MATURING INTERORGANISATIONAL INFORMATION SYSTEMS

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MATURING INTERORGANISATIONAL INFORMATION SYSTEMS

Bevordering van Interorganisationele Informatiesystemen
(met een samenvatting in het Nederlands)

Proefschrift

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To my beloved parents,
who always put me first.

Preface

After a little less than four years of PhD research, I have come to understand that the most-read part of any PhD thesis is the preface. So if I want as many people as possible to understand something about interorganisational information systems, this is where I should make my case. However, I also learned that a preface is the most-read part because it usually contains acknowledgements to the persons that have been indispensable in the creation of the thesis at hand. It is here that I observe a similarity between interorganisational information systems and PhD theses: you cannot successfully realise them on your own.

Indispensable in the realisation of this thesis were the members of the reading committee: Professors Benn Konsynski, Kai Reimers, Jos van Hillegersberg, Mattijs Numans, and Jan Grijpink. I am grateful for your interest and time to assess my work during one of the busiest periods of the year. I also would like to express my gratitude to the anonymous reviewers that were involved in reviewing the seven scientific papers that are incorporated in this dissertation. Moreover, I want to thank the various co-authors of these articles for travelling along with me on important parts of my PhD journey: Ron van Rooij, Pim den Hertog, Roel Huiden, Glenn van Rijn, Robert Verheij, and Jan Grijpink. I truly enjoyed our collaboration.

I want to thank my colleagues of the Organisation & Information group at Utrecht University: Huub, Inge, Johan, Marco, Michiel, Remko, Rik, Sandor, and Slinger. Quite a few of you have first been my lecturers, and it was a pleasure to work together with you 'on the other side'. The times have sometimes been tough, but this never affected the team spirit within our group. In that respect I should also mention my fellow PhD candidates: Amir, Benny, Eva, Gilbert, Henk, Jaap, Jan, both Jurriaans, Kevin, Marlies, Martijn, Michiel, Naser, Nico, Pascal, Ralph, Ravi, Rogier, Tjitske, and Willem. Some of you already obtained your PhD, and for the others I hope you will reach this milestone as soon as you would like.

I made the conscious decision to conduct my PhD research part-time. This meant I spent 'the other half of the week' in Utrecht as well, but then in the role of researcher/consultant at Dialogic *innovation & interaction*. This combination has been heavy and sometimes crazy, but not one day did I regret my decision to do it this way. I am indebted to the founding fathers of Dialogic: Christiaan Holland, Pim den Hertog, Rob Bilderbeek, and Sven Maltha. Only because you offered the required flexibility, I was able to enjoy these two jobs at the same time. Many data used in this dissertation originate from Dialogic projects/collaborations. Following in the footsteps of Karianne, it seems to me you have a recipe for success. Furthermore, I want to show gratitude to my smart and kind-hearted colleagues that are known as Dialogics: Arthur, Bert, Bram, Carolien, Cor-Jan, Frank, Hugo,

Jaap, Jesse, Leonique, Matthijs, Mirjam, Reg, Robbin, Rudi, Stein, and Tommy; and those that left too soon, most notably: Barbera, Jeroen, and Jurgen.

Near the end of 2011, I went to Vancouver to complete my dissertation. I want to express thanks to Izak Benbasat and Ron Cenfetelli for having me as a Visiting Scholar, and all others at the Sauder School of Business, the University of British Columbia, for a rewarding learning experience. Especially Andrew Burton-Jones deserves mention for pointing out literature on multilevel theory. Thanks as well to Emily and Victor Chia, who provided me with a home away from home. In the process of successfully finishing my thesis, I also received much appreciated help from Dio van Maaren, Sandra Verdonk, and Saskia Spencer.

I am most thankful for my promotor Sjaak Brinkkemper and my co-promotor Ronald Batenburg. Sjaak, thank you for teaching me the inner workings of academia, clearing my path of possible obstacles, and showing me the way from milestone to milestone. Ronald, knowing you for over nine years, I very much admire your intellect, creativity, and the amazing amount of work you put up with every day. Thank you for guiding me from my first bachelor year up till now. I sincerely hope we can continue our collaboration in the future.

I feel truly blessed with my circle of friends, including the 'Uni-gang': Daniël, Guido, Jasper R. (thanks for all those wonderful Wednesday nights), Jasper V., Jeroen, Joost, Jurjen, Lieke, Margreet, Martine, Sandra, and Swathi; and the 'Hilversum-gang': Eskeline, João, Maaike, Marijn S., and Paula. I also want to mention Leen and Sijmen here.

I want to thank my other friends and my family as well, especially those friends who I consider family: 'Tante Trijnie', Sophie, Nic, Anneline, Folkert, and Willemijn. Thanks for all your interest in and warmth surrounding me. I cannot express enough gratitude to my closest friends – Imke de Jong and Robert Vonk – who always believe in and listen to me. Imke, thanks for being my sounding board and for our never-ending Skype conversation. In addition, you have proofread virtually my whole dissertation (ecxept for tis setnece). Robert, thank you for being such a great friend for such a long time. Although it may sound strange, you distracting me almost every Saturday night (and on many other occasions) has been invaluable in the completion of this dissertation. I am proud to have you two standing next to me as my paranymphs during my public defence.

Finally, I dedicate this thesis to my beloved parents, who have been there for me every step of my life. It breaks my heart that my father did not live long enough to hold this book in his hands and join me for the defence ceremony, but I am grateful that he was able to see the final manuscript. Mum and dad, it is great that you are so proud of your son, but – whether you believe in nature or nurture – you are the ones who made this achievement possible. Thank you.

Marijn Plomp – Hilversum, January 2012

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Introduction

1 General introduction

1.1 Motivation

Today, more and more information exchange occurs digitally, through the use of ICT. Information systems that cross the boundaries of a single organisation are also known as interorganisational information systems. Many organisations and interorganisational networks have adopted these systems in practice. Looking back, this has not been a straightforward process; in many cases organisations are struggling with the deployment of interorganisational information systems – even today (cf. Schmidt, Otto, & Österle, 2010). Many interorganisational ICT projects do not come to fruition or deliver less than the expected results. Sometimes the results are even counterproductive. Prominent examples from recent Dutch history are the heated debate around the implementation of a national Electronic Patient Record (cf. Schäfer et al., 2010), and the much criticised implementation of a national chip card for public transport (cf. Plomp, 2011). Both public and private parties seem to be reluctant to adopt these kinds of systems. This is not surprising, as it usually entails giving up part of their authority and a need to conform to standards. On the other hand, we see many successful implementations of interorganisational information systems. Famous are the examples of Dell, Hewlett-Packard, and Wal-Mart (e.g. Alvarado & Kotzab, 2001), and their Dutch counterparts like Albert Heijn, HEMA and bol.com. Each of these organisations managed to optimise their supply chain and thereby outperform their competitors. Also in the non-profit, governmental sector there are some prominent success stories, e.g. the Dutch interorganisational information system for the drug addicts' health care chain (Grijpink, 2010). Furthermore, it should be noted that there are many highly successful systems of which we do not hear so much, perhaps precisely because they are functioning without problems. In general, we see that there exists a lot of variation in terms of adoption levels and system types, both across and within sectors. But why does one value chain succeed in its interorganisational collaboration and accompanying information systems, whereas another has so much trouble? What are the factors that influence this?

When discussing information systems (whether they are interorganisational or not), it is tempting and intuitive to consider the characteristics of those systems, the technology. However, the determinants that influence the uptake of interorganisational information systems are complex and not only related to the system itself. Many organisational variables play an important role as well, and these are complex as they pertain to more than a single organisation. Kuan and Chau (2001) put it as follows: "The decision to adopt an IT, and inter-organizational systems, is not primarily based on the characteristics of the technology itself. In the case of EDI adoption, the decision also depends upon other factors related to the internal organization and the external environment." We agree with this conclusion

and throughout this dissertation, we consider both the technological and organisational dimension. In doing so, we follow the socio-technical tradition (cf. Cherns, 1976; Mumford, 1987; Clegg, 2000; Bunker, Kautz, & Pyne, 2008). The recent stream of business–IT alignment theory and its validation (see Chan & Reich, 2007) also provides a fundamental reason for considering both dimensions. Other classifications than these two dimensions exist as well, e.g. sometimes a threefold distinction is made, as in the technology-organisation-environment framework of Tornatzky and Fleischer (1990). The main point is that it is not *only* the technological, or *only* the organisational dimension that is of importance.

Studying interorganisational information systems is complex, as there are numerous definitions for them (see the following section), choosing an appropriate unit of analysis is difficult, they cross-cut the public and private domain, and they are sometimes hard to distinguish or delimit. In this research, interorganisational information systems are empirically studied in various ways (with a focus on Dutch cases) and from multiple viewpoints. In doing so, we hope to contribute to the knowledge on this topic, thereby enabling better practices and improving policy.

1.2 Interorganisational information systems

Interorganisational information systems (IOIS) have been studied as early as the mid sixties of the previous century (cf. Kaufman, 1966). The field of IOIS is still active however, and can be considered highly relevant from both a scientific and a practitioner perspective, as there are large economic and societal interests at stake (see also §1.5 on the relevance of this dissertation research). In this almost half a decade, many terms and definitions have surfaced, but not one seems to be 'dominant'. In this dissertation, we use the most generic term possible: interorganisational information systems. But even here, we see two different schools of thought: one convinced that it should be abbreviated to 'IOS', the other claiming this should be 'IOIS'. We use these and other terms interchangeably, as will become clear in this section. We will explore the domain of this dissertation through describing some of the key terms and concepts, beginning with our own concept: chain digitisation. To better understand the concept of *chain digitisation*, it is probably best to look at the two words that comprise the concept: 'chain' and 'digitisation'.

1.2.1 What is a chain?

Michael Porter (1985) describes a *value chain* through a figure that depicts an organisation as consisting of different activities (Figure 1.1). These processes can be classified into primary and support activities. The primary activities form a sequence, from inbound logistics through operations to outbound logistics, marketing and sales, after which service is deliv-

ered. This explains the name value chain: a series of activities – a chain – each of which adds value in their own way. Note that it is a single organisation that is considered a 'chain' here.

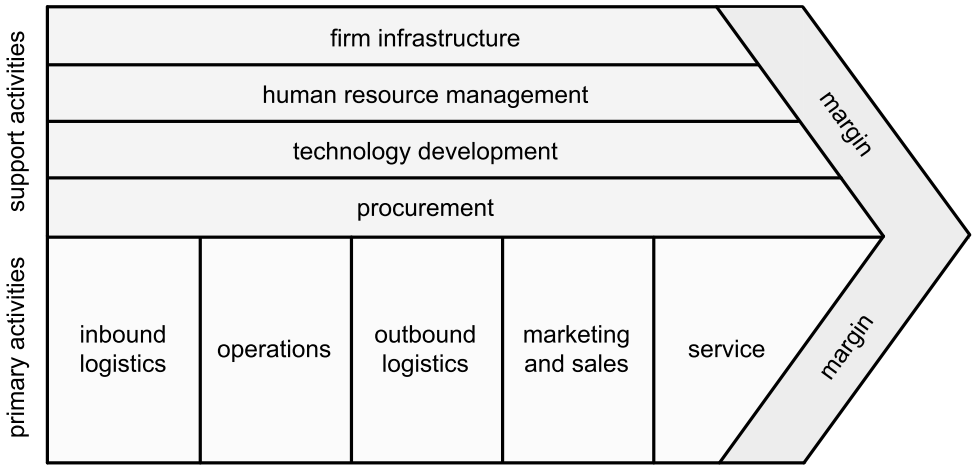

Figure 1.1 An organisation as a value chain (based on Porter, 1985)

However, when we look further than the boundaries of an individual organisation, we see that organisations almost always are part of a larger whole of organisations that supply to and demand from each other. This has been termed the *value system* (Porter, 1985) or the industrial value chain, in order to indicate the difference with an individual organisation (Ward & Peppard, 2002). Every organisation in the value system has a particular input, executes a process on that input, in order to provide a certain output. It often happens that an organisation in the value system takes on only one of the distinct functions described by Porter. Think of a manufacturer (operations), transporter (logistics) or ICT service provider (technology development). All these organisations individually have a value chain as shown in Figure 1.1, but their principal function in the whole value system is only one of these activities.

