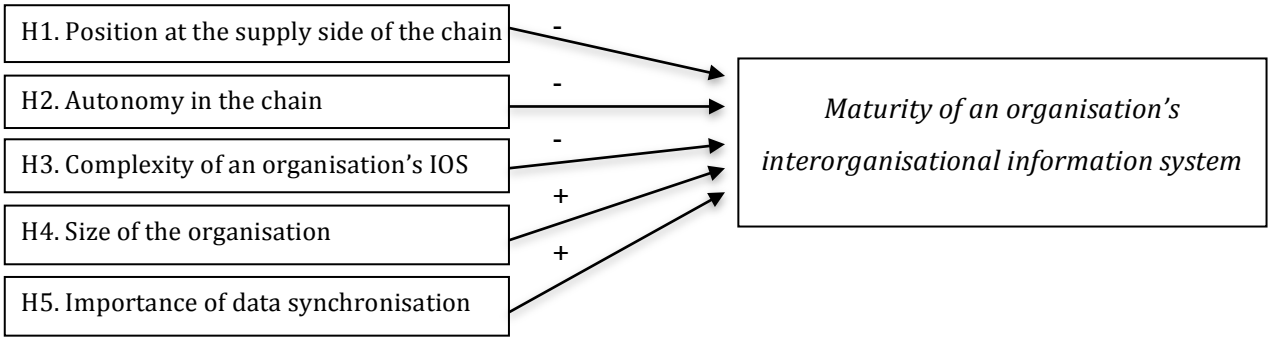


Figure 1. Conceptual model

Note that the direction of the correlation is negative for hypotheses 1, 2 and 3, whereas the direction of the correlation is positive for hypotheses 4 and 5.

2.8 Specific research objective

This research assesses how position in the chain can help explain the variance in IOS maturity. It assesses whether size- and autonomy of the organisation, complexity of IOS and the importance of data synchronisation relate to the maturity in IOS. The result is the level of correlation and the degree of explained variance of IOS maturity by the independent variables.

Chapter 3. Methodology

In this chapter, the research design and approach are explained. It describes the chosen research strategy, how variables are measured and how the selection of instances has been done. Finally, it discusses how data was collected and which analyses are performed on the data.

3.1 Research strategy

This research is designed as a theory-testing research. The maturity of IOS and the position in the supply chain are the major variables that require testing, but several other variables that can influence the maturity of IOS have also been proposed. The variables used in this study do not necessarily comprise an exhaustive list. The hypotheses have been formulated as a probabilistic relation between the dependent and independent variables. A probabilistic relation is defined by Dul and Hak (2008) as a relation in which, on average, both A and B increase or decrease at the same time. It assumes that if A is higher that it is likely that B will be higher. Considering that a large number of instances can provide sufficient data to distinguish existing variations between organisations, the strategy used in this study is a survey.

3.2 Survey

Using a survey in the form of a questionnaire that allows answering on an ordinal scale has provided an efficient approach to the collection of data from a large group of organisations. The use of a questionnaire could have affected the validity of the results due to raised social desirability bias or acquiescence bias (agreeing with statements as presented). In this study, the hierarchical relation between customer and supplier could potentially have added to the biases. Suppliers might have felt the need to give more positive answers to retain the relation with their customer. While individual results are not shared with other organisations, all results are visible to one wholesale organisation (Electrobot B.V., to be introduced later) that provided access to conduct this survey. The nature of the questions in this study did not involve giving personal opinions or exposing the (lack of) competitive advantage and therefore the distortion of data by biases in the answers is expected to be limited.

The approach of this survey can be summarised by the following steps:

1. Building a measurement model and questionnaire
2. Determining population and sample selection
3. Pilot interview (1 expert)
4. Pre-test (4 organisations)
5. Collection of sample (72 organisations)

3.3 Measurement

To ensure that reliable and valid concepts are developed for testing in this survey, the formulation of the concepts in this study follow a method by Dul and Hak (2008). They provide a methodological framework for the formulation of reliable and valid measurements in the intended object of study, which is based on an article by Adcock and Collier (2001). Their approach consists of the following steps:

" *1. Formulate a precise definition of the concept;*
2. Determine the object of measurement;
3. Identify the location of the object of measurement;
(not the same as the object of study)
4. Specify how evidence of the value of the variable will be extracted from the object of measurement;
5. Specify how sources of evidence will be identified, selected and accessed;
6. Specify how evidence will be recorded;
7. Specify how data will be categorised; " Dul and Hak (2008)

Following this approach resulted in a measurement protocol. Whether 'real-world' validity can be achieved in this study remains to be observed. This is a study in social sciences where researchers like Rossiter (2011) claim that aiming at high internal consistency and reliability is not enough to provide for 'real-world' validity. The above-described steps do have many parallels with Rossiter's approach to design highly content-valid measures of the constructs.

Table 1. Summary of measurement protocol, Independent variables

Concept	Measurement	Reference	Scale
1. IOS Maturity The level of capability in an organisation to perform interorganisational information exchange.	*See Table 2.*	*Plomp, 2010; Plomp, 2012*	5P Likert
2. Position in the chain The relative upstream- or downstream position of an organisation in the supply chain.	Supply finished products B2B	This study	Category: retailer, wholesaler, supplier
	Purchase finished products B2B		
3. Autonomy The level of freedom for an organisation to make its own decisions without depending on dominant players in the chain.	Freedom to make its own decision and allocation of internal resources	*Child, 1972; Hambrick & Finkelstein, 1987; Munkvold, 2005*	5P Likert
	The (lack of) dependence on dominant players		
4. Complexity of IOS The level of difficulty to upgrade and adapt the functions in an organisation's IOS architecture.	The upgradeability of IOS	*Hendricks, Singhal and Straman, 2007*	5P Likert
	The architecture of IOS	*Baldwin and Clark, 2000; BCS/RAE, 2004*	
	The adaptability of IOS	*See pre-test Appendix A., Klein 2016*	
5. Size The number of registered employees in an organisation.	The number of employees	*Cox, Mowatt, & Prevezer, 2003; Zhu & Kraemer, 2005; Geri and Ahituv, 2008; Teo et al., 2009, Rajaguru & Matanda, 2011*	Integer; Log(Size) & Category: 1 - 9 Micro, 10 - 49 Small, 50+ Medium and Large
6. Importance of data synchronisation The level of awareness of the requirement- or competitive advantage regarding data exchange processes in an organisation.	The requirement for data exchange	*Vigtil, 2007*	5P Likert
	The use of data synchronisation to improve service levels and competitive advantage.	*Cooper et al., 1997; Brewer and Speh, 2000; Mentzer et al. 2001*	

The summary in table 1. explains how the dependent variable, Concept 1. IOS Maturity, is affected by the independent variables concept 2. to concept 5. and how they are measured. The full measurement protocol is described in Appendix C.

It should be noted that the importance of data synchronisation could be perceived as having endogeneity with IOS maturity. This means that, when there is more importance of data synchronisation, the capabilities in IOS will automatically be higher. However, having awareness of data synchronisation does not automatically mean that financial- or

human resources are available or dedicated towards improving IOS. This can manifest by financial resources that cannot be acquired, employees lack of capabilities and when importance of data synchronisation is not embodied in the collective vision of the management. Because of these differences, endogeneity is rejected.

Table 2. Detailed measurement of dependent variable

Concept	Dimensions	Sides	Measurement
1. IOS Maturity	**Organisational Dimension**	**Demand Side**	Contracting and evaluation Strategic planning Proces Optimisation Product development
		Supply Side	Contracting and evaluation Strategic planning Proces Optimisation Product development
	Technological Dimension	**Demand Side**	Ordering Payment Invoicing Sourcing Forecasting
		Supply Side	Sales Invoicing Forecasting Product development Logistics

The IOS maturity score is calculated by adding up all measurement scores. For example:

Organisational Dimension	Demand Side	
Organisational Dimension	Supply Side	
Technological Dimension	Demand Side	
Technological Dimension	Supply Side	+
1. IOS Maturity		

Alternatively, 'Technological Demand Side' and 'Technological Supply side' can also add up to a 'Technological IOS Maturity Score', and consequently:

Technological IOS Maturity = Tech. Demand Side + Tech. Supply Side

Organisational IOS Maturity = Org. Demand Side + Org. Supply Side

Demand Side IOS Maturity = Org. Demand Side + Tech. Demand Side

Supply Side IOS Maturity = Org. Supply Side + Tech. Supply Side

In addition to the total IOS Maturity Score, these different dimensions and sides of IOS Maturity are also used individually in the analyses to assess detailed effects of the independent variables.

3.4 Questionnaire

The questions for measuring the maturity of IOS through a questionnaire have been proposed by Plomp (2012). The face-validity of these questions has been tested by conducting a pilot interview with an expert on IOS. All questions were first formulated in English to find equivalent definitions as found in the literature review. The complete questionnaire was then translated to Dutch by the researcher. The translation is checked and verified by a native English friend who also masters the Dutch language.

Answers for the questionnaire are recorded through a 5-point Likert scale that vary from 'strongly agree' to 'strongly disagree' or from 'always' to 'never'. The only question that is open ended is about the size of the organisation and should be answered with a numeric value of the total number of employees in the organisation. Using the total number of employees instead of FTE's allows for better insight into how many physical users are using the information system. Filling out the questionnaire took approximately 15 minutes. The questionnaire is attached in Appendix D and E.