A similar concept is that of a *supply chain*. This is often represented as a system of organisations and the connections between them (Shapiro, 2009). In this system, products typically follow a downward flow (from producer to end user), although it is also possible that products move in the opposite direction, e.g. in case of repair, incorrect orders or recycling. Besides the stream of physical goods, there are several other streams, as can be seen in Figure 1.2 (Stern, El-Ansary, Coughlan, & Anderson, 2001). A slightly coarser subdivision is that into flows of goods, services, finance and information (Mentzer et al., 2001).

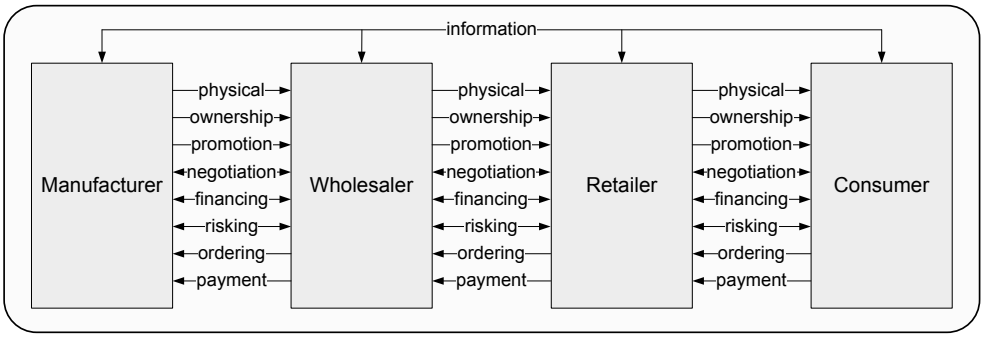

Figure 1.2 Different flows within a chain (based on Stern et al., 2001)

Another term that is often used in interorganisational research to describe the object of interest is *network*. It is a sometimes heated debate whether one should speak of chains or networks, as both concepts have their advantages and disadvantages. Chain is perceived as the more traditional concept: invariable and linear, whereas a network is supposed to be dynamic and cyclical. Although the term network indicates that we are dealing with complex relationships, it may also lead to confusion, as in ICT the term network can refer to a more technical concept as well. Furthermore, network also sometimes refers to more non-binding relations, whereas a chain points to parties that collaborate together towards a joint goal. The latter term also focuses more on the primary process. In the end it remains a matter of which aspects one would like to emphasise and also of personal preference. In this dissertation, we mainly use the term chain, but this is regarded interchangeable for 'network'. The same goes for the term value and supply chain, which is therefore often abbreviated to simply 'chain'.

1.2.2 What is digitisation?

In its simplest form, *digitisation* is executing a (business) process using ICT, which is currently being done by hand[1]. Although this can already lead to huge advantages, there is sometimes more to gain through more radical changes, such as adjustment of the process. Digitisation in this dissertation is thus broadly defined, namely as the result of an organisational change through ICT. The emphasis lies on the end result and not the process (digitising).

[1] Strictly speaking, a process that is not done by hand can be digitised as well. This is referred to as mechanisation, or, if the machines also have some degree of self-regulation, automation (Harris, 2002). Think of a mechanical cash register, through which the till roll is moved and printed by means of electricity. This is not something that is done by hand, yet it is only digitisation when there is storage and/or transmission of data, through 'zeros and ones'.

Laudon and Laudon (2002) describe the various digitisation possibilities based on what they call the "spectrum of organisational change". According to them there are four types of organisational change through ICT, in increasing order of change: (i) automation, (ii) rationalisation, (iii) reengineering, and (iv) paradigm shifts. Each of these types of change uses ICT in a different way and leads to a different end result. As the change is more far-reaching, both return and risk increase.

Business Process Automation (BPA) is the earlier mentioned execution of labour using ICT, while it was previously done without. For example, instead of keeping track of product inventory in a notebook, this happens in Excel. Rationalisation or *Business Process Improvement* (BPI) frequently follows an earlier round of automation. Through doing things digitally, problems often surface which can be easily remedied. An example would be taking stock only once a day, instead of every time a product (almost) runs out. *Business Process Reengineering* (BPR) goes much further in changing procedures, by breaking through existing assumptions. Unnecessary activities are removed from the process, so this method may lead to labour reduction. BPR could involve a scan system at the point of sale, which automatically keeps track of stock levels. Finally, in case of a paradigm shift, the base of existence of the entire organisation can change. An example of such an extreme change is a company that closes its physical store and becomes an online store. The distinction between BPR and paradigm shifts remains a grey area, illustrated by the fact that not all treatises take the latter type into account (e.g. Dennis, Wixom, & Tegarden, 2002).

Hoogeweegen, Teunissen, Vervest, and Wagenaar (1999) present, for this dissertation, a relevant extension to the types of organisational change through ICT described above. They briefly mention *Business Network Redesign* (BNR): using ICT to optimise the performance of a chain by investigating how the various activities can best be distributed among the different parties in the chain. Think for example about a retailer that predicts demand (and hence the required production) instead of the manufacturer, who traditionally does this. This is based on the notion that the retailer has a better view of the 'end of the chain', i.e. what the real consumer demand will be. This is in fact already an example of the combination of the terms 'digitisation' and 'chain', the topic of the next section.

1.2.3 The what and why of chain digitisation

Now that it is clear what we understand by a chain and by digitisation, defining the composite concept is simple: the digitisation of a chain. Chain digitisation is thus a form of *interorganisational collaboration through ICT*. That ICT is what we call an interorganisational information system.

The actual implementation of the concept of chain digitisation has, just like the available technology, evolved over the years. About three decades ago Barrett and Konsynski (1982)

wrote about: "shared information systems that cross organizational boundaries and benefit all participants" and referred to these systems as inter-organisation(al) information sharing systems. Almost half a century ago, Kaufman (1966) already published a Harvard Business Review paper entitled "data systems that cross company boundaries", in which he discusses the forms and possibilities of these systems. Interestingly, a significant part of his contribution focuses on the time-sharing of computing resources, a clear indication of the time it was written in. In the nineties, Electronic Data Interchange (EDI; e.g. Iacovou, Benbasat, & Dexter 1995) was the major interorganisational ICT development. In this century, Soliman and Janz (2004) describe the existence of internet-based inter-organisational systems (IBIS), an IOIS variant which uses the communication standard that made the internet popular (i.e. TCP/IP). Technically, this is often on the basis of XML-sheets, which are frequently a direct translation from the earlier EDI-standards.

Of great importance when considering chain digitisation are the relationships and dependencies in chains, e.g. because the information that one organisation provides (and how) affects other players in the chain (Ward & Peppard, 2002). To be able to successfully digitise a chain, it is important that everyone is in agreement, and that the 'plugs fit'. Clear arrangements must be made, both organisational and technological.

What has not changed much throughout the years, are the advantages of interorganisational information systems. Barrett and Konsynski (1982) mention three potential benefits of IOIS: cost reductions, productivity improvements, and product/market strategy. More recently, Morrel and Ezingeard (2002) come to similar conclusions in their SME-specific study. They indicate that organisations often start with IOIS for reasons of efficiency, effectiveness, and/or competitive positioning. Finally, we mention the work of Frohlich and Westbrook (2001) into the effects of integration between supply chain partners on their performance. In their study, they consider typical chain digitisation variables like access to planning systems and joint EDI networks. They show that there are different integration strategies ("arcs of integration"), and find support[2] for the hypothesis that higher integration leads to higher performance.

1.3 Research questions

The main research question in this thesis is:

> *MRQ: How can the maturing of interorganisational information systems be furthered through the development of theoretical models, empirical measurements, and practical policies?*

[2] As Frohlich and Westbrook (2001) indicate themselves, this result does not prove the causality, but it strengthens the general assumption that this relationship exists.

We address this complex question through three sub-questions:

> *SQ1: What are the technological and organisational levels of chain digitisation and how can these levels be measured?*
>
> *SQ2: How can these concepts be empirically applied to the Dutch retail and health care sector?*
>
> *SQ3: How can policies to improve the use of interorganisational information systems be formulated and evaluated?*

We will now further explain each of these three sub-questions.

Ad SQ1: What are the technological and organisational levels of chain digitisation and how can these levels be measured?
In order to be able to identify/understand the factors that influence the success of interorganisational information systems, we should first be able to measure the level of interorganisational information systems. This issue forms an important part of this dissertation, which we address through developing a maturity model.

Many maturity models for organisations have 'network' or 'chain orientation' as the highest possible level (e.g. Handfield & Straight, 2004; McLaren, 2006; Schoenfeldt, 2008). In practice however, there exist different degrees and types of interorganisational collaboration. Differences exist for instance between bilateral (e.g. buyer-supplier, mergers) and multilateral (e.g. networks, franchises) collaboration, but also whether the collaboration takes place at the level of support, the primary process or policy (cf. Grijpink, 2010). Many typologies exist that portray these different forms of collaboration. Daft (2001), for instance, presents a typology with the dimensions 'relation between organisations' (collaborating or not) and 'organisation type' (comparable or not). This leads to different forms of collaboration (or the lack thereof): resource dependency, population ecology, collaboration network, and institutionalism.

Next to this organisational perspective, there exists the technological perspective. Some chain collaborations have devised complex XML-sheets conforming to extensively documented standards. In other cases, e-mail seems to suffice. In the same way, there can be a direct coupling between systems, or an overarching chain information system for the entire value chain. It is not so much typologies, but more 'technology waves' that illustrate this dimension best. As indicated above, new generations of technologies (e.g. EDI, XML, cloud computing) tend to quickly follow each other. However, considering only the technological dimension implies technological determinism, which can be argued to be a too simplistic view (cf. Chae, Yen, & Sheu, 2005).

All in all, we conclude that there are many valuable contributions stemming from both the organisational and the technological perspective. Referring to the socio-technical approach

described above, it is essential to combine these two dimensions. This is not simple, but we attempt to do this in chapters 2 and 3.

Ad SQ2: How can these concepts be empirically applied to the Dutch retail and health care sector?

The two chapters that address SQ1, both contain an empirical application (i.e. one on the retail sector and one across sectors – both profit and non-profit). As we feel that the field of interorganisational information systems benefits greatly from empirical research, in further studying these concepts, we did additional field work in the highly relevant sectors of retail (profit) and health (non-profit; although it can be argued that this is changing).