3.5 Population and sample selection

A complete supply chain like Consumer Electronics (CE) contains too many branches to realistically compare the organisations. To be able to find a sample of the population that actually use their interorganisational information systems with each other, this study chose organisations in the 'accessories' branch of the CE supply chain in the Netherlands as the population. The available positions in the chain can be organised into three categories: Supply side (suppliers, manufacturers), Supply and Demand (wholesalers and importers) and Demand Side (retailers and e-tailers).

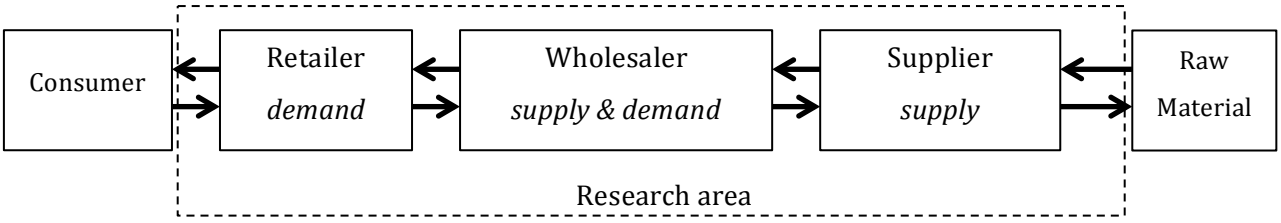


Figure 2. Simplified information exchange in the supply chain for CE

Retailer Physical retailers and e-tailers that share information through their website to potential consumers and are billed by trade organisations. Extended information sharing mainly exists on the demand side by using the trade organisations inventory and drop shipping products directly to the consumer

Wholesaler Trade organisations with information exchange on both demand- and supply-side. Not limited to one link in the chain but could also consist of multiple trade organisations buying and selling from each other.

Supplier Mainly focuses on supplying information to the trade organisations. Extended collaboration can be expressed by sharing product availability, by forecasting and by offering overstock discounts.

An organisation can also perform multiple of these supply chain functions at the same time. For example, a supplier can also sell its products directly to retailers in addition to selling to wholesalers. Organisations can also be a retailer in this chain and a wholesaler in another supply chain. This study uses the most prominent activity of the organisation in the accessories branch of the CE supply chain for determining the organisations position.

3.5.1 Population

CBS provides the following numbers of organisations in business as of Q1 2016 in relation to the population of this study.

Table 3. Number of organisations in the Netherlands Q1 2016 tentative (CBS Statline, 2016)

Group	Type	# Organisations
Retailer	Physical retail stores in consumer electronics	975
	Online stores in consumer electronics	1980
Wholesaler	Wholesale in large household appliances	210
	Wholesale in small household appliances	320
	Wholesale in consumer electronics	645
	Other Electro technical/IT wholesale	*
Supplier	Consumer electronics industry	200
	Other manufacturers for steel/plastics	*
	Foreign manufacturers through sales offices	*

** Number of organisations is not available because there is no clear line which organisations are part of the CE supply chain.*

While the figures for retailers and wholesalers are likely to accurately represent the population it should be noted that several electro technical- and IT wholesale organisations also sell audio-/video- related products. However, the number of organisations of this type and their market share are limited.

Estimating how many manufacturers in CE are based in the Netherlands is difficult, as some of them have their production abroad. These organisations have sales offices in the Netherlands but these are not always registered under CE Industry to CBS. In addition, there are many other types of manufacturers such as for steel or plastic accessory products. Therefore, no accurate estimate on the number of manufacturers can be indicated.

3.5.2 Access to instances

The instances were selected from a database from a profitable trade organisation (Electrobot B.V.) in CE accessories. This ensured the connection of all selected organisations across the three categories. Additionally, Electrobot B.V. served as an entrance to get access to the representatives of organisations such as CEO's and managers who have the knowledge to provide the information required for this questionnaire.

Electrobot B.V. was established in 1968 and can be described as an international wholesaler and manufacturer of audio- and video- accessories. Electrobot B.V. currently has 17 employees and is based in Nieuw-Vennep, The Netherlands. About 70% of the total revenue is generated from organisations in the Netherlands. About 80% of the purchasing comes from organisations that master the Dutch language. To avoid bias by translation errors the language of the questionnaire is in Dutch. Only representatives from organisations that master the Dutch language are asked to participate.

3.5.3 Sample

The organisations for the sample were manually selected and they are randomised based on the expected number of employees. This carefully selected sample is still considered non-random but this approach is necessary to allow access to a large number of organisations through the organisation's business network. When this study sums up to a single supply chain maturity score, this number of instances should be weighed according to the number of demand, demand/supply and supply side organisations within the actual chain. The number of Dutch wholesale- and supplier organisations in the accessories branch is limited. Therefore, the total number of respondents (58) is the best possible result for this population.

Retailers in this sample include the second largest brick-and-mortar CE retailer in the Netherlands (BCC) and the two biggest CE and appliances e-retailers in the Netherlands (Bol.com and Coolblue). On the purchase side, large multinationals such as Panasonic, Miele and Procter & Gamble have responded. The largest CE trade organisation in the Netherlands (Amacom) is also included in the respondents. In contrast to these large organisations many micro- (1-9 employees) and small- (10-49 employees) organisations have been included in this study.

3.6 Pilot, pre-test and collection of sample

Pilot interviews

By performing a pilot interview potential problems and future errors in this research were identified and eliminated (Bryman & Bell, 2011). A pilot interview has reduced acquiescence bias and allowed the researcher to evaluate the face validity and reliability of the survey. The pilot involved an interview based on the questionnaire conducted with an expert representative from the population to assess the inaccuracies and gaps. The questionnaire was then modified according to the identified areas of improvement. The results of this pilot interview can be found in the report in Appendix A.

Pre-test

The improved questionnaire was then pretested to 4 respondents to make sure the quality of the full sample allowed for the intended statistical analysis and to see if other flaws appear. Pre-test respondents were observed while completing the questionnaire to check for readability, understandability and other unclarities. After completion the questionnaire was used to discuss the face validity. The results from this pre-test can be found in Appendix B. Adjustments were made to the questionnaire based on the received feedback. After processing all feedback from pilot and pre-test the collection of data for the sample was initiated.

Collection of sample

All selected organisations were contacted personally by phone to either schedule a physical appointment or to give instructions on how to participate. The questionnaire was then sent out digitally using Google Forms but to improve the response rate it was also available on paper (12 paper questionnaires have been processed). The person who answered the questionnaire on behalves of the organisation needs the knowledge and overview of the processes associated with

information exchange and collaboration along with the IT-based solutions that facilitate them. This person could, for example, be an SCM-employee, system administrator or manager.

A list of carefully selected organisations was created prior to sending out the questionnaires to keep track of the non-response bias. A total of 58 responses have been received out of 72 sent questionnaires. Organisations have been contacted several times and the reasons for not returning the questionnaire were 1. Time constraints (3x), 2. Forwarded to a colleague who has more knowledge, no response (3x) and 3. Not interested / other (8x).These reasons for non-response are not expected to have affected the results.

3.7 Data analysis

First, the data was cleaned by identifying coding errors, outliers and logical consistency of answers. When values were missing, the representative was contacted to supply these answers. All representatives were able to supply the missing answers. There are no missing values in the dataset and none of the responses have been removed from the dataset either.

All analyses are performed in 'R'. By using 'R' all calculation scripts can be easily documented and shared. 'R' also allows for extensive graphical output for the results section. It was expected that CFA or SEM had to be used and 'R' has packages available to perform these analyses.

Individual relationships between all constructs were determined using Spearman's correlation. Spearman is being used because the answers are ranked on an ordinal scale. The means and standard deviation for the variables are assessed. A multiple regression analysis with all variables results in evidence for the effect size of the independent variables on the dependent variable. The results are assessed on generic effects that independent variables have on IOS maturity, but also specific effects for the maturity of smaller groups in size- and position categories. To check for correlation between independent variables the results were tested for multicollinearity using the Variable Inflation Factor (VIF) and on Heteroscedasticity with a Breusch-Pagan test. Cronbach's alpha values are not calculated because all independent variables are based on formative constructs. The size of the questionnaire is already comprehensive and therefore raising the number of questions is undesirable.

Maturity scores are individually plotted for the organisational- and technological dimensions, the organisation types and the organisation sizes to identify trends in the results.

Chapter 4. Analysis

This chapter reports the results of the survey. Descriptive analyses are provided first to define the outline of this study. Then, through multiple regression the effect size of the individual variables is assessed. The effects of the independent variable for 'position in the chain' are reported in more detail to show the effect size for each of the positions: retailer, wholesaler and supplier. A short conclusion links these findings to the hypotheses in this study.

4.1 Descriptive analytics

Data was collected from 58 respondents distributed across three positions in the supply chain and from three different sizes of organisations.

Table 4. Summary of respondents

		Responses per category			
	# Employees	**Retailer**	**Wholesale**	**Supplier**	**Total**
Micro	**1 - 9**	18	9	2	29
Small	**10 - 49**	8	4	7	19
Medium & Large	**50+**	3	2	5	10
Total		29	15	14	N=58

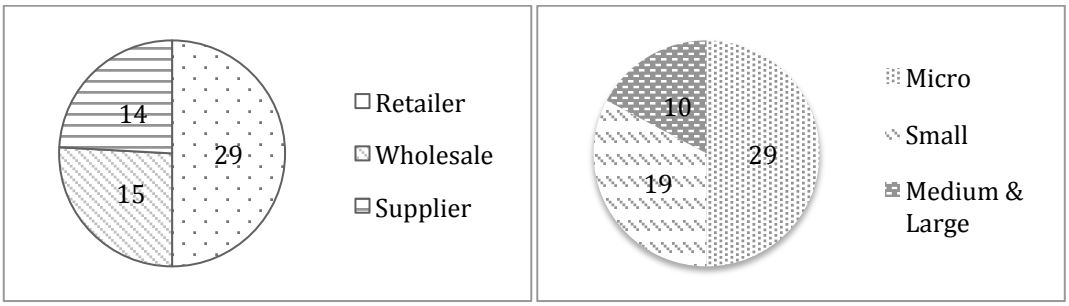


Figure 3. Pie charts of respondent distribution

80% of these respondents are members of the senior management team such as owners, chief officers and store managers. The other 20% consist of account managers or developers who have access to the correct information. All of them are considered sufficiently competent to have answered the questions in the survey correctly.

4.1.1 Outliers

The dataset has been tested for outliers by creating boxplots for each scale and subscale. The only variable that could be affected by outliers is the number of employees in the organisation. A boxplot shows that 11 values are considered as outliers. All values can be found in the 'Medium & Large' category except for one, which is the largest organisation of the 'Small' category. Neither of these values has affected the findings because the number of employees is only used as a logarithmic function or as a categorised variable as seen in table 5.

4.1.2 Correlation matrix, means and standard deviations

In table 5 all correlation coefficients are plotted along with their significance stars. In this correlation matrix, all dimensions and combinations are plotted to provide detailed insight into all dimensions and variations in size and positions in the chain. The maturity score and all of its dimensions are sums of each other and their correlation scores are therefore irrelevant in the matrix. They are listed for their mean- and S.D. scores and to see how they correlate with the independent variables. The results in the correlation matrix provide several significant results in both the general and specific regions.

Generic correlations

The importance of data synchronisation significantly correlates ($P < 0.001$) with all dimensions of maturity. With a coefficient of 0.36 to 0.55, the effect size is considerable. The direction of the relation is positive which means that when the importance of data synchronisation increases the maturity of IOS also increases.
The effect caused by the complexity of IOS is also significantly correlated ($P < 0.001$) with the technical dimensions of the IOS maturity on both the supply- as the demand side of organisations. In line with the formulated hypothesis, the effect of complexity of IOS seems to be negatively correlated with a coefficient between -0.27 and -0.37 with IOS maturity. This means that organisations with more complex information systems have lower IOS maturity scores.

Autonomy does not show robust significant correlations but does reveal a correlation at $P < 0.05$ with the organisational dimension of the demand side of organisations. And although insignificant, this negative correlation is also visible across all other dimensions of the maturity of IOS.

Correlations on specific categories

Size as a logarithmic value shows significant relations with maturity. For the correlation matrix, the categories for size and position are combined into 9 different categories to allow for more detail in the analysis. This approach leads to several significant correlations:

1. The medium/large supplier has the most and largest significant correlations with the maturity of IOS. With a correlation coefficient of 0.40 at $P < 0.01$ they seem to achieve higher levels of maturity compared to other categories. Correlations exist on all dimensions of maturity, although correlation on the technological dimension is not considered significant at the $P < 0.05$ level.
2. Medium/large wholesale organisations also have a positive correlation with the maturity of IOS on the supply side of the technological dimension with a coefficient of 0.29 at $P < 0.05$ and this also results in a significant correlation with the maturity of IOS with a coefficient of 0.30 at $P < 0.05$. This implies that medium/large wholesale and supplier organisations achieve higher maturity levels compared to all other categories.
3. The micro wholesale organisations have a significant correlation of 0.37 ($P < 0.01$) with the complexity of their information systems. They show lower levels of the importance of data synchronisation at -0.28 at $P < 0.05$. This means that micro wholesale organisations have a lower importance of data synchronisation and a higher complexity of their information system.
4. Small retailers have a negative correlation with the maturity of IOS on the supply side of the organisational dimension with a coefficient of -0.28 at $P < 0.05$.
5. Micro suppliers have a negative correlation with the maturity of IOS on the supply side of the technological dimension with a coefficient of -0.31 at $P < 0.05$. This effect is not considered robust because it does not lead to any correlation in the higher level dimensions such as the maturity or in the technological dimension.
6. Medium wholesale organisations significantly correlate with autonomy (0.27, $P < 0.05$) and medium/large retailers significantly correlate with importance of data synchronisation (0.28, $P < 0.05$)

Table 5. Descriptive statistics and spearman correlations for relevant variables

	Variable	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12
1	IOS Maturity	88.948	21.466	48	129												
2	Technological dim.	55.586	11.231	34	76	0.88***											
3	Organisational dim.	33.362	12.692	14	56	0.91***	0.61***										
4	Demand side	45.724	11.866	17	68	0.91***	0.78***	0.86***									
5	Supply side	43.224	11.66	19	66	0.91***	0.83***	0.80***	0.66***								
6	Tech. Demand side	28.172	6.093	10	38	0.75***	0.80***	0.55***	0.86***	0.50***							
7	Org. Demand side	17.552	7.335	7	35	0.86***	0.60***	0.92***	0.90***	0.66***	0.56***						
8	Tech. Supply side	27.414	7.317	10	40	0.73***	0.87***	0.47***	0.48***	0.86***	0.40**	0.45***					
9	Org. Supply side	15.81	6.536	7	31	0.80***	0.51***	0.90***	0.65***	0.82***	0.45***	0.67***	0.42**				
10	Autonomy	3.44	0.671	2.25	5	-0.23	-0.15	-0.27*	-0.23	-0.20	-0.17	-0.22	-0.09	-0.26*			
11	Importance Datasync	3.263	1.175	1	5	0.55***	0.54***	0.45***	0.48***	0.52***	0.39**	0.45***	0.51***	0.36**	-0.21		
12	Complexity of IOS	2.541	0.853	1	5	-0.33*	-0.37**	-0.23	-0.25	-0.35**	-0.27*	-0.19	-0.34**	-0.23	0.06	-0.36**	
13	Log(size)	2.613	2.059	0	11.7	0.50***	0.45***	0.44***	0.45***	0.46***	0.33*	0.45***	0.41**	0.36**	-0.11	0.38**	-0.06
14	Micro Retailer	0.31	0.467	0	1	-0.18	-0.05	-0.26*	-0.18	-0.15	-0.04	-0.26	-0.05	-0.22	0.24	0.09	-0.23
15	Micro Wholesale	0.155	0.365	0	1	-0.16	-0.22	-0.09	-0.11	-0.19	-0.11	-0.09	-0.24	-0.07	-0.09	-0.28*	0.37**
16	Micro Supplier	0.034	0.184	0	1	-0.10	-0.21	0.02	-0.03	-0.16	-0.02	-0.03	-0.31*	0.06	-0.23	-0.12	-0.08
17	Small Retailer	0.138	0.348	0	1	-0.26	-0.18	-0.27*	-0.24	-0.23	-0.19	-0.22	-0.11	-0.28*	0.06	0.09	0.22
18	Small Wholesale	0.069	0.256	0	1	0.16	0.21	0.08	0.15	0.14	0.17	0.10	0.18	0.04	-0.10	-0.09	-0.13
19	Small Supplier	0.121	0.329	0	1	0.03	-0.08	0.11	-0.05	0.09	-0.16	0.06	0.02	0.15	0.07	-0.20	-0.07
20	Medium Retailer	0.052	0.223	0	1	0.16	0.20	0.09	0.19	0.10	0.16	0.18	0.17	-0.02	-0.10	0.28*	0.07
21	Medium Wholesale	0.034	0.184	0	1	0.30*	0.28*	0.26	0.24	0.31*	0.17	0.25	0.29*	0.22	-0.27*	0.20	-0.23
22	Medium Supplier	0.086	0.283	0	1	0.40**	0.28*	0.43***	0.36**	0.37**	0.25	0.37**	0.23	0.41**	0.05	0.14	-0.02

Greyed out values are irrelevant because they are summations

Dummy values indicating % response per category

N = 58 significance * p ≤ .05 ** p ≤ .01 *** p ≤ .001

4.2 Statistical tests

Based on the correlation matrixes and correlation plots several tests have been executed to verify the results.

4.2.1 Interaction effects

In the correlation plot a significant negative relation can be identified between the variables for data synchronisation and complexity (-0.36, P < 0.01). All variables have been standardised and a multiple regression has been performed to test for interaction effects between the three independent variables: autonomy, importance of data synchronisation and complexity. No significant interactions can be identified.

Then, size and position were introduced to the interaction plot. This resulted in a significant interaction for Log (size) and Wholesale with the importance of data synchronisation. Then a two-way ANOVA was conducted that identified the effect of Log (size) and the importance of data synchronisation. There was a statistically significant interaction between the effects of Log (size) and the importance of data synchronisation, F (1, 54) = 1.976, p = .01655. Another two-way ANOVA for the interaction effect of wholesale and the importance of data synchronisation did not result in a significant interaction.