In retail, an increasing rate of change, global competition, ever-more demanding consumers, a heavy administrative burden, and a seemingly perpetual financial crisis put organisations under heavy pressure. This is particularly true for SMEs. ICT can be said to be a double-edged sword in this context (cf. Turban, King, Viehland, and Lee, 2004). On the one hand, it can be a threat to smaller retailers for its disintermediation effect and competition through e-tailing (cf. Chircu & Kauffman, 1999), and by its supply chain management effectuation of the larger (franchise) organisations (cf. David, 2008). On the other hand, ICT likewise provides opportunities to smaller retailers, like opening up new sales channels, reducing administrative tasks and/or enabling strategic management of their enterprise (Turban et al., 2004).

Similarly, the Dutch health care sector is under heavy pressure. As is the case in many developed countries, demand for health care services is on the rise, whereas at the same time supply is becoming limited (OECD, 2010a; Bodenheimer, Chen, & Bennett, 2009; Margolius & Bodenheimer, 2010). This asks for innovative solutions, of which better use of interorganisational information systems could be one. At the same time, other problems related to the primary process need to be addressed. For instance, can the out-of-hours post access a patient's medical data when the family doctor is not available?

In answering SQ2, we do not literally apply the model from the previous sub-question, but rather create new, (sector-)specific models, which build on this concept of addressing both the technological and the organisational dimension of interorganisational information systems.

Ad SQ3: How can policies to improve the use of interorganisational information systems be formulated and evaluated?

We approach the policy concept from two quite different directions. The similarity however, is that we empirically study policies. First, we attempt to formulate an information strategy

for social chains[3] that takes into account the threat of identity fraud. Secondly, we study one of the major Dutch ICT innovation policy programmes from the past decade, and analyse its effectiveness in terms of increasing the uptake of interorganisational information systems among SMEs.

Both approaches are however, directed towards the same goal: better future policies that lead to improved uptake of interorganisational systems on the one hand, and safer systems on the other.

1.4 Research approach

The research questions listed are answered through the various chapters of this thesis; 9 in total. All chapters – besides the introductory and concluding chapters – have been written and published (or accepted for publication) as individual papers. This brings about sometimes extensive or partly overlapping introductions, and also a considerable 'mix' of study objects (cf. Table 1.1). However, these studies form a cross-section of the research that can be done in the field of interorganisational information systems, and – more importantly – together they provide an answer to the research questions. The first and the last chapter of the dissertation provide an integral overview of the studies.

Table 1.1 Focus of the different dissertation chapters

Chapter	Focus					
	Generic	Maturity	Retail	Health	SME	Policy
2	X	X	X		X	X
3	X	X				
4			X		X	
5		X	X			
6				X	X	
7	X			X		X
8					X	X

In order to make the research themes explicit, they are listed in Table 1.1, together with an indication of which chapter covers what topics. 'Generic' signifies that the chapter contains some general theory that is not considered sector-specific. 'Maturity' relates to the development of a model of growth. 'Policy' is addressed in two different ways in this thesis: (i) as

[3] It should be noted however, that these social chains become increasingly mixed with private chains/companies, and the relevance of our work may therefore extend beyond the social domain. Consider for instance the banking sector, for which identity fraud (related to e.g. skimming, money laundering) forms a major threat as well.

(information) strategies for interorganisational collaboration, and (ii) as governmental policies (e.g. subsidies) for stimulating the uptake of interorganisational ICT. The other themes are considered self-explanatory.

Besides different topics, the various chapters also bring about the use of several research methods. Below, we briefly describe the different research methods that are applied over the course of the chapters. A summary is presented in Table 1.2.

Table 1.2 Research method(s) applied in each chapter

Chapter	Research methods applied				
	Literature study	Model development	Survey		Case study
			Questionnaire	Interview	
2	X	X	X	X	
3		X	X		
4	X	X	X		
5		X	X	X	
6	X		X		
7					X
8			X		

- *Literature study*. All chapters contain some form of literature study, as it is good academic practice to ground your research in existing theories and study related work. The more extensive literature reviews can be found in chapters 2, 4, and 6.
- *Model development*. In design science (cf. Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008), model development is considered an important part of a research project. We list this here as a separate method. Chapters 2, 3, 4, and 5 all contain original models, developed based on existing work. In chapter 3 we use the chain digitisation model from the preceding chapter, but further develop it, and formulate a conceptual model regarding the determinants of chain digitisation maturity as well.
- *Survey*. All chapters in this thesis are based on empirical data and in almost every case these have been collected through surveys. Survey research can be further differentiated into two broad types: questionnaires and interviews (Trochim & Donnelly, 2008). *Questionnaires* are applied in chapters 2, 3, 4, 5, 6 and 8. We employ pencil-and-paper questionnaires, online surveys (both 'primitive', i.e. "please complete this document" and 'advanced', i.e. using an online survey tool), and computer-assisted telephone interviewing (CATI). *Interviews* were conducted for the study reported on in chapter 2 (semi-structured interviews), and during the

POS vendor company visits described in chapter 5 (validation interviews). Of course, many more conversations have taken place over the course of this research, but the application of interviewing as a research method is fairly limited.

- *Case study*. In chapter 7, we describe two case studies; one in the criminal justice and one in the health care domain. These case studies and the chapter as a whole conform to the theory of Chain-computerisation and its method of chain analysis.

1.5 Research relevance

We now discuss the relevance of the research included in this dissertation. We argue that it has relevance for both science and for practice/society as a whole.

1.5.1 Scientific relevance

Answering the main and sub research questions contributes to the body of knowledge in the area of interorganisational information systems. It has been argued that this is a fundamentally different domain than that of individual organisations (e.g. Plomp & Grijpink, 2011b; chapter 7 of this dissertation) and that there exists a need for theories focused at this interorganisational level. Literature discussing the level of chain digitisation often focuses on one single organisation. As chain digitisation exceeds the level of a single organisation, its maturity actually should be measured at the chain level as well. McCormack, Bronzo Ladeira, and Valadares de Oliveira (2008) stressed the importance of maturity models that take into account the wider context of the supply chain and also indicated that such a model does not yet exist. In chapter 2, we develop one. In chapter 5 we develop yet another maturity model that did not exist, specifically aimed at the chain digitisation maturity of point-of-sale systems.

All chapters contain empirical data. This is of course related to the relevance to practice (see below), but it also furthers the development of scientific theory. We conduct both generic (i.e. across sectors) and specific (i.e. within a sector) studies. We address the topic of interorganisational information systems from different units of analysis, ranging from individual organisations (see for example chapter 4) to entire chains (e.g. chapter 7).

Little is known on how small organisations use ICT and how they deal with the possibilities ICT offers them (Southern & Tilley, 2000). We specifically address SMEs in several chapters of this dissertation (refer to Table 1.1).

We believe we also provide some methodical innovation. In interorganisational research, there exists the problem of how to analyse a value chain which consists of many partners. In an ideal world, we would like to collect information from all chain partners. However, this requires substantial time and effort, and furthermore, it is often not possible to gain

access to all partners in a chain. We find new ways to deal with this issue, for example, in chapter 2 we study retail sectors through their trade organisations.

1.5.2 Relevance for practice and society

The major scientific questions in the field of interorganisational information systems are firmly grounded in practice. When we ask the scientific question why so many chains fail to successfully adopt IOS, we pose a question that is very relevant to those actual chains as well. Interorganisational information systems are large-scale systems, which entails that there are many parties involved, both public and private.

Specifically, the retail sector is very important for the Netherlands, from an economical (high turnover), social (high employment), and cultural (many immigrants work in this sector) perspective. Health is also one of the dominant sectors of the Dutch society, but here the problem is more that the costs of and demand for health care are rising, while at the same time the available resources in terms of money and labour force are not. The debate on the national Electronic Patient Record (cf. Schäfer et al., 2010) shows that there is also a high political relevance. And of course, in the end, the medical domain is all about the lives of people. An (in)adequate interorganisational information system can make the difference between life or death.

Many data used in this research (i.e. the data sets from chapters 2, 5, 6, and 8) can be directly related to research projects for external parties (i.e. the Dutch Ministry of Health, Welfare and Sport, the Dutch Ministry of Economic Affairs, and HBD – the Dutch central industry board for retail trades). The other chapters are also based on empirical data collected among practitioners, like CIOs (chapter 3), small retailers (chapter 4), and those active in the criminal justice and health care domains (chapter 7). This underlines the practical relevance of the research that has been conducted.

1.6 Overview of recurring concepts

Besides the central concepts of interorganisational information systems and chain digitisation, which were introduced above, there are some other recurring concepts in this dissertation research (many of these concepts can be directly related to the themes in Table 1.1). In order to facilitate the understanding of the subsequent chapters, we provide brief introductions on these concepts below.

Supply chain management – or the importance of supply and demand

Supply chain management (SCM) is an approach that builds on the concept of the supply chain (see above). It is hard to give a (good) definition of SCM, because the term is used frequently and in different contexts. Based on an analysis of literature in the SCM field, Tan (2001) confirms this and even talks about 'abuse' of the term. Yet, according to Tan, three

dominant trajectories can be distinguished: SCM focuses on (i) the purchasing and supply activities of manufacturers, (ii) the transportation and logistics functions of wholesalers and retailers, and (iii) any value-adding activity from obtaining raw materials to the end user (and even further: recycling). Although this latter approach is preferable in terms of completeness, it is not the best from the perspective of practical feasibility, because it concerns (too) many parties and processes.

Although the term demand chain management has been used by some scholars (e.g. Heikkilä, 2002; Jüttner, Christopher, & Baker, 2007) to focus on the other side of the chain, the main focus remains on relations with suppliers (wholesalers and manufacturers). Furthermore, supply chain management is often related to a more 'technical' approach of interorganisational relations, also known as operations research. It involves working with optimisation models and chain simulations, e.g. through linear programming (cf. Shapiro, 2009).

In this dissertation, we view SCM mainly as a form (or synonym) of chain digitisation. However, we emphasise the importance of considering the whole chain (i.e. both supply and demand), thereby deeming the term *supply* chain management less practical.

Maturity models

Maturity models (or lifecycle models, models of growth) are common in information systems, but also in other domains, to define different – distinct – maturity levels of a process or activity (Nolan, 1979; King & Teo, 1997). A maturity model describes the stages through which an entity (e.g. a system, process, organisation or value chain) can progress or evolve. Each level is used to characterise the state of this entity (Clark & Jones, 1999).

Maturity models have often been criticised for being too generic, not adequately describing the development path, and lacking empirical validation (Alonso-Mendo, Fitzgerald, & Frias-Martinez, 2009). Of course, a model is a simplification of reality, and maturity models form no exception in this respect. We believe however, that the different types of interorganisational systems fit the characteristics of a typical maturity ladder. Furthermore, we attempt to avoid some of the typical pitfalls of maturity model studies in our research method, e.g., through applying the models in practice and doing so through various research methods.

The concept of a maturity model is relevant to this dissertation, in that it is our approach to answer the first sub-question (SQ1). We develop and empirically validate a maturity model in chapter 2. In chapter 3, we further operationalise this model and again conduct empirical measurements with it. Finally, in chapter 5, we develop another maturity model, specifically aimed at measuring the chain digitisation maturity of point-of-sale systems.

Chain-computerisation

Both the concept of chain-computerisation and the accompanying theory were coined by Grijpink (1997; Grijpink & Plomp 2009; Grijpink, 2010 provides an English overview). Chain-computerisation specifically focuses on social chains (e.g. chains aimed at health or security). Following this theory, chains are dynamic concepts, determined by a so-called 'dominant chain problem'; a problem that none of the parties in the chain can solve on its own. According to Grijpink, the only way to ensure successful interorganisational collaboration – and thus to have a chance that the implementation of an interorganisational information system succeeds – is when it is both necessary and feasible. The theory provides four assessment profiles to check whether this is the case. Over 25 chains have been analysed using this method as part of the Chain Landscape Research at Utrecht University (Plomp, 2011).