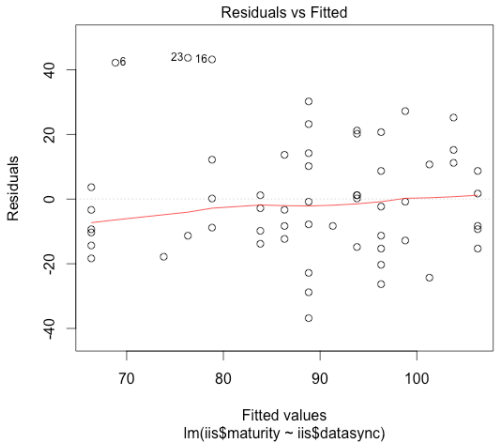
The table with the regression and the ANOVA analysis can be found in Appendix F.

4.2.2 Heteroscedasticity

Based on a visual inspection of residuals plotted against fitted values for IOS maturity and the importance of data synchronisation, heteroscedasticity might occur. Performing a studentised Breusch-Pagan test on this scale results in:

BP = 1.4228, df = 1, p-value = 0.2329.

With a P value at 0.2329, the possibility of heteroscedasticity can be rejected.



4.2.3 Multicollinearity

To test for multicollinearity the Variance Inflation Factor (VIF) has been calculated. VIF measures how the variance of the estimated regression coefficients is increased in comparison to variables that are not linearly related. VIF values between 1 and 5 suggest that the variables are moderately correlated.

Table 6. Test for multicollinearity

Variable	VIF
Autonomy	1.180729
Data sync	1.682329
Complexity	1.199296
Small	1.261143
Medium	1.622613
Retailer	2.178061
Wholesale	1.843875

4.3 Hierarchical regression

A multiple regression is performed on the proposed conceptual model in this thesis. The independent variables for autonomy and complexity both do not explain significant shares of the variance in this model with a combined adjusted R-squared of 0.123. Adding the variable for data synchronisation to the first model in the multiple regression does help for explaining the variance in maturity. Based on the correlation matrix it is expected that adding the categories for size (model 2) and position in the chain (model 3) to the regression increases the explained variance for the dependent variable.

The results for the multiple regression have been plotted in table 7. Based on these results it is expected that the hypothesis for autonomy and complexity are insignificant and therefore can be rejected. However, the size and position in the chain might be able to explain in more detailed whether the effects of autonomy and complexity can be found on specific categories. The variables for the importance of data synchronisation, size and retailer all have significant effects to explain the variance in maturity.

Table 7. Hierarchical regression model

	Dependent variable:		
	IOS Maturity		
	(1)	(2)	(3)
Autonomy	-4.030	-3.691	0.005
	(3.637)	(3.379)	(3.248)
Data sync	8.495***	5.910**	9.045***
	(2.221)	(2.225)	(2.218)
Complexity	-3.854	-4.598	-3.764
	(2.996)	(2.792)	(2.588)
Log(Size)		3.626***	2.821**
		(1.169)	(1.176)
Retailer			-15.150***
			(5.615)
Wholesale			2.253
			(6.210)
Constant	84.885***	84.570***	68.607***
	(18.754)	(17.415)	(16.775)
Observations	58	58	58
R2	0.334	0.436	0.555
Adjusted R2	0.297	0.394	0.502
Residual Std. Error	17.998 (df = 54)	16.713 (df = 53)	15.142 (df = 51)
F Statistic	9.028*** (df = 3; 54)	10.259*** (df = 4; 53)	10.591*** (df = 6; 51)
Note:			*p<0.1; **p<0.05; ***p<0.01

4.4 Detailed multiple regression on position

By proposing three new models: retailer, wholesaler and supplier category-specific effects can be identified.

Table 8. Multiple regression on categories for position

	Dependent variable:		
	IOS Maturity		
	Retailer	Wholesale	Supplier
Autonomy	1.692	-16.244	1.646
	(3.996)	(11.284)	(6.086)
Datasync	11.377***	-1.740	13.394**
	(2.896)	(5.145)	(4.591)
Complexity	-1.955	-3.538	-1.576
	(4.544)	(4.753)	(7.356)
Log(Size)	1.128	9.192**	2.027
	(1.783)	(4.076)	(1.839)
Constant	38.577	140.681**	47.601
	(23.979)	(46.126)	(33.474)
Observations	29	15	14
R2	0.518	0.658	0.668
Adjusted R2	0.437	0.521	0.521
Residual Std. Error	13.996 (df = 24)	16.858 (df = 10)	14.839 (df = 9)
F Statistic	6.436*** (df = 4; 24)	4.814** (df = 4; 10)	4.536** (df = 4;9)
Note:			*p<0.1; **p<0.05; ***p<0.01

The results in table 8 again fail to identify a significant relation between the independent variables for autonomy and complexity with the dependent variable. Based on the correlation and regression models these hypotheses:

H2. The autonomy of an organisation is negatively related to the IOS maturity in an organisation.

H3. The complexity of an IOS in an organisation is negatively related to the IOS maturity in an organisation
both are rejected.

The importance of data synchronisation shows significant correlation and improves the adjusted R-squared considerably. For this reason, hypothesis 5: "*H5. The importance of data synchronisation for an organisation is positively related to the IOS maturity in an organisation.* " is accepted.

4.5 Plot of maturity levels

To create an overview the maturity levels in the organisational and technological dimension are recoded to a value between 1 and 5 by dividing the maturity score by the number of questions in that category (Technological / 20, Organisational / 14). These values are plotted in figure 5.

Few organisations can manage to achieve a high organisational maturity score without first acquiring a higher technological maturity score. Only one organisation achieved a technological maturity score higher than 3 without achieving an organisational score of 2 or higher.
None of the companies has achieved a score in the highest 20% of either dimension, even though key players in this market have been included in this study.

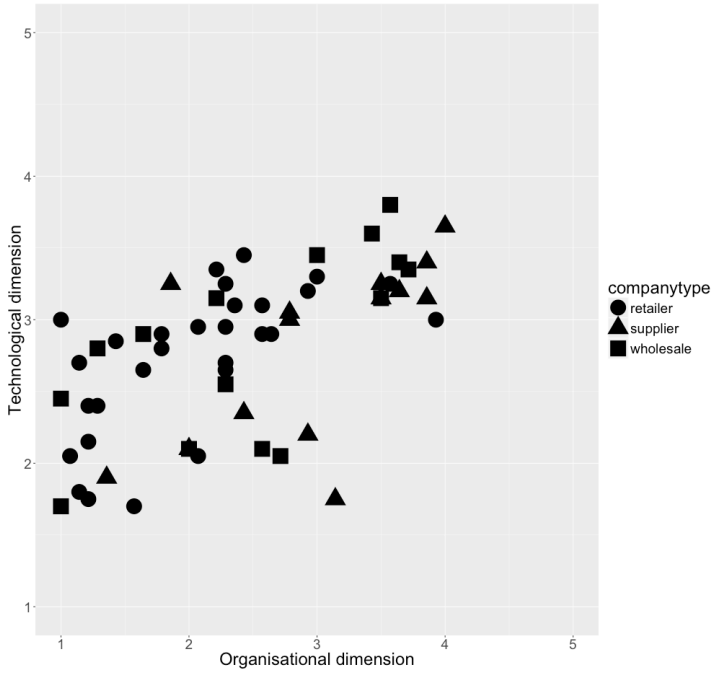


Figure 5. Maturity plot in two dimensions

A more detailed look at the distribution of maturity scores along the positions in the supply chain can be found in the boxplot in figure 6. While the hypothesis was formulated negatively, expecting that suppliers have a lower maturity compared to wholesalers and retailers, this boxplot proves otherwise. All values, Means, SD etc. are increasing for positions located at the supply side of the chain.

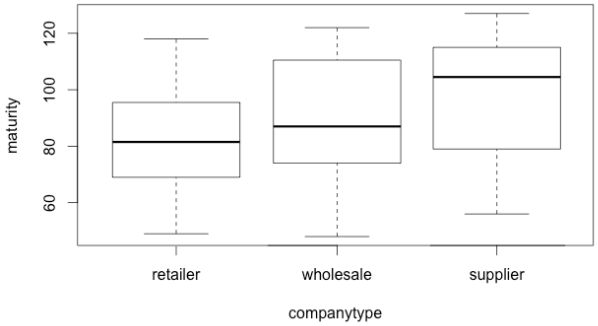


Figure 6. Boxplots maturity and position

For that reason hypothesis 1: "*H1. The position at the supply side of the supply chain is negatively related to IOS maturity in an organisation."* is rejected.
A significant effect exists, but the effect is in the opposite direction.

The same approach for the categories of size is plotted in figure 7. This figure shows that when organisations have more employees, the maturity score also increases. The differences between micro- and small organisations are fairly small, but the score and min/max values for medium/large-sized organisations are considerably higher. This and the significant correlations lead to accepting hypothesis 4: "*H4. The size of an organisation is positively related to the IOS maturity in an organisation."*

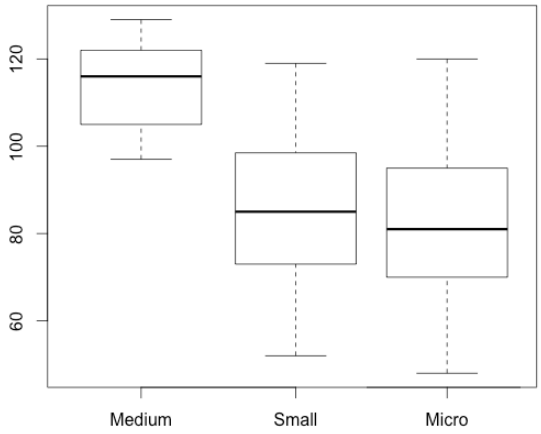


Figure 7. Boxplots maturity and size

4.6 Summary of results

REJECTED* *H1. The position at the supply side of the supply chain is negatively related to the IOS maturity in an organisation.*

**There is a significant effect, but it is facing in the opposite direction.

REJECTED *H2. The autonomy of an organisation is negatively related to the IOS maturity in an organisation.*

REJECTED *H3. The complexity of an IOS in an organisation is negatively related to the IOS maturity in an organisation.*

ACCEPTED *H4. The size of an organisation is positively related to the IOS maturity in an organisation.*

ACCEPTED *H5. The importance of data synchronisation for an organisation is positively related to the IOS maturity in an organisation.*

Chapter 5. Discussion and conclusion

In this chapter, the findings in relation to their theoretical assumptions are discussed. Then the limitations of this research approach are assessed, followed by the evaluation of suggestions for future research. Implications for theory and practice are reported prior to finishing this research study with a final conclusion.

5.1 Discussion

The goal of this research was to contribute to the existing theory on interorganisational information systems maturity. This contribution is manifested by a quantitative analysis on how the position in the chain adds to the explained variance of the IOS maturity. Based on literature it was argued that IOS maturity consists of an organisational dimension and a technological dimension that is affected by position in the supply chain and other independent variables.

The findings in this research reject the hypothesis that an organisation on the supply side is negatively related to the IOS maturity in an organisation (H1), but only because the direction of this relation proved to be in the opposite direction. Correlation coefficients and multiple regression show significant results and therefore the position in the supply chain adds a convincing new dimension on explaining the variance in IOS maturity. Not retailers, but rather suppliers achieve higher IOS maturity scores and this effect can be best explained by re-evaluating the interpretation of the costs induced on the suppliers. As claimed by Osegowitsch and Madhok (2003) customers concentrate more on their own competencies and they rely on their suppliers for providing information solutions. Instead of seeing this as a burden the suppliers could instead use this as an opportunity to gain a competitive advantage by providing these services instead of declining to raise their costs structure.

Another way to explain the inverted direction of the effect is the history that suppliers have with more complex system integration and automated exchange of information through Electronic Data Interchange (EDI). The EDI format has been used for over 40 years to improve operational processes and the implementation of EDI is more applicable to suppliers than to retailers. Current development in XML information exchange only requires an adjustment in the protocols used while maintaining all processes for information exchange that are already in place. The type of transactions that a supplier

exchanges can also be more suitable for integration, due to its industrial suppliers- and customers and their larger scale.
This does not mean that retail organisations cannot achieve high maturity scores, but on average these organisations perform less than the supplier category. The wholesale organisations only do slightly better in their maturity scores than retailers.

The effect of the importance of data synchronisation on IOS maturity also shows a compelling relation. In all dimensions and categories, significant results are reported to support this hypothesis (H5). An important note is that the importance is measured by the requirements of the organisations to use data synchronisation and the benefits by improving their business by data synchronisation. In this study, the perceived importance by the management and the barriers to implement data synchronisation are not measured. It may be concluded that in this study the technological dimension of the importance of data synchronisation was more thoroughly examined. The technological importance of data synchronisation can also be perceived as a synonym for the maturity or already 'performing' in IOS. Indeed, when organisations are already exchanging information with many of their partners, it becomes important to maintain that position. To maintain the position, it can be necessary to keep the flow of information going because systems are now programmed to learn and take action based on the exchanged information. The question to ask here is whether the information exchange is required to keep the business going or whether this could be seen as a process optimisation which can also be replaced by teaching employees to make (less-than-perfect) decisions based on internal forecasts. While sub-optimal, process optimisation can be replaced by more labour intensive processes and therefore maturity of IOS is not always parallel to the importance of data synchronisation. Having awareness of data synchronisation does not automatically mean that financial- or human resources are available or dedicated towards improving IOS. This skewness between maturity and importance can grow if financial resources cannot be acquired, the employees lack of capabilities or when importance of data synchronisation is not embodied in the collective vision of the management.

Based on the results, this study can also accept the effect of size on the maturity of IOS in organisations (H4). Combining the size of the organisation with the position in the chain allows for explaining the effect in more detail. By creating categories such as 'small retailer' and 'medium supplier' the effects of independent variables can be assigned to any of these specific groups. This prevents the dismissal of effects of variables when no

correlation can be found for the complete dataset. Not only does adding the independent variable for size of the organisation to the regression prove a significant relation, it also adds 0.122 to the adjusted R-squared and therefore strengthens the used model. While this significant relation exists, it may be difficult for micro organisations to achieve high maturity scores, but the boxplot in chapter 4 proves that these outliers do exist.

Two of the proposed relations of independent variables with IOS maturity are rejected because of insufficient statistical support. The complexity of IOS was expected to be negatively related to the maturity of IOS (H3). A negative correlation between these variables can be traced back to a relation between the complexity of IOS and the supply side of the technological dimension (-0.34 at $P < 0.01$). This single relation ultimately causes complexity to correlate to IOS maturity. However, when this result is assessed in a multiple regression analysis, a robust relation between the two variables cannot be justified. The absence of a relation could be due to the exponential innovation that exists in software development. The perceived availability of intelligent software to facilitate information exchange can satisfy the needs of organisations. An example is data brokers like Transus that offer services to automatically translate EDI, XML and other information messages to a format that the IOS on the receiving-side can integrate. This solves the need for multiple custom applications to do the translation from within the IOS. The proposed lock-in with their IT providers could therefore diminish and complexity is no longer perceived to be negatively related to IOS maturity.

The effect of autonomy on the maturity of IOS (H2) is also rejected. There are no signs that autonomy can explain any of the variance in IOS maturity. A possible explanation could be that dominant, and thus considered autonomous, organisations in the supply chain do not use their position to exclude other players in the chain. Instead of not suffering from the lack of information sharing, they benefit by promoting the use of their own protocol for information sharing. Besides, the posed challenge by Munkvold (2005) that autonomous organisations have to adopt e-collaboration could also manifest in a way where they can force adoption of their information protocol to the other players in the chain. The measures of 'autonomy' might also impact the outcome because dominant players are different than organisations that have no interorganisational relations at all. For example, an organisation that produces and sells handmade pottery is able to operate autonomously in a completely different perspective than the described dominant player in this study.

When assessing the theoretical value of this study, this research can be compared to prior research by Plomp (2012). Plomp proposed the model used for measuring IOS maturity and performed research to find maturity scores in several supply chains. The important differences between Plomp's (2012) study and the current study are that Plomp used 'chains' as a unit of analysis, data is collected from one organisation in each supply chain and that the scales of maturity scores were unknown and thus might be different to the scales used in this study. Furthermore, Plomp (2012) identified two other independent variables that, in addition to the ones used in this study, could also have an effect on IOS maturity: communication & collaboration (ability to collaborate) and interorganisational trust.

While the results by Plomp (2012) prove no existing relation between the variables for communication and trust, it does accept a relation for complexity and autonomy whereas this study rejects this relation. Plomp (2012) reports correlations for complexity with IOS maturity of -0.29 at a significance level of $P < 0.05$ and autonomy at the organisational dimension of IOS maturity at -0.38 at $P < 0.05$. When comparing this to the correlation matrix in this study, the coefficients for complexity is -0.33 at $P < 0.05$ and autonomy at the organisational dimension is -0.27 at $P < 0.05$. While these results are similar it is questionable to accept the hypothesis based on the above-mentioned results from Plomp (2012) alone. Plomp (2012) is not reporting any regression and that is where this study proves that the variance explained by these two variables is very limited. The results of this thesis show that researchers have to be careful to use the variables for complexity and autonomy in the CE supply chain. For research in other supply chains, these limitations should also be assessed.

Another finding through dividing the maturity of IOS into an organisational dimension and a technological dimension is the pattern of results shown in the scatterplot in chapter 4. The advantage of this study is that the results are based on individual organisations that are strongly connected within their supply chain and that for this reason a comparison between their scores is possible. When analysing the scatterplot it is to be observed that a necessary condition can exist on the organisational dimension to be able to achieve a higher level of technological maturity. With regard to the outliers, organisations need an organisational maturity score of 2 or higher to be able to exceed a technological maturity score of 3 or higher. It can be a necessary condition to have organisational

arrangements in place to be able to use the technological solutions at higher levels of maturity.

5.2 Limitations

While the results are generalised to organisations in the CE supply chain it must be stressed that the number of responses for size- and position categories are limited. While all possible wholesalers and suppliers were non-randomly contacted from the database, it does not mean that a census is achieved for the population. For example, the analysis of the micro supplier has n=2. The results of this study can be used to generalise the findings to the population, but it is not advisable to be used for a broader generalisation.

The constructs for autonomy, complexity and data synchronisation are all formative constructs and for that reason internal validity is questionable. To address this issue multiple questions for each measure could have been added, but at a current questionnaire size of 50 questions, it becomes difficult to find respondents that are willing to take the time to fill it out. Due to time constraints, this was not feasible for this study. While the face validity of the measures for these constructs has been assessed by the expert during the pilot interview, this does not guarantee a good fit with the construct.

The exploration of literature revealed two ways to assess the importance of data synchronisation. The requirements for doing business are addressed and measured in this study but the perception of importance by top management of the organisation has not been measured. Because the scope of this study did not allow to accommodate for this social approach, this dimension has been left out. Interpretation of the 'importance of data synchronisation' variable in this study should thus be perceived as the requirement of data synchronisation for doing business.