Chain-computerisation is relevant to this thesis in that it provides a perspective on interorganisational collaboration in non-profit chains. It is referenced throughout the dissertation, e.g. it offers one of the maturity models found in the literature study of chapter 2. Furthermore, it is extensively used in chapter 7, where a more elaborate explanation of the theory will be provided.

Point-of-sale (POS) systems

Point-of-sale (POS) systems are a specific type of retail ICT. In their most basic form, they are a computerised version of the cash register, which is traditionally used by retailers to ring up customers' purchases. There are several advantages to POS systems. Besides the use of sales data from a POS system for marketing purposes, time consuming administrative activities like ordering, customer management, stock control, order tracking, and satisfying regulations can be reduced as well. Recently, POS systems also provide the ability to connect to other systems across company boundaries, thereby enabling chain digitisation. While much literature exists on supply chain management and retailing in general, little research has been performed on POS systems and their role in this field.

In POS systems we recognise the typical two sides of interorganisational relations: supply and demand. On the one hand, there is the connection with for example the wholesaler, with whom for instance inventory level sharing or even automatic ordering can be arranged. On the other hand, there is the relation with the customer, typically an individual, but there are also institutional customers (these are typical for food retailers, e.g. companies or restaurants that order large amounts). Towards the customer, ordering can for example also be digitised through a web shop.

Although POS systems are strictly speaking not interorganisational ICT, they do provide many potential possibilities for interconnecting with other organisations, as we will see in chapter 5. But more importantly, they form – especially for small retailers – the ICT back-

bone of the average retail organisation. That makes the POS system an important last node for chain digitisation in the entire value chain, and thereby also makes the basic adoption of these systems (see chapter 4) a relevant issue.

Health information systems

The health care sector has its own specific information systems. Hospitals have hospital information systems, pharmacies have pharmacy information systems, and the systems of general practitioners are called GP information systems. What makes them particular however, is that they deal with patient data. These data are more sensitive (e.g. in terms of privacy), more complex (e.g. in terms of the richness of information, for example imagery) and involve more simultaneous stakeholders (e.g. family doctor, specialist, hospital, pharmacist, insurance company) than those of a typical product that goes through a value chain.

Health information systems are particularly relevant to the context of chapter 6, and – to a lesser extent, as we discuss them in a generic sense there – to chapter 7. In the former we discuss the situation of the Dutch primary care, whereas in the latter we discuss (among other things) the health care sector as a whole.

1.7 Thesis outline

This thesis consists of nine chapters, divided over five parts. The first part is this introduction and the last part contains the conclusions. The remaining, intermediate parts are:

- *Part II: Developing a maturity model for chain digitisation.* This part contains two related studies concerning the development and operationalisation of a maturity model for chain digitisation. It also contains empirical work, namely the application of the model on the Dutch retail sector, and on Dutch organisations in general.
- *Part III: Studies on interorganisational information systems in retail and health.* The three chapters in this part focus on empirical application of interorganisational concepts in the retail and health sector. Two chapters concentrate on point-of-sale (POS) systems. This is a type of information system that is specific to the retail sector and forms the central part of a retailer's ICT. The third chapter describes a study on interorganisational ICT in primary care.
- *Part IV: Policy studies on interorganisational information systems.* In this part we shift our attention to the policy perspective. We look at interorganisational chains as a whole and work towards an information strategy that takes into account the threat of identity fraud. Finally, we evaluate a policy programme in terms of its success in furthering the uptake of interorganisational ICT.

These three parts match with the three elements of the main research question. They also form a logical sequence: from developing theoretical concepts, through empirical application, to policy formulation. However, all parts contain some of all these elements. For instance, in part II there is empirical application as well, and in part IV there is theory development too. A more detailed overview of the dissertation's structure is given below.

Part I: General introduction

Chapter 1 – General introduction
In the first – this – chapter, we describe the motivation for this thesis research and sketch the domain/context of interorganisational information systems, in which it should be placed. We present the research questions and approach, and indicate the relevance of this dissertation research. Finally, we discuss some relevant concepts and lay out the structure of the thesis.

Part II: Developing a maturity model for chain digitisation

Chapter 2 – Measuring chain digitisation maturity: An assessment of Dutch retail branches
In this chapter, we present the results of a literature study on maturity models for chain digitisation. Based on this outcome, a measurement model and typology for chain digitisation maturity are developed. This chapter also includes an empirical application of that model to the retail sector of the Netherlands; a prelude to the other retail-focused chapters of the thesis (i.e. chapters 4 and 5).

Chapter 2 has been published in *Supply Chain Management: An International Journal* (Plomp & Batenburg, 2010).

Chapter 3 – Determining chain digitisation maturity: A survey among Dutch CIOs
In chapter 3, we further operationalise the maturity model from the preceding chapter and, through a survey among Chief Information Officers (CIOs) of Dutch organisations, search and find determinants that correlate with chain digitisation maturity. We also extend the model by plotting the different organisations in the typology and applying cluster analysis.

Chapter 3 has been submitted for journal publication (Plomp, Batenburg, & Van Rooij, n.d.); a shorter version has appeared in the *Proceedings of the 23rd Bled eConference "eTrust: Implications for the Individual, Enterprises and Society"* (Plomp, Van Rooij, & Batenburg, 2010).

Part III: Studies on interorganisational information systems in retail and health

Chapter 4 – Determinants of point-of-sale system adoption: A survey among small retailers in the Netherlands

This is the first of two chapters focusing on point-of-sale (POS) systems. Although these retail-specific information systems are not interorganisational per se, they do provide many opportunities for chain digitisation, as we will see in chapter 5. Here, we examine the determinants of the adoption of POS systems by small retailers. We base our conceptual model for predicting adoption on eight existing adoption models. Next, we visited actual retailers asking them to fill out a survey, in order to validate our conceptual model.

Chapter 4 was included in the *Proceedings of the 17th Americas Conference on Information Systems* (Plomp, Huiden, & Batenburg, 2011).

Chapter 5 – Chain digitisation support by point-of-sale systems: An analysis of the Dutch product software market

In this chapter, we turn our attention to the POS product software market. We analysed the point-of-sale systems available from Dutch software vendors and positioned these systems in a maturity model based on the functionalities they provide, considering both backward and forward chain digitisation.

Chapter 5 has been accepted for publication in the *International Journal of Information Technology and Management* (Plomp, Van Rijn, & Batenburg, in press).

Chapter 6 – Adoption of interorganisational ICT in primary care

In the sixth chapter, we consider the situation of the Dutch health care sector, specifically in primary care. After reviewing health information systems literature, we empirically analyse the factors that play a role in the adoption of interorganisational ICT by surveying family doctors (GPs).

Chapter 6 has appeared in the *Proceedings of the 15th International Symposium on Health Information Management Research* (Plomp, Batenburg, & Verheij, 2011).

Part IV: Policy studies on interorganisational information systems

Chapter 7 – Towards an information strategy for combating identity fraud in the public domain: Cases from healthcare and criminal justice

In this chapter of the thesis, we ponder how to arrive at a successful information strategy to combat identity fraud in the large-scale processes of the public domain. We consider two cases, in which we focus truly on the chain level: one from the domain of criminal justice and one from the health domain.

Chapter 7 has been published in the *Electronic Journal of e-Government* (Plomp & Grijpink, 2011b). An earlier version was included in the *Proceedings of the 11th European Conference on e-Government* (Plomp & Grijpink, 2011a).

Chapter 8 – ICT policy to foster interorganisational ICT adoption by SMEs: The Netherlands Goes Digital case
This penultimate chapter deals with the influence of government policy on the adoption of interorganisational ICT by SMEs. By comparing survey data from participating SMEs with a control group of SMEs that did not participate in this particular policy programme, we check for differences in adoption.

Chapter 8 has been submitted for journal publication (Plomp, Batenburg, & Den Hertog, n.d.); an earlier version has been published in the *Proceedings of the 24th Bled eConference "eFuture: Creating Solutions for the Individual, Organisations and Society"* (Plomp, Batenburg, & Den Hertog, 2011).

Part V: Main conclusions & outlook

Chapter 9 – Main conclusions & outlook
In the final chapter of this dissertation, the main findings are discussed. Furthermore, we reflect on the thesis as a whole. Finally, we present a research agenda for possible future studies on the topic of interorganisational information systems.

Part II:
Developing
a Maturity Model
for Chain Digitisation

2 Measuring chain digitisation maturity: An assessment of Dutch retail branches[4]

Purpose *– The purpose of this article is to develop a validated measurement model and typology for chain digitisation maturity, defined as the degree of interorganisational collaboration through ICT.*

Design/methodology/approach *– Through a literature (meta) study, 22 existing maturity models are found and analysed, on the basis of which an integrated framework is developed. This framework is subsequently applied to interorganisational collaboration within the Dutch retail sector (i.e. retailers and their wholesalers, manufacturers, customers, and trade organisations). The measurement model is tested by determining the chain digitisation level of 24 different retail sub-sectors (branches) through desk research, interviews, and surveys. Data are collected at the level of the branch, mainly through representatives of trade organisations.*

Findings *– The framework (i.e. measurement model) appears to be applicable to describing the Dutch retail sector and comparing its branches, providing both expected and new insights. The typology supports the vision of the combination of two dimensions: the level of technology and the level of organisation.*

Research limitations/implications *– The framework has been applied to the (Dutch) retail sector only. It seems suitable for application to other sectors as well.*

Practical implications *– The empirical application provides an extended view of the current situation of the (Dutch) retail sector with regard to chain digitisation. On this basis, a roadmap can be derived to support the adoption and deployment of chain digitisation among retail organisations.*

Originality/value *– Our framework for chain digitisation and the derived typology are of value to the SCM research community, as they are specifically developed and tested at the level of interorganisational chains.*

[4] This work was originally published as: Plomp, M. G. A., & Batenburg, R. S. (2010). Measuring chain digitisation maturity: An assessment of Dutch retail branches. *Supply Chain Management: An International Journal, 15*(3), 227-237.

2.1 Introduction

The field of interorganisational information systems (IOIS) has a long history (e.g. Barrett & Konsynski, 1982) and many different terms to describe it have been introduced. Most prominently supply chain management (SCM) related terms such as supply chain automation, supply chain integration, and collaborative planning, forecasting, and replenishment (CPFR), but also more organisational/business related terms such as interorganisational collaboration, virtual organisations, and value networks or IT-related terms such as interoperability, e-business, and chain computerisation.

Trends like increasing competition, more demanding consumers, rising administrative burden, and a pending economic recession in many parts of the world make IOIS interesting for many organisations. The alleged advantages of IOIS seem to meet these challenges through cost reduction, productivity improvements, and innovation for competitive positioning (Barrett & Konsynski, 1982; Morrel & Ezingeard, 2002). There are many examples of (mainly large) organisations that have experienced significant improvements after altering their supply chain processes such as (the chains of) Dell, Wal-Mart, and Hewlett-Packard (Alvarado & Kotzab, 2001). A retail specific example is the study of Vieira, Yoshizaki and Ho (2009), which looks at collaboration intensity in Brazilian large retail networks. It can be seen as an omission that there are fewer examples for smaller organisations. There seems to be no clear insight into which factors drive small businesses to adopt and deploy IOIS.