Many retailers in the CE supply chain appear to be connected to a retail chain or purchasing organisation, for example Electro world, Electronic Partners and Bang & Olufsen. About 50% of all retailers that responded are independent retailers; the others are part of several chains. The implications for these retail chains are that the initiatives and responsibilities for IOS (maturity), especially on the purchasing side often lie with the purchasing organisation instead of with the retailers themselves. While all respondents were able to accurately assess the maturity of their systems, it is possible that this diverted responsibility could have distorted the data for any of these retailers.

5.3 Future research and implications

Based on the mentioned limitations, the first suggestion is that future research should add a more social approach to assessing the organisational dimension of IOS maturity for the independent variables used in this study. This social approach for example consists of the perception of IOS by top management. The sample for a quantitative sample has to be larger to ensure that all position- and size categories have sufficient responses for realistic generalisation to the population.

Furthermore, this study enriches the value of the maturity model proposed by Plomp (2012) and replication of this study in other supply chains further contributes to strengthening the model. It might even be necessary to dismiss a universal set of independent variables and research the individual requirements for a maturity model in each individual supply chain. This means that supply chains do not compare to each other, but that benchmarking within one supply chain is more accurate.

Another suggestion for further research is a practical approach on how this theoretical model can help organisations to benchmark their IOS maturity score against other organisations. Such an approach could help coordinate a supply chain to perform better as a whole instead of just the sum of its parts. Achieving operational excellence on a higher level and possibly reducing the ecological footprint could be the ultimate goal.

A theoretical implication of this study is that autonomy and complexity of IOS as proposed by Plomp (2012) cannot be added to the IOS maturity model without critically reassessing their relation. However, this study does strengthen the ability for an IOS maturity model to be able to score organisations accurately. The organisational and technological dimensions help to provide a complete overview on IOS maturity. The reported increase in variance in this report implicates that position in the chain should also be added in future research on IOS maturity.

Suppliers and wholesalers that are willing to use this information in practice for improving their competitive advantage could use an evasive strategy to bypass the retailers with low IOS maturity scores. Smaller size organisations that are capable of adopting systems for information exchange exist and by improving the relationships with these partners the performance of the whole supply chain can improve. When organisations find that they are on the low end of IOS maturity they might need to accept that IOS is here to stay and take action.

5.4 Conclusion

This study adds to existing literature by arguing that the position in the chain is a critical variable in assessing IOS maturity in organisations. The importance of data synchronisation must be stressed because it shows a significant correlation to IOS maturity while future researchers should be cautious when using autonomy or complexity to explain IOS maturity. It also proves that studying IOS with organisations as a unit of analysis can have a significant contribution to assessing overall supply chain capabilities. Scoring organisations on their IOS maturity and assessing this result in relation to other organisations in the chain can help to improve chain performance in IOS.

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Appendix A. Pilot Interview Report

Date: 22-02-2016
Interviewee: Rob de Kleijn
Company: Nederlandse Expert Groep
Retail organisation in Electronics with +/- 140 physical stores
Role: ICT administrator and EDI Specialist
Interviewer: Danny Smit

Summary

Rob has read the research proposal and questionnaire and at first sight feels it is quite close to what he calls 'practice'. He is impressed with the backgrounds provided on the topic and confirms that it is in line with how the market is currently evolving. The necessity of IOS is rapidly increasing and the demand for connecting with- and communicating through systems is growing.

He expects that large distribution companies will perform well on the maturity of IOS. Brands that have their own distribution are expected to perform less, as they drive profit on the exclusivity of their brand and are probably the only ones that can supply that product (e.g. Miele). The larger the company becomes the more important data synchronisation will become. The 'Nederlandse Expert Groep' attempts to be flexible by integrating with as many different formats and communication methods as possible to grow their chances on success.

What might be missing in the determinants for maturity of IOS could be dealing with security issues and possibly the vision of the suppliers and retailers. Some distributors allow information to flow freely where others do not give any insight. Also implementing strict- and high security measures is not contributing to IOS maturity in both technical- as functional point of view. Also a sixth hypothesis could be added 'flexibility in several solutions for data synchronisation'.

Rob would like to see attention for 'how' to achieve maturity in IOS. Which IT tools will allow companies to collaborate as effectively with other systems? Are there any standards

or ways of thinking that have the potential to establish in the future? This should also take in to account the amount of flexibility in systems necessary to achieve the commercial goals by using these IT tools. How can these systems be adapted to integrate with partners in the future? After the technical approach companies should find the will to integrate with every other system.

The questions are properly related to this research. Keep in mind that the questions have a very strategic focus and therefore aim for management/executive level when sending out the questionnaires.
Three suggestions for questions that could be added:

- is the company supplying products to the consumer using fulfilment or drop shipment?
- does the IOS manage service-, warranty and return administration.
- measuring the adjustability of systems

Appendix B. Summary of pre-test results

Total number of preset subjects: 4

Subject 1

Company name: Electrobot B.V.

Company type: Wholesaler

Time elapsed: 10min

Key findings:

Some question can be answered from different perspectives. Electrobot B.V.'s attitude for using data synchronisation has changed dramatically over the years and therefore there is an internal contradiction on the vision on this subject. Also defining the current possibilities for 'adding functionality for interaction' is hard, but since there has not been a situation where we could not communicate, we should probably agree that we can manage that. Questions about payment on the purchase side were confused with payments on the sales sides by mentioning iDeal.

Actions for improvement:

1. Ask other pre-test subjects to think more aloud
2. Structure of the printed questionnaire should improve. Title and introductions of chapters should be positioned right above the questions.
3. Change the order of part 9. Autonomy, to make testing for internal validity less obvious.

Subject 2

Company name: Schoonderbeek B.V.

Company type: Retailer

Time elapsed: 10min

Key findings:

Skipped first question of chapter 9 because he could not understand it.

Consider 7-point Likert scale for the agree/disagree questions. The subject would rather answer in between to be more nuanced. However changing part of the questionnaire to 7-point and leaving the rest 5-point would be confusing, therefore 5-point Likert throughout the questionnaire is acceptable.

In chapter 4 'my' organisation was used, but misinterpreted 'my' as the researchers' company. Main reason for this conclusion was vagueness of the first question of Chapter 4.

Actions for improvement:

1. Structure of the printed questionnaire should improve. Title and introductions of chapters should be positioned right above the questions.
2. First question in Chapter 9 is confusing.

Subject 3

Company name: Algerin B.V.

Company type: Wholesale

Time elapsed: 15min

Key findings:

Subject considers sales ordering systems when assessing purchase section of the questionnaire. Section about organisational aspect is still considered from a technological point of view. Afterwards he claims that these questions have been answered correctly though. He skips first question of chapter 9. When explained after he finishes, he does understand what it means. He suggests that examples of the targeted IT systems could have helped the subject with answering. It could be a website or even an outlook application.

Actions for improvement:

1. Change first question of Chapter 9.
2. Explain what IT systems are allowed for answering these questions.
3. Separate purchase and sales sections

Subject 4

Company name: Andrea XL

Company type: Retailer

Time elapsed: 6min

Key findings:

Digital questionnaire does not function on Internet Explorer 11. Pressing the circles for the answers do not work. Subject does not understand the word 'Zakenpartner' (Business Partner) and mistakes it with shareholder. He is uncertain whether email applications would qualify as IT systems. First question of chapter 9 is vague.
Questionnaire is difficult and would require people with 'higher education' to fill it out.

Actions for improvement:

1. Change all instances of 'Zakenpartners' (Business Partners) with 'Klanten/leveranciers' (Customers/suppliers).
2. Actively show that Internet Explorer 11 will not work
3. First question of chapter 9 should be changed. Worked together to create a clear and simple question.
4. Besides giving examples of IT systems, also exclude e-mail applications.

NOTE:

All 'actions for improvement' have been changed in between the subjects. Most changes needed several iterations but where perfected in co creation with subject 4. We are confident that this version is suitable for collecting the full dataset.

Appendix C. Measurement protocol

CONCEPT 1 Dependent variable
The maturity of an organisation's interorganisational information system

Definition:

The organisational- and technological maturity score of an IOS in an organisation.

Variable:

Degree of maturity

Object of measurement:

For measuring the IOS maturity we will need to define two dimensions:

Technological dimension: Degree connectivity using the information system.

Organisational dimension: Degree of arrangements for collaboration with partners.

These dimension each consist of two components for measuring either supply-side or demand-side maturity (Plomp, 2010; Plomp, 2012)

Concept	Dimensions	Sides	Measurement
1. IOS Maturity	**Organisational Dimension**	**Demand Side**	Contracting and evaluation Strategic planning Proces Optimisation Product development
		Supply Side	Contracting and evaluation Strategic planning Proces Optimisation Product development
	Technological Dimension	**Demand Side**	Ordering Payment Invoicing Sourcing Forecasting
		Supply Side	Sales Invoicing Forecasting Product development Logistics

Location of the object of measurement:

Technological dimension:	Functionality overview from the information system.
Organisational dimension:	Practices in place for collaboration with partners outside of the organisation found in verbal- or written agreements, protocols or manuals.

Extraction-, sources- and recording of evidence

For each dimension and component the representative of the organisation should reproduce all information about the current functionality and practices in place. This information should come from operating manuals, by accessing the software and by consulting employee's to verify practices. The evidence will be recorded by the representative by selecting the answers in the questionnaire.