In this chapter, we depart from the notion that without considering the organisational dimension, the deployment of technology (i.e. ICT) will be less useful and/or effective (e.g. Scott Morton, 1991; Daft, 2001; Turban, McLean, & Wetherbe, 2001; Luftman & Kempaiah, 2007). This is particularly the case for the success of interorganisational systems, including e-business (Zhu & Kraemer, 2002). The common notion is that technological and organisational systems reinforce each other, as evidenced for example by theory on business–IT alignment (Henderson & Venkatraman, 1993). At every scale and level, technology and management (or 'organisation') should be related.

Literature discussing the level of chain digitisation often focuses on one single organisation. As chain digitisation exceeds the level of a single organisation, its maturity actually should be measured at the chain level as well. Here, there seems to be a white spot. McCormack, Bronzo Ladeira, and Valadares de Oliveira (2008) stressed the importance of maturity models that take into account the wider context of the supply chain and also indicated that such a model does not yet exist. In this chapter, we develop such a framework and validate the resulting measurement model at the level of interorganisational chains within a number of branches (i.e. sub-sectors of an industry).

Finally, it should be noted that we specifically use the term *chain digitisation* instead of IOIS to stress that it encompasses collaboration between multiple organisations, i.e. firms working together along value/supply chains through ICT. Chain digitisation is therefore to be interpreted as a broad concept. While some scholars make a distinction between the supply and demand side of chain management or automation, from a chain digitisation perspective this distinction is not or less relevant.

Given the above, we address three questions in this chapter:

1. First, we set the question of *how to measure the degree of chain digitisation at the level of interorganisational chains, recognising both the technological and organisational dimension?*
2. Second, we address the question of *how to model alignment for chain digitisation (at the level of interorganisational chains)?*
3. Question one and two build upon each other, for if we want to be able to say anything about the alignment, we need to actually distinguish different degrees of chain digitisation. We argue that policies to improve alignment at the level of interorganisational chains require a yardstick to actually determine the degree of chain digitisation. This leads up to our third and final research question: *how to validate this model empirically in the context of the Dutch retail sector?*

The structure of this article is as follows. First a meta-analysis (literature study) is presented which leads to an overview of existing models. Based on this, an integrated framework for measuring chain digitisation is developed, including a typology to classify interorganisational chains in this respect. Both the measurement model and typology are applied to a number of branches within the Dutch retail sector. At the end of the chapter, limitations of this work are discussed, and to conclude, suggestions for future research endeavours are given.

2.2 Meta-analysis: Existing models

Our search for academic models for measuring chain digitisation started by focusing on what can be labelled *maturity models* or *lifecycle models*. Models that were selected as relevant are models for interorganisational collaboration, preferably those mentioning ICT. Hence models that describe the development process or 'transformation' of interorganisational systems (e.g. strategy formulation, identification of opportunities, system design, etc.) were left out of the scope. We also focused on models that explicitly present different and defined levels or stages of deployment. Furthermore, only scientific publications (i.e. books, articles, and conference proceedings) were included. We did not exclude specific types of

publications, as in computer science books, conferences, and journals are considered to be of equal importance (Meyer, Choppy, Staunstrup, & Van Leeuwen, 2009).

The models referenced in this section were found through an online literature search. Two search engines were used in this undertaking: Google Scholar and Omega. Google Scholar is a 'general purpose' academic-oriented search engine, which provides the user with selected scientific articles. Not much research has been done on this relatively new and public search engine, but a study by Jacsó (2008) evaluates the strengths and weaknesses of Scholar. A positive aspect is that it covers many scientific journals and books. The main downsides of Scholar mentioned by Jacsó are erroneous counting of results and problems in automatically distinguishing author names from the rest of the text. These shortcomings do not seem to affect our current purposes. Our second literature search engine was Omega, the name given to the online content search engine of Utrecht University. Omega covers over 16 billion full-text papers from thousands of digital journals of different disciplines. Publishers included are Ebsco, Elsevier Science Direct, JStor, SpringerLink, IoP, ArXiv, Karger, Pubmed Central, Oxford Journals, and Highwire.

A total of 12 different queries (18 when English/American language differences were accounted for) were used with the keyword combination: "maturity" OR "model" AND

- "chain digiti[z|s]ation",
- "chain computeri[z|s]ation",
- "interorgani[z|s]ational cooperation",
- "interorgani[z|s]ational collaboration",
- "interorgani[z|s]ational information systems",
- "IOIS",
- "IOS",
- "supply chain",
- "SCM",
- "value chain",
- "organi[z|s]ational network",
- "business network".

The online literature search provided many hits (i.e. literature sources found), but only a few publications fit our scope. At first, a total of 413,588 hits was found, 55 through Omega

and 413,533 through Google Scholar. Note that these numbers are likely to include duplicates, both between and within search engines. While the limited number of search results from Omega can be considered as key findings, Google Scholar added many publications that were not included in the databases of university libraries and academic publishers. In terms of triangulation, we therefore believe that it is useful to use multiple search engines. Furthermore, the number of hits differed greatly between search terms, ranging from 6 for "chain digitisation" to 179,038 for "IOS".

We applied a stepwise method in performing the literature study. Based on the assumption that search engines tend to list the most relevant results first, only the first 100 were analysed. Subsequently, a second query was performed, where the search term was combined with the term "maturity model" to further limit the result set. This was done in order to double-check for possibly relevant items that were not discovered in the first 100 results. If this again yielded more than 100 results, these were also analysed, and subsequently limited by another query: the search term combined with "maturity model" (this time as a connected phrase, e.g. "SCM maturity model"). This never led to more than 100 results for a search term.

Our analysis of the search results consisted of checking the title and abstract (if available) of the source and scanning the publication for a maturity model (table, chart, or list of items). When after careful reading a 'unique' maturity model for chain digitisation was found (i.e. one that met our focus criteria and was developed by the original author or authors), it was included in our selection. Table 2.1 presents a schematic overview of the 22 models that were found and selected through this literature study process.

Comparing the list of 22 models reveals several differences. The main differences found are related to their degree of documentation, number of levels, scope, domain focus, and cumulativeness. These characteristics of the models are highly important, because they provide a specific perspective on the domain of chain digitisation maturity. As we will elaborate below, this table enables us to determine several common denominators for developing our integrated chain digitisation maturity model.

Not every chain digitisation model is *documented* to the same degree. Many models (10 out of 22) were presented in a paper published in an international peer-reviewed journal. Others were published in a book (5), conference paper (6), or statistical report (1). Also, the extent to which models are presented in the papers differs. Sometimes the model is the main topic of the publication (e.g. Folinas et al., 2004), whereas in other cases it is only a small part of the publication (e.g. Seidman & Sundararajan, 1998) or only a picture of the model is presented (e.g. Handfield & Straight, 2004).

Table 2.1 Overview of models of chain digitisation and their levels

Name	Author(s)	Year	Source	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Levels of information sharing between organisations	Seidmann and Sundararajan	1998	Book chapter	Ordering information	Operational information	Strategic information	Strategic and competitive information		
Levels of supply chain integration	Tyndall, Gopal, Partsch, and Kamauff	1998	Book	Open-market negotiations	Cooperation	Coordination	Collaboration		
Organisational interoperability maturity model	Clark and Jones	1999	Conference	Independent	Ad hoc	Collaborative	Combined	Unified	
Chain computerisation: organisation profile	Grijpink	1999	Journal	Informal talks	Formal consultation	Joint decision making	Ad hoc joint action (chain projects)	Common network organisation	
E-business development framework	Poirier and Bauer	2000	Book	Internal supply chain optimisation	Network formation	Value chain constellation	Full network connectivity		
Arcs of integration	Frohlich and Westbrook	2001	Journal	Inward-facing	Periphery-facing	Supplier- or customer-facing	Outward-facing		
Evolution of enterprise resource planning	Kalakota and Robinson	2001	Book	Manufacturing integration (MRP)	Enterprise integration (ERP)	Customer-centric integration (CRP)	Inter-enterprise integration (XRP)		
Interorganisational information systems types	Shah, Goldstein, and Ward	2002	Journal	No electronic integration	Low integration	Moderate integration	High integration		

Stages of growth for e-business (SOGe) model	Prananto, McKay, and Marshall	2003	Conference	No clear direction for the organisation's e-business initiatives	E-business initiatives are increasingly considered as an important component of the organisation's business	Clear direction for e-business initiatives development, but still technology-centric	E-business adoption and development is becoming more business-focused	E-business initiatives aim to provide strategic benefits by building strategic systems	E-business is deeply embedded throughout every aspect of the organisation; strong integration
Levels of collaborative planning, forecasting, and replenishment (CPFR)	Skjoett-Larsen, Thernøe, and Andresen	2003	Journal	Basic CPFR	Developing CPFR	Advanced CPFR			
Types of supply chain evolution	Folinas, Manthou, Sigala, and Vlachopoulou	2004	Journal	Core logistics activities' efficiency	Coordination of internal organisational processes	Inter-enterprise business exchanges	Establishment of dynamic networks between virtual organisations		
Supply chain redesign capability maturity model	Handfield and Straight	2004	Conference	Basic beginnings	Moderate development	Limited integration	Fully integrated supply chains		
Business process orientation maturity model	Lockamy and McCormack	2004	Journal	Ad hoc	Defined	Linked	Integrated	Extended	
Levels of information technology adoption	Wang, Chang, and Heng	2004	Journal	Essential functions	Single department / operation process	Cross department / multi-process integration	Enterprise integration process	B2B integration / collaborative business	
Collaboration continuum	McDougall, Rajabifard, and Williamson	2005	Conference	Cooperation	Mutual adjustment	Alliance	Corporate partnerships		

Name	Author(s)	Year	Source	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Levels of supply chain integration	McLaren	2006	Conference	Functional focus	Internal integration	Linked network	Integrated network	Optimised network	
Development phases of ICT use	Statistics Netherlands	2006	Statistical report	No external data communication	External data communication; no website, sales, electronic product delivery, or on-line after-sales service	Website	Electronic sales	Electronic product delivery and/or after sales service	Linking the company's order processing system with that of buyers/clients
Construction supply chain maturity model (CSCMM)	Vaidyanathan and Howell	2007	Conference	Ad-hoc	Defined	Managed	Controlled		
Levels of inter-organisational information system development	Williamson	2007	Journal	Elementary IOS	Intermediate IOS	Advanced IOS			
Stages of process integration	Aryee, Naim, and Lalwani	2008	Journal	Optimisation	Integration	Supply synchronisation	Demand synchronisation		
Supply chain management maturity model	Schoenfeldt	2008	Book	Siloed company	Internal integration	One level of integration / partnership	Two levels of integration	Entire chain integration	
Maturity levels for interoperability in digital government	Gottschalk	2009	Journal	Computer interoperability	Process interoperability	Knowledge interoperability	Value interoperability	Goal interoperability	

With regard to the *number of levels* or stages, we found that most models (18 out of 22) have four or five levels. Two models consisted of six levels and two other models mentioned only three stages. It is notable that the labels of these latter models (i.e. Skjoett-Larsen et al., 2003; Williamson, 2007) are not very informative. Both have a 'basic-intermediate-advanced' way of naming their levels. Another finding is that different labels are used between models for what might be considered the 'same' maturity level. E.g. one could say that the level 'core logistics activities' efficiency' defined by Folinas et al. (2004) is similar to the level 'functional focus' as defined by the model of McLaren (2006). However, we do not aim to create a common standard here, to actually make this kind of mappings between the levels of all models. We therefore remain by comparing the models with regard to their number of levels, i.e. their 'range' or scope.

An interesting point concerning the *scope* is that most chain digitisation models encompass the entire chain (e.g. from producer to customer), but differ with respect to their focus on the single organisation or (a part of) a chain as the level of observation or measurement. This distinction between the organisational and chain level is quite basic in the field, as described for instance by Harland (1996). She distinguished four levels of SCM research: internal chain, dyadic relationship, external chain, and network. Each of the 22 models we found obviously has at least some form of chain orientation (i.e. moving beyond the level of the internal chain) – otherwise it would not have been included in the selection. Nevertheless, at least 8 of the models focus entirely on an individual organisation, whereas others do so for the first levels and direct their attention to the entire chain only at the higher levels of the model (e.g. Folinas et al., 2004). Only 3 models have a specific chain focus in that they depart not from the viewpoint of an individual focal organisation, but from the chain itself. We will return to this point when we discuss our own integrated framework.

Concerning the *domain focus* of the chain digitisation models, 11 models were found to concentrate on organisational aspects such as processes, governance, and product standardisation (e.g. Grijpink, 1999). Three models can be considered to be focused on the use of information technology (e.g. Statistics Netherlands, 2006). The remaining 8 models take both domains into account (e.g. Folinas et al., 2004).

A specific comparison can be made of the differences in *cumulativeness* of the models. In general, a specific trait of maturity models is that levels are assumed to be cumulative. That is, achieving *level x* implies that *level x–1* is also fulfilled. Capability Maturity Model based quality models, for instance, apply this principle to assessing or benchmarking firms or departments (Paulk, Weber, Curtis, & Chrissis, 1995). The general idea is that compliance with all 'lower' parts of the ladder is required as they are necessary conditions to achieve the higher ones; that is, no parts or (sub-)steps can be skipped. Some models do not comply with this (interestingly enough, largely unwritten) rule. At the lowest level they define an

organisation as 'inward-facing', while at level four it is labelled 'outward-facing'. It is not defined by the authors, however, that an outward-facing organisation probably still deals with internal matters adequately. Moreover, the authors of these models do not claim to comply with the accumulation assumption themselves. In only one model description (Statistics Netherlands, 2006) was it stated explicitly that the 'accumulation assumption' is not valid for this model. Also, only for one model (Grijpink, 1999) was it acknowledged that the model *does* adhere to the assumption. In general, however, all models do comply with the general notion of maturity models that each level is 'better' or 'higher' than the level that precedes it. It should be noted that the differences between levels cannot be explicated as the levels are mostly described in words instead of 'hard measurements'. Still, one should realise that all chain digitisation models define ordinal scales at most.

2.3 Towards an integrated framework

Based on the 22 models found and the subsequent analysis of these models in the previous section, we developed an integrated framework. This framework incorporates the contents of many models as well as our specific findings with respect to model scope, domain focus, and the number of levels.

From the finding that models focus on organisational or technological aspects or both, we argue that a combined model should take both dimensions into account. The recent stream of business–IT alignment theory and its validation (see Chan & Reich, 2007) provides a fundamental reason for the organisational and technological domain to coincide. In particular, with complex systems as interorganisational chains, the alignment of business and IT is crucial in order to achieve successful collaboration. This also implies that it requires actors at the chain level to coordinate this interorganisational business–IT alignment (a 'value chain orchestrator' for instance). From our literature analysis, however, it appeared that most models focus on measuring the activities or policies of a single organisation. This defines or measures the 'chain readiness' of an organisation, but if we want to analyse the degree of digitisation of the chain itself, however, we should define a model that addresses behaviour at the level of the chain accordingly.

Based on these starting points we delineate our framework for chain digitisation to model the alignment of the organisational and technological dimension, explicitly, at the chain level. In doing so, we first define the two dimensions separately to ensure that we cover each by its domain-specific developments and indicators. Then, we define the range of both dimensions as equally as possible by setting the 'minimum' and 'maximum', and subsequently divide this range into four levels that are also as equally divided as possible. Most models we found in our literature study consist of four levels. This seems a sensible amount, comprising one level for 'low' or 'no' chain digitisation, one for 'full' or 'com-

plete', and two for the remaining intermediate levels between these. Because we want to assess alignment, we formulate both dimensions with the same number of levels.

2.3.1 The technological dimension

When we consider the chain digitisation models from our online literature study that have an explicit technological component, it stands out that their structures are quite similar. At the lower levels there are no or hardly any technologies that have linkages outside the organisation itself, whereas at the highest level of the models, extensive technological integration between parties is realised. The levels we define are similar to those defined by Folinas et al. (2004) and Statistics Netherlands (2006). These two chain digitisation models provide indicators to enable (indicative) measurements, and cover the broadest spectrum of the recent developments in IT from a chain perspective.

For the technological dimension we distinguish four different levels that represent an increasing degree of chain digitisation:

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 & 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 come from multiple locations through open standards and architectures (Van Beers & Bouwman, 2007).

Earlier we referred to the accumulation assumption of maturity models, that is, when a certain level is achieved all lower levels need to be passed. Here, we do not follow this assumption as we believe that in our technological dimension for a specific *level x*, a technology may be required that actually obsoletes technology from *level x–1*. A good example is the

recent replacement of Electronic Data Interchange (EDI) by eXtensible Markup Language (XML) technology (Zhu, Kraemer, Gurbaxani, & Xu, 2006).

2.3.2 The organisational dimension

Just as with the technological dimension, almost all of the models we analysed in the literature study that relate to the organisational dimension have a similar structure. There is, however, diversity as to *which* organisational aspect is concerned, probably because 'organisation' is a broader concept. It is notable that many chain digitisation models focus on the extent of collaboration: internal, between some parties, or across the entire chain. The models of Wang et al. (2004) and Schoenfeldt (2008), for instance, assume that interorganisational collaboration is only relevant for the extended chains.

For the organisational dimension of chain digitisation we distinguish four different levels which cumulate along an ordinal scale:

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, King, Viehland, & Lee, 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.

2.3.3 Integration: A typology for chain digitisation

Business–IT alignment implies that interorganisational chains benefit from a strong connection between the technological and organisational dimension as defined above. From this it can be assumed that interorganisational alignment is more successful if both dimensions are on the same maturity level. This can be called alignment by 'levelling' (cf. Batenburg & Versendaal, 2008), and can be seen as a precondition for the 'direct' alignment as defined by Henderson and Venkatraman (1993) and Luftman and Kempaiah (2007). Therefore we combine the two previously described dimensions into a single framework, that is a 4 by 4 matrix, within which different (integrated) chain digitisation situations can be defined. To maintain an overview, we distinguish the four situations or types, depicted in Figure 2.1 as the four quadrants of the matrix:

- *Basic chain digitisation*. Within this interorganisational chain, both collaboration and the available technology are at a low level. There is bilateral collaboration at best and technology is used for transactions only. Regarding their maturity, both dimensions are in balance, however. This can for instance be the case in interorganisational chains that encompass relatively standard and frequent processes and transactions, such as in markets for fast-moving consumer goods.

- *Technological proficiency*. Despite the fact that the interorganisational collaboration is still low, the available technology within this interorganisational chain is of a more sophisticated level (i.e. no less than at the point of e-collaboration). The two dimensions are not in balance. This can be the case if an interorganisational chain has standard, frequent transactions that require relatively low levels of trust between the parties. These can be e-auctions or e-marketplaces in industrial markets for raw materials and the logistics/transport sector.

- *Relational proficiency*. As the opposite of technological proficiency, within this interorganisational chain there is advanced collaboration (i.e. multilateral collaboration or more), but the technology lags behind with regard to the chain digitisation maturity. Again, there is no balance between the two dimensions. This could occur in interorganisational chains that deal with non-standard transactions that involve a high amount of trust and hence personal contact, such as in one-of-a-kind industry or project-based sectors like the construction industry.

- *Advanced chain digitisation*. Within this interorganisational chain, the available collaboration and the existing technology are both at the same, developed level. Hence, both dimensions are in alignment with each other. Interorganisational chains that concern products or services that have complex specifications but are nevertheless ordered with high or predictable frequency are examples of this type.

Examples are the mature e-commerce industries such as travel agencies and multimedia consumer markets.

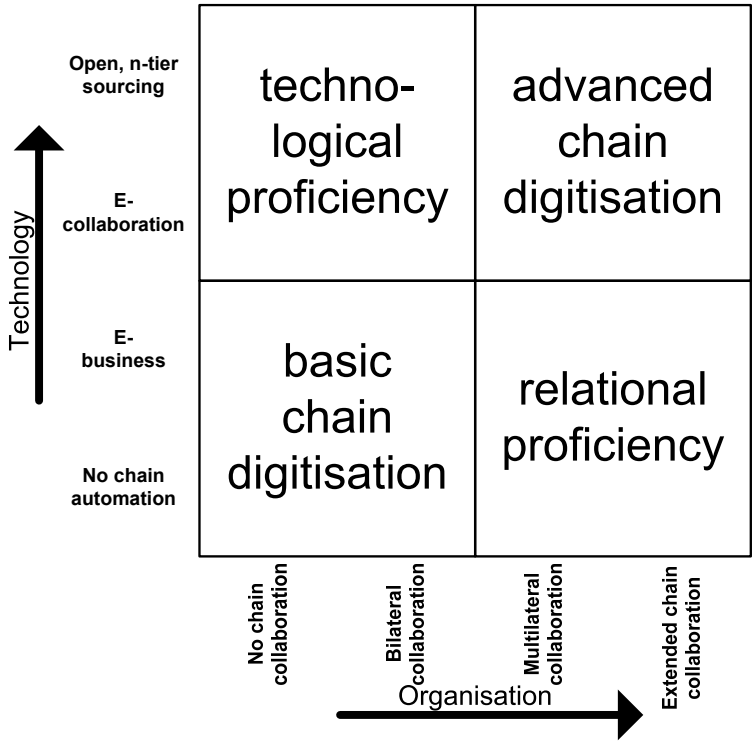

Figure 2.1 A typology for chain digitisation

Note that the above-mentioned types do not imply a sequential order of development. Although it is likely that an interorganisational chain will start at *basic chain digitisation* and through *technological* or *relational proficiency* develop towards *advanced chain digitisation*, it is also possible that direct development from the former to the latter occurs. The framework primarily indicates that there is considerably less chain digitisation at the first than there is at the last type, and that the other two types are in-between this. Also, it can be the case that interorganisational chains that are 'misaligned' are still successful in terms of their added value; likewise the chains that have both low technological and low organisational maturity might not need to grow to a higher maturity level because of their specific circumstances ('situationality').

2.4 Empirical application: The Dutch retail sector

To apply our framework in practice, field research within the Dutch retail sector was performed. First the motives for selecting this sector will be described. Subsequently the method will be presented, followed by the results.

2.4.1 Motives

The threats described in the introduction of this chapter (competition, demanding customers, administrative burden, and economic recession) are very much the reality for the small and medium-sized enterprises (SMEs) that make up about 95% of the Dutch retail sector. A recent study by order of the European Commission (2008) shows that EU retailers tend to use less e-business compared to US retailers. Furthermore, SME retailers are behind larger companies with regard to ICT uptake. Earlier, other scholars studying Scottish (Wagner, Fillis, & Johansson, 2003) and Norwegian companies (Vaaland & Heide, 2007) also found that SMEs generally lag behind their larger counterparts with respect to SCM. Vaaland and Heide call for more research on this topic, preferably focused on one sector and in other countries.