How will data be categorised

Data will be coded using a 5-point Likert scale that will vary from 'strongly agree' to 'strongly disagree'.

CONCEPT 2; Independent variable

The position in the supply chain

Definition:

The relative upstream- or downstream position of the organisation in the supply chain.

Variable:

Position

Object of measurement:

Organisation is purchasing finished products from business partners (B2B) in the supply chain (yes/no). Organisation is supplying finished products to non-end-user business partners in the supply chain (yes/no).

Location of the object of measurement:

Database of business partners

Extraction-, sources- and recording of evidence

The representative of the organisation should reproduce the existence of business partners (B2B) on the upstream- and downstream side. This information can be extracted from the information system or by consulting employees. The evidence

will be recorded by the representative by selecting the answers in the questionnaire. (this answer is the same for all further independent variables)

How will data be categorised

The data can be divided into three categories:

1. Retailer (purchasing yes, supplying no)
2. Supplier (purchasing no, supplying no)
3. Wholesale (purchasing yes, supplying yes)

CONCEPT 3

Autonomy in the supply chain

Definition:

The freedom for the organisation to make its own decisions without depending on dominant players in the chain.

Variable:

Degree of autonomy (Munkvold 2005)

Object of measurement:

The freedom of an organisation to make its own decisions on the use and allocation of its own internal resources without following expectations or demand from linkage partners (Child, 1972; Hambrick & Finkelstein, 1987) and the (lack of) dependence on relations with dominant players in the supply chain.

Location of the object of measurement:

Current relations with dominant partners.

Availability of substitutes for key products and -partners

Extraction-, sources- and recording of evidence

See concept 2

How will data be categorised

Data will be coded using a 5-point Likert scale that will vary from 'strongly agree' to 'strongly disagree'.

CONCEPT 4

Complexity of an organisation's IOS

Definition:

The level of difficulty to upgrade and adapt the functions in an organisation's IOS architecture.

Variable:

Degree of complexity

Object of measurement:

The upgradeability of IOS (Hendricks, Singhal and Straman, 2007)

The architecture of current IOS (BCS/RAE, 2004; Baldwin and Clark, 2000)

The adaptability of IOS (see pre-test Appendix A., Klein 2016)

Location of the object of measurement:

Blueprint design of the information system. Estimates by IT supplier or from employees responsible for IT within the organisation.

Extraction-, sources- and recording of evidence

See concept 2

How will data be categorised

Data will be coded using a 5-point Likert scale that will vary from 'strongly agree' to 'strongly disagree'.

CONCEPT 5

Size of the organisation

Definition:

The number of registered employees in the organisation.

Variable:

Size of the organisation

(Cox, Mowatt, & Prevezer, 2003; Zhu & Kraemer, 2005; Geri and Ahituv, 2008; Teo et al., 2009; Rajaguru & Matanda, 2011)

Object of measurement:

The number of employees (not FTEs) of the organisation, this number is not limited to a single store or office but should cover the whole organisation.

Location of the object of measurement:

Personnel administration

Extraction-, sources- and recording of evidence

See concept 2

How will data be categorised

The integer value of the total number of employees in the organisation will be converted to Log (Size) to accommodate for large differences in size. Categorising in groups (small, medium, large) has also been considered for the analysis but this would cause a loss of detail in the data.

CONCEPT 6

Importance of data synchronisation

Definition:

The level of awareness in the organisation for processes regarding data exchange.

Variable:

Degree of importance

Object of measurement:

The requirement for data exchange for the organisations operations (Vigtil 2007). Data synchronisation to raise service levels and competitive advantage (Cooper *et al*., 1997; Brewer and Speh, 2000; Mentzer et al. 2001).

Location of the object of measurement:

Estimates by sales- and purchasing managers

Extraction-, sources- and recording of evidence

See concept 2

How will data be categorised

Data will be coded using a 5-point Likert scale that will vary from 'strongly agree' to 'strongly disagree'.

Appendix D. Questionnaire Original (Dutch)

5P Likert* schaalverdeling: 1. Nooit, 2. Zelden, 3. Soms, 4. Vaak, 5.Altijd

5P Likert schaalverdeling**: 1. Helemaal mee oneens, 2. enigszins mee oneens, 3. neutraal, 4. enigszins mee eens, 5.helemaal mee eens

Var	Type	Vragenlijst interorganisationele informatiesystemen
		1. Gegevens
name	text	**Bedrijfsnaam:**
function	text	**Functie:**
employees	integer	**Aantal medewerkers** (aantal personen, niet FTE)**:**
company type	*list*	**Uw organisatie is het beste te omschrijven als** a: (Web)winkel b: Groothandel c: Fabrikant
		2. Inkoopzijde LET OP: nu volgen er vragen over de INKOOPzijde van uw organisatie
		2.1 Technologie *Uitleg: Met IT systemen/applicaties wordt bedoeld: automatiseringssystemen (bijv. ERP), product-informatiesystemen (PIM), klant-informatiesystemen (CRM), maar ook de gekoppelde online diensten zoals een webshop of online portal. E-mailprogramma's zoals Outlook tellen niet mee als informatiesysteem. Met 'eigen' IT systemen/applicaties wordt verwezen naar systemen binnen uw organisatie en niet naar portals van uw klant/leverancier.* *Ter ondersteuning van de inkoopfunctie gebruikt uw organisatie eigen IT systemen/applicaties voor:*
Q1	5P Likert*	Bestellen van producten of diensten on-line
Q2	5P Likert*	Verwerken van on-line betalingen voor bestelde producten en diensten

Q3	5P Likert*	Ontvangen van digitale facturen
Q4	5P Likert*	Zoeken van leveranciers in de markt
Q5	5P Likert*	Uitnodigen van leveranciers voor het offreren van prijzen
Q6	5P Likert*	Houden van on-line veilingen
Q7	5P Likert*	Samenwerken met leveranciers voor voorspelling van uw verwachte vraag
Q8	5P Likert*	Samenwerken met leveranciers voor het ontwikkelen van nieuwe producten of diensten
Q9	5P Likert*	Managen van capaciteit of voorraden van leveranciers
Q10	5P Likert*	Afwikkelen van service-, garantie en omruilingen

2.2 Organisatie

Organisatie, inkoopzijde

Uitleg: Naast het hebben van IT systemen/applicaties kunnen er afspraken zijn voor informatie-uitwisseling tussen bedrijven. Met afspraken wordt hier verwezen naar afgesproken werkwijzen, regels of methoden voor informatieuitwisseling.
Ter ondersteuning van de inkoopfunctie past uw organisatie specifieke afspraken toe voor:

Q11	5P Likert*	Vastleggen van leveringscontracten
Q12	5P Likert*	Vastleggen van strategische allianties
Q13	5P Likert*	Delen van strategische informatie
Q14	5P Likert*	Evalueren van leverancierspresta ties op waarden in het contract
Q15	5P Likert*	Vastleggen van gezamenlijke procesbeschrijvingen met leveranciers
Q16	5P Likert*	Samenstellen van een gezamenlijke werkgoep met leveranciers
Q17	5P Likert*	Afstemmen van uw strategie met die van uw leverancier

3. Verkoopzijde

LET OP: nu volgen er vragen over de VERKOOPzijde van uw organisatie

3.1 Technologie

Uitleg: Met IT systemen/applicaties wordt bedoeld: automatiseringssystemen (bijv. ERP), product-informatiesystemen (PIM), klant-informatiesystemen (CRM), maar ook de gekoppelde online diensten zoals een webshop of online portal. E-mailprogramma's zoals Outlook tellen niet mee als informatiesysteem. Met 'eigen' IT systemen/applicaties wordt verwezen naar systemen binnen uw organisatie en niet naar portals van uw klant/leverancier.
Ter ondersteuning van de verkoopfunctie gebruikt uw organisatie

		eigen IT systemen/applicaties voor:
Q18	5P Likert*	Ontvangen van online bestellingen
Q19	5P Likert*	Mogelijk maken van online betaling voor bestelde producten of diensten
Q20	5P Likert*	Sturen van digitale facturen
Q21	5P Likert*	Sturen van offerte's
Q22	5P Likert*	Het beantwoorden van vragen betreffende voorstellen of offerte's
Q23	5P Likert*	Het houden van veilingen/uitverkoop bijvoorbeeld op B2B of B2C marktplaatsen
Q24	5P Likert*	Samenwerken met klanten voor voorspelling van hun verwachte vraag
Q25	5P Likert*	Samenwerken met klanten voor het ontwikkelen van nieuwe producten of diensten
Q26	5P Likert*	Managen van capaciteit of voorraden van klanten
Q27	5P Likert*	Verzorgen van dropshipments naar de klant

3.2 Organisatie

3. Organisatie, verkoopzijde

Uitleg: Naast het hebben van IT systemen/applicaties kunnen er afspraken zijn voor informatie-uitwisseling tussen bedrijven. Met afspraken wordt hier verwezen naar afgesproken werkwijzen, regels of methoden voor informatieuitwisseling.