Logistics and supply chain management are the core business of the retail sector as they are mostly the last party in the chain (i.e. moving products from producer through wholesaler and retailer towards the end customer). This puts the retail sector in a specific chain position and makes it an interesting domain for chain digitisation. Finally, retail is concerned with trade, which is an important activity for the macro economy.

2.4.2 Method

Instead of querying retail organisations, we collected data at the level of trade organisations that represent a certain retail branch. As the retail sector is very diverse due to the nature of the traded products, this provides an interesting opportunity to explore differences by the type of retail branch. One can think of differences between food and non-food branches or supply- and demand-driven branches, as the logistics and specificity of the interorganisational chains differ greatly. Trade organisations were chosen because they represent many SME retailers and they commonly have knowledge of the important players in the interorganisational field (e.g. manufacturers, suppliers), regulations, and consumer trends. It should be acknowledged however, that only one actor has been queried per branch.

The population of Dutch branches was examined through desk research, interviews, and surveys. Data collection took place from November 2006 to June 2007. Desk research was performed for 35 different retail branches. In terms of 'size', branches varied with regard to the number of retailers, turnover and employment. This desk research consisted of collecting branch statistics, visiting the websites of trade organisations, and performing Google

searches for the specific branches. Then 12 trade organisations of an equal number of retail branches were investigated through semi-structured face–to-face interviews with representatives of the trade organisations. The remaining trade organisations (23) were approached with a questionnaire through post and e-mail, which had a similar setup as the interview.

2.4.3 Results

Of the 35 retail trade organisations, 24 took part in the research; a participation rate of 69%. The 11 trade organisations which did not participate maintained their refusal after repeated requests by telephone. They brought up various reasons such as lack of time, interest in, and/or knowledge about the subject. Non-response analysis shows that it is unlikely that the non-response group of branches is biased, as it consists of traditional and modern, food and non-food, and small as well as large branches.

The scoring process used to classify branches onto the technological and organisational dimensions of our framework was based on combining several sources. Basically, the answers to the interview and survey questions were cross-validated with documents and other secondary sources. For instance, the application of the technological dimension was based on indicators as the advancement of purchase and ordering systems within the branch, and the existence of communication (ICT) standards for formatting, storing and exchanging retail product data. The organisational dimension was based on indicators as the existence of formal interorganisational bodies through which the supply chain partners communicate and collaborate on a regular basis, and specific organisational 'platforms' to enable and support chain digitisation within the branch. After the maturity scores for all retail branches were allocated and assigned in a comparative way, these were finally validated by the respondents and an expert on the Dutch retail sector. As some retail branches were quite diverse (for instance, some retailers have fully automated their external connections, while other still struggle with their internal shop automation), scoring them at one unified maturity level was complex. For this reason, in some cases an 'average' or a score between two levels was imputed.

Figure 2.2 shows the scores of the 24 retail branches, plotted on both the technological and the organisational dimension of chain digitisation. For the Dutch retail sector, it is found that in general the level of chain digitisation is low. This is in line with research in other countries and the expectations of the Dutch central industry board for retail trades. Most branches are of the 'limited chain digitisation' type. Nevertheless, 6 branches are positioned within the 'relational proficiency' type (see also Figure 2.2).

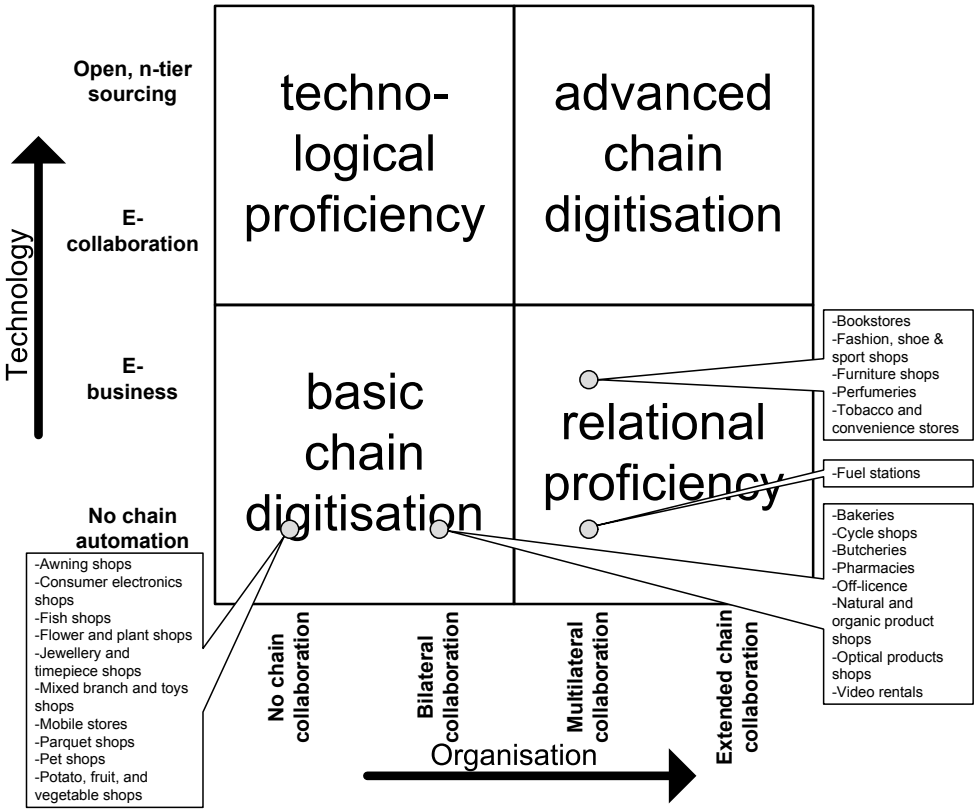

Figure 2.2 The 24 retail branches plotted in the typology

A first expectation that can be tested using these results concerns the difference between the food and non-food retail branches, as these deal with different types of products and related chain logistics. Food products, for instance, are more vulnerable to time and temperature fluctuations, putting more pressure on chain collaboration and information exchange throughout the chain (Kärkkäinen, 2003). From Figure 2.2 it appears however, that the food branches have lower maturity scores on both dimensions. Secondly, we tested the expectation that the supply-driven and demand-driven branches differ with regard to their levels of chain digitisation. Supply-driven retailers might be more mature because of supply chain pressure from their 'pushing' wholesale and manufacturing chain partners (cf. Daft, 2001). A difference between these two types of branches cannot be confirmed by the results, however. Hence, alternative explanations are needed to understand the systematic varieties we find in the chain digitisation scores of the branches. During our field work for instance, we experienced that some branches are more 'conservative' in interorganisational cooperation by culture or tradition. Also scale or size probably matters, in terms of chain length or product diversity. Specific indicators lack to explicitly test these alternative explanations

however. Also, the number of observations (i.e. the number of branches included) draws upon empirical limitations to execute subsample comparisons. We return to this point in the discussion section.

2.5 Conclusion

In sum, this chapter presents a framework and a typology for chain digitisation at the level of interorganisational chains. The framework builds upon a meta study of existing maturity models of chain digitisation. In order to test its validity, the framework was applied to measure the chain digitisation level – in both organisational and technical respects – of 24 Dutch retail branches. The results show that, as of 2007, the interorganisational chains within the Dutch retail sector are generally immature in their organisational and technological levels of chain digitisation. Exceptions are retail chains within the perfume, tobacco, clothing, books, and furniture branches that show moderate levels of chain digitisation. It appears hard to discover specific patterns underlying these maturity differences between the 24 retail branches. Basic differences between food and non-food, or between supply- and demand-driven branches, appear not be systematically related to the level of chain digitisation. Hence, alternative explanations need to be explored. These might be expected from conditions like the length and diversity of the supply chain, regulatory requirements, branch culture or traditions. These conditions might have interaction effects on the maturity of chain digitisation. For instance, new laws on ingredient track and tracing in the food sector put pressure on the sharing of information throughout the chain (Ménard & Klein, 2004). As a result parties are enforced to mutually adapt their IT systems and establish a body that governs the matter of chain digitisation within the branch.

The model and data we present in this chapter can be used as a basis for further research. As a follow-up to the data we have now collected through trade organisations, it will be interesting to interview representatives of all organisations that build a particular interorganisational chain. In this way, how chain actors differ in their chain digitisation ambitions and perceptions can be explored (cf. Harland, 1996). This undertaking is of course extensive, but would be rewarding in terms of debunking the actual chain connections and locating specific chances and barriers.

With regard to our framework, an interesting extension would be the relaxation of the (implicit) assumption that 'the higher the (chain digitisation) maturity level, the better'. At present, it remains unclear whether this is truly optimal for every chain – especially in the retail sector, including its many SMEs. It might be appropriate to apply a contingency approach and explore the situational factors of our maturity dimensions. This means that it is not assumed that a higher chain digitisation maturity level is always better; it might be 'locally optimal', that is, sufficient for a certain branch. It is interesting to view the maturity

models as typologies: they describe the different phases in which a chain can subsist, but do not indicate whether one phase is better than another.

Related to this, it is possible to relax the assumption behind the alignment thesis that organisational maturity preferably coincides with a similar level of technological maturity. For instance, organisations at a certain organisational level of chain collaboration can share the necessary information through a joint information system to which all parties have access. At the same time however, this chain can just as well be supported through a recurrent physical gathering of (representatives of) all parties. In the same vein, there can be a full operational chain information system, but no or only a small amount of parties willing to share their information because the standard for exchanging product specifications is not accepted by all parties in the chain. In all cases, whether maturity levelling as a form of alignment is required will be dependent on the situation. Further research can concentrate on this point of situationality, that is, what kind of chain digitisation is suitable for which condition.

Finally, an extension of this study is to apply the framework to larger enterprises, other sectors and branches, as well in other countries. Especially the non-profit sector springs to mind, for instance healthcare and governmental organisations. Also, a longitudinal research that follows the chain digitisation development of certain branches will contribute or lead to extended insights.

2.5.1 Implications

Given the fact that the framework is proven to be applicable for measurement and benchmarking at the level of interorganisational chains, it can also be used to support different branches in their ambition to improve their level of chain digitisation. First of all, policy makers and trade organisations can use the framework as a measurement tool to determine their current level of chain digitisation. Secondly, they can think of a roadmap for chains within their branch that can help to increase their degree of chain digitisation. This matches the goals of both European and national governments that increasingly focus on stimulating the adoption of ICT by small and medium-sized enterprises (SMEs). Since SMEs statistically lag behind large firms in IT adoption and use because of their limited resources, creating chain digitisation projects can support them in collectively overcoming these barriers (cf. European Commission, 2002; Renner, Vetter, Scheiding, Remotti, & Cavallini, 2008). Moreover, this research shows that also small organisations should focus on both technological and organisational aspects in adopting these technologies. Branches can learn from each other in this respect. For instance, branches that are relatively mature in the technological aspects of chain digitisation can learn from branches that are more advanced in organisational cooperation, and vice versa. By finding similarities in their

chain characteristics, and comparing their technological (ICT) and organisational initiatives, branches can improve their level of chain digitisation mutually and in parallel. To actually execute a branch-specific roadmap towards mature chain digitisation, that projects the 'to be' situation, is a matter of tailoring and of further research. The maturity levels as defined by our framework and indicators can be a useful support in this. Basically, it helps supply chain partners and interorganisational bodies to initiate specific projects for chain collaboration, chain digitisation and joint investments.

3 Determining chain digitisation maturity: A survey among Dutch CIOs[5]

Interorganisational or chain information systems have become a frequent subject of scientific research, but not often an empirical perspective on these systems is taken. In this study we develop a model for measuring the chain digitisation maturity of organisations (as a proxy for chains) and validate it by conducting a survey among 33 CIOs. We measure maturity on both technology and organisation, on both the supply and demand side of the focal organisations, resulting in four maturity dimensions. Furthermore, we show through a cluster analysis that the dataset can indeed be differentiated along those dimensions. Finally, three determinants, namely complexity of chain digitisation solutions, synchronisation of data, and the size of the organisation, appear to be correlated with chain digitisation maturity. We conclude that the topic of chain digitisation alignment deserves further research, as does its situationality for profit and non-profit organisations.

3.1 Introduction

The term chain information systems (CIS) has been coined by Grijpink as a new term and a critical precondition for successful digital collaboration in (inter)organisational chains (cf. Grijpink, 1999; 2005). CIS can be viewed as a specific subset of interorganisational (information) systems (IOIS or simply IOS), which are probably better known as these have a longer history (e.g. Barrett & Konsynski, 1982). Many different terms belong to the IOS field. Most prominently are supply chain management (SCM) related terms such as supply chain automation, supply chain integration, and collaborative planning, forecasting, and replenishment (CPFR). Also IOS cover organisational / business related terms such as interorganisational collaboration, virtual organisations, and value networks or IT-related terms such as interoperability, e-business, and chain computerisation.

In this chapter, we focus on CIS and 'chain digitisation' instead of IOS, to stress that it encompasses collaboration between multiple organisations. We define chain digitisation as

[5] This work has been submitted for journal publication.

An earlier version was published as: Plomp, M. G. A., Van Rooij, R. C. M., & Batenburg, R. S. (2010). Chain digitisation maturity and its determinants: A Dutch CIO survey and case study. In *Proceedings of the 23rd Bled eConference "eTrust: Implications for the Individual, Enterprises and Society"* (pp. 364-377). Bled, Slovenia.

"firms working together along value/supply chains through ICT" (Plomp & Batenburg, 2010; chapter 2 of this dissertation). It is therefore to be interpreted as a multiparty concept.

The interest in CIS is driven by trends like increasing industry network complexities, due to more competition, demanding consumers and suppliers, increasing governance, and cost control as a result of the recent economic recession. This rightly applies to the public domain, as the issues of public bodies (e.g. healthcare, justice) call for a multiparty and inter-organisational approach. The alleged advantages of CIS appear to specifically meet these challenges of public organisations, and promise cost reduction, productivity improvements, and innovation (Morrel & Ezingeard, 2002). Many papers address these advantages through studying (the maturity of) specific organisational information systems. However, there is not much research on the *maturity* of CIS *on the chain level*. Furthermore, we are aware of few empirical studies on this topic, especially those that focus on *both* the supply and the demand side.

Based on the above, we formulate the following research question for this chapter:

> *How can chain digitisation maturity be measured and how do organisational and technological characteristics determine an organisation's chain digitisation maturity?*

The meaning of the title of this chapter is therefore twofold: (i) *how to determine* chain digitisation maturity and (ii) *what factors determine* chain digitisation maturity?

The structure of the remainder of this chapter is as follows. First, an outline of the theoretical background of this research will be given, followed by our conceptual model. Next, the applied research methods will be presented, followed by a description of the results. This results section presents the scores on the variables studied, and also the outcome of both a cluster and a correlation analysis. These results lead to the conclusion, in which the key points of this research are summarised. We end with some topics of discussion, including limitations of this study and opportunities for future research.

3.2 Theory & conceptual model

While in IOS and SCM traditionally a distinction between the supply and demand side of chain management is made, from a chain digitisation perspective this distinction is not or less relevant. When the object of analysis is the entire chain, a distinction between supply and demand side cannot be made. In that case, the focus lies on the interorganisational collaboration as a whole, which takes place on the *chain level* (Grijpink, 1999). However, when we focus on the chain digitisation capabilities of a *specific organisation*, a distinction between its supply and demand side maturities can and should be made (Frohlich & Westbrook, 2001). For example, the maturity with regard to supply-side functions like (e-)procurement (Plomp & Batenburg, 2009) is not necessarily related to the maturity of

demand-side functions like CRM (Batenburg & Versendaal, 2007). When we are interested in maturity from a chain perspective, but use a specific organisation as the unit of analysis, there is a measurement possible on both the 'upstream' and 'downstream' side of the focal organisation. Hence, chain digitisation maturity is treated here as a two-sided concept.

In analysing this concept, we specifically focus on the relationship with the external environment, i.e. the organisation's suppliers and customers. In the tradition of the Resource Based View (RBV), which was described as "analysing firms from the resource side rather than from the product side" (Wernerfelt, 1984), the focus lies more on the internal resources of an individual organisation. Barney (1991) further developed this theory by emphasising that the RBV focuses on the internal organisation and by defining resources as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm". In order for resources to be of (strategic) value to a firm, they need to adhere to the VRIN criterion: they should be valuable, rare, inimitable and non-substitutable. More recently, the related Dynamic Capabilities View (DCV) has been developed. DCV "offers the more dynamic variety of the RBV by emphasising that possessing a set of resources with VRIN characteristics is not enough to stay competitive in a changing business context" (Den Hertog, 2010). Dynamic capabilities are defined as "the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments" (Teece, Pisano, & Shuen, 1997). This shifts our attention to changing capabilities/resources, but also more towards the external environment: the value system. Or as Teece (2007) puts it: "the concept and practice of open innovation underscore the importance of broad-based external search and subsequent integration involving customers, suppliers, and complementors". In these external value chains or business networks, there are many important but hard to answer questions, e.g. related to opportunities and limitations, influence, and control (Håkansson & Ford, 2002).

We depart here from the notion that the deployment of technology (i.e. IT) will be less useful and effective without considering the organisational dimension (e.g. Scott Morton, 1991; Daft, 2001; Turban, McLean, & Wetherbe, 2001; Luftman & Kempaiah, 2007). This is particularly the case for the success of IOS (Zhu & Kraemer, 2002) and hence we will research if and how this applies to CIS as well. We propose and apply a measurement model for chain digitisation, by designing maturity scales and levels of CIS, assuming that technology and management (or 'organisation') are constantly interrelated (e.g. Mumford, 1987; Orlikowski, 1992; Henderson & Venkatraman, 1993).

For the dimensions and levels of our chain digitisation maturity model, we build upon our recent work on chain digitisation maturity (Plomp & Batenburg, 2010; chapter 2 of this dissertation). There, based on 22 existing maturity models a framework is defined, de-

picted in Figure 3.1. It consists of two dimensions: technology and organisation, with four maturity levels each. For the technological dimension, these levels are:

1. *No chain automation*. There is no interorganisational technology, i.e. there are no digital connections to the outside world.
2. *E-business*. ICT is used to cross the borders of the organisation. This is sometimes called extended ERP or XRP, indicating that the internal information system extends outside the organisation itself (Kalakota & Robinson, 2001). In this phase, the focus lies on transactional processes.
3. *E-collaboration*. ICT serves collaboration between multiple parties in the chain. Standards and standardisation play an important role here. E-collaboration comprises tactical processes.
4. *Open, n-tier sourcing*. The ICT from the previous level is available and used by all ('n') parties within and between value chains. Data come from multiple locations through open standards and architectures (Van Beers & Bouwman, 2007).

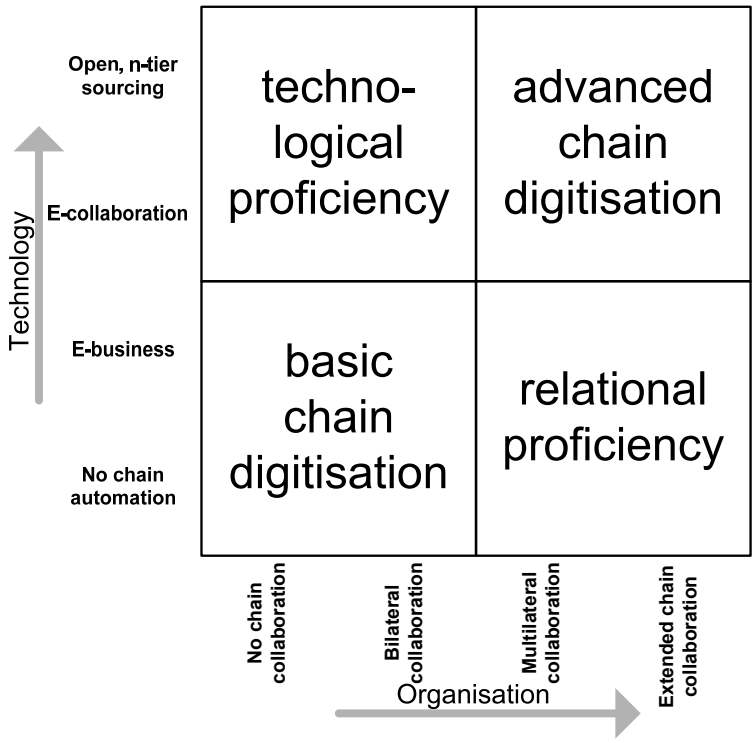

Figure 3.1 Chain digitisation maturity levels for both the technological and organisational dimension (Plomp & Batenburg, 2010; chapter 2 of this dissertation)

For the organisational dimension, the following levels have been defined:

1. *No chain collaboration*. There are no interorganisational relationships.
2. *Bilateral collaboration*. There is collaboration with another organisation, which is often a connected link of the value chain (e.g. a retailer working together with its supplier).
3. *Multilateral collaboration*. The same as the previous level, but with multiple parties. It can for example be in the form of collaborative planning, forecasting, and replenishment (CPFR) or collaborative commerce (Turban, King, Viehland, & Lee, 2004).
4. *Extended chain collaboration*. There is collaboration between multiple parties across multiple links within and between value chains. The interaction is truly many-to-many and '*n*-tier', including the customers and suppliers of all chain organisations.

As can be seen in Figure 3.1, when these two dimensions are combined, four types of chain digitisation can be distinguished:

- *Basic chain digitisation*. Within this type of interorganisational chain, both collaboration and the available technology are at a low level. There is bilateral collaboration at best and technology is used for transactions only. Regarding their maturity, both dimensions are in balance, however. This can for instance be the case in interorganisational chains that encompass relatively standard and frequent processes and transactions, such as in markets for fast-moving consumer goods.
- *Technological proficiency*. Despite the fact that the interorganisational collaboration is still low, the available technology within this type of interorganisational chain is of a more sophisticated level (i.e. no less than at the point of e-collaboration). The two dimensions are not in balance. This can be the case if an interorganisational chain has standard, frequent transactions that require relatively low levels of trust between the parties. These can be e-auctions or e-marketplaces in industrial markets for raw materials and the logistics/transport sector.
- *Relational proficiency*. As the opposite of technological proficiency, within this type of interorganisational chain there is advanced collaboration (i.e. multilateral collaboration or more), but the technology lags behind with regard to the chain digitisation maturity. Again, there is no balance between the two dimensions. This could occur in interorganisational chains that deal with non-standard transactions

that involve a high amount of trust and hence personal contact, such as in one-of-a-kind industry or project-based sectors