Ter ondersteuning van de verkoopfunctie past uw organisatie specifieke afspraken toe voor:

Q28	5P Likert*	Vastleggen van leveringscontracten
Q29	5P Likert*	Vastleggen van strategische allianties met klanten
Q30	5P Likert*	Delen van strategische informatie met klanten
Q31	5P Likert*	Evalueren van uw prestaties op waarden in het levercontract
Q32	5P Likert*	Vastleggen van gezamenlijke procesbeschrijvingen met klanten
Q33	5P Likert*	Samenstellen van een gezamenlijke werkgoep met klanten
Q34	5P Likert*	Afstemmen van uw strategie met die van uw klanten

4. Klanten / Leveranciers

Uw organisatie:

Q35	5P Likert**	bepaalt zelf hoe arbeidsuren en financiële middelen worden ingezet, klanten/leveranciers hebben hier geen inspraak op.
Q36	5P Likert**	Is afhankelijk van lange termijn relaties met dominante klanten/leveranciers
Q37	5P Likert**	Kan gelijkwaardige alternatieven aanbieden wanneer belangrijke producten onbeschikbaar worden
Q38	5P Likert**	Kan voortbestaan door het behoud van dominante

		klanten/leveranciers

5. Data synchronisatie

		Uw organisatie:
Q39	5P Likert**	Vereist data synchronisatie van partners om dagelijkse werkzaamheden te kunnen uitvoeren
Q40	5P Likert**	Heeft een hoger servicelevel door data synchronisatie met uw partners
Q41	5P Likert**	Gebruikt data synchronisatie om efficiëntie en effectiviteit van uw activiteiten te verbeteren
Q42	5P Likert**	Gebruikt data synchronisatie om eigen voorraadniveau ‘s laag te houden

6. Functionaliteit van informatiesysteem

		Het informatiesysteem in uw organisatie:
Q43	5P Likert**	Kan eenvoudig functionaliteit toevoegen voor interactie met klanten/leveranciers
Q44	5P Likert**	Wordt onderhouden en geupgrade door (een) systeembeheerder(s) die complexe functionaliteit kunnen toevoegen of uitbreiden
Q45	5P Likert**	Kan geupgrade worden met complexe functionaliteit door het aanschaffen van additionele modules
Q46	5P Likert**	Is ontwikkeld volgens een architectuur die het toevoegen van complexe functionaliteit toelaat
Q47	5P Likert**	kan bestaande koppelingen met klanten/leveranciers eenvoudig wijzigen
		Ik ben terughoudend over data synchronisatie:
Q48	5P Likert**	Vanwege de kans op beveilingsrisico's
Q49	5P Likert**	Door een gebrek aan vertrouwen in andere partijen binnen de supply chain
Q50	5P Likert**	Omdat dit niet past binnen de visie van de organisatie

Appendix E. Questionnaire translated to English

5P Likert* scale: 1. Never, 2. Rarely, 3. Sometime, 4. Very often, 5.Always

5P Likert** scale: 1. Strongly disagree, 2. Disagree, 3. Undecided,

4. Agree, 5.Strongly agree

Var	Type	Questionnaire interorganisational information systems
		1. Data
name	text	**Company name:**
function	text	**Function:**
employees	integer	**Number of employees** (number of persons, not FTE)**:**
company type	*list*	***Your organisation can be best described as:***
		a: (online) Retailer b: Wholesale c: Supplier
		2. Purchasing
		ATTENTION: the following questions involve the PURCHASING side of your organisation
		2.1 Technology
		Explanation: IT systems/applications in this questionnaire refer to: Business information systems (for example ERP), product information systems (PIM), client-information systems (CRM), but also integrated online services such as web shops or online portals. Email applications like Outlook do not count as information systems. When asking for 'own' systems/applications it refers to systems that your company owns and not portals owned by your clients or suppliers. *To support the purchase function, does your organisation use specific IT systems/applications for:*
Q1	5P Likert*	Ordering goods or services online?
Q2	5P Likert*	Arranging payments online for ordered products or services?

Q3	5P Likert*	Receiving e-invoices?
Q4	5P Likert*	Finding suppliers in the market?
Q5	5P Likert*	Inviting suppliers to quote prices or submit proposals?
Q6	5P Likert*	Running online auctions?
Q7	5P Likert*	Collaborating with suppliers to forecast your demand?
Q8	5P Likert*	Collaborating with suppliers to design new products or services?
Q9	5P Likert*	Managing capacity or inventories of suppliers?
Q10	5P Likert*	Handling of service, warranty and returns

2.2 Organisation

Organisation, purchasing side

Explanation: Besides owning IT systems/applications there can be arrangements for information exchange between companies. Arrangements in this questionnaire refer to agreed processes, protocols or methods for information exchange.

To support the purchase function, does your organisation apply specific (i.e. customised and written) organisational arrangements to:

Q11	5P Likert*	Document delivery contracts on the operational level?
Q12	5P Likert*	Settle strategic alliances?
Q13	5P Likert*	Share strategic information?
Q14	5P Likert*	Evaluate supplier performance on contract parameters?
Q15	5P Likert*	Document joint process descriptions with suppliers?
Q16	5P Likert*	Govern a joint work team with suppliers?
Q17	5P Likert*	Align your strategy with your suppliers' strategy?

2. Sales

ATTENTION: the following questions involve the SALES side of your organisation

3.1 Technology

Explanation: IT systems/applications in this questionnaire refer to: Business information systems (for example ERP), product information systems (PIM), client-information systems (CRM), but also integrated online services such as web shops or online portals. Email applications like Outlook do not count as information systems. When asking for 'own' systems/applications it refers to systems that your company owns and not portals owned by your clients or suppliers.

To support the sales function, does your organisation use specific IT systems/applications for:

Q18	5P Likert*	Receiving online orders?
Q19	5P Likert*	Enabling payments online for ordered products or services?
Q20	5P Likert*	Sending e-invoices?
Q21	5P Likert*	Sending offers?
Q22	5P Likert*	Answering calls after proposals or tenders?
Q23	5P Likert*	Launching sales auctions, for example on B2B or B2C marketplaces?
Q24	5P Likert*	Collaborating with customers to forecast their demand?
Q25	5P Likert*	Collaborating with customers to design new products or services?
Q26	5P Likert*	Managing capacity or inventories of customers?
Q27	5P Likert*	Handling drop shipments to the customer

3.2 Organisation

3. Organisation, sales side

Explanation: Besides owning IT systems/applications there can be arrangements for information exchange between companies. Arrangements in this questionnaire refer to agreed processes, protocols or methods for information exchange.

To support the purchase function, does your organisation apply specific (i.e. customised and written) organisational arrangements to:

Q28	5P Likert*	Document delivery contracts on the operational level?
Q29	5P Likert*	Settle strategic alliances with your customers?
Q30	5P Likert*	Share strategic information with customers?
Q31	5P Likert*	Evaluate your performance on contract parameters?
Q32	5P Likert*	Document joint process descriptions with customers?
Q33	5P Likert*	Govern a joint work team with your customers?
Q34	5P Likert*	Align your strategy with your customers' strategy?

4. Clients / Suppliers

The continuity of our company:

Q35	5P Likert**	is not affected when allocating internal resources without regarding demand or expectation of linkage partners
Q36	5P Likert**	depends on long-term relationships with dominant business partners
Q37	5P Likert**	does not rely on the retention of dominant business partners
Q38	5P Likert**	can supply equal substitutes when key products are unavailable (supply) can purchase equal substitutes when key products are unavailable (purchase)

5. Data synchronisation

Our organisation:

Q39	5P Likert**	requires data synchronisation from partners to perform day-to-day operations
Q40	5P Likert**	has a higher service level by data synchronisation with partners
Q41	5P Likert**	uses data synchronisation to improve efficiency and/or effectiveness of our activities
Q42	5P Likert**	uses data synchronisation to keep inventory levels low when supplier is keeping stock.

6. Functionality of information system

The Information system in our organisation

Q43	5P Likert**	can easily adopt interorganisational communication with partners
Q44	5P Likert**	is maintained and updated by (a) system integrator(s) who can add or expand complex functionality
Q45	5P Likert**	can be upgraded with complex functionality by purchasing additional modules
Q46	5P Likert**	has an architecture that allows adding complex functionality
Q47	5P Likert**	can easily adjust existing integrations with customers/suppliers

I am restrained on data synchronisation:

Q48	5P Likert**	Due to the risk on security risks
Q49	5P Likert**	By a lack of trust towards other parties in the supply chain
Q50	5P Likert**	Because it does not fit in our company's vision

Appendix F. Test for interaction effects

```
================================================
                        Dependent variable:
                    ----------------------------
                               maturity
------------------------------------------------
autonomy                        -1.311
                                (3.220)

datasync                       7.774***
                                (2.279)

complexity                      -4.748*
                                (2.731)

logsize                        4.202***
                                (1.407)

retailer                       -14.322**
                                (5.584)

wholesale                       1.830
                                (6.313)

datasyncsize                    -2.137*
                                (1.161)

datasyncretailer                -4.561
                                (4.749)

datasyncwholesale              -10.914*
                                (5.539)

Constant                       77.407***
                               (16.924)

------------------------------------------------
Observations                      58
R2                               0.601
Adjusted R2                      0.526
Residual Std. Error       14.771 (df = 48)
F Statistic            8.042*** (df = 9; 48)
================================================
Note:                *p<0.1; **p<0.05; ***p<0.01
```

ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
iis$datasync	1	7853	7853	27.679	2.53e-06	***
iis$logsize	1	2530	2530	8.918	0.00424	**
iis$datasync:iis$logsize	1	561	561	1.976	0.16550	
Residuals	54	15321	284			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Appendix G. Dataset and R scripts

An anonymised version of the collected dataset and copies of the used R scripts are available on request. For enquiries please send an e-mail to: email@dannysmit.eu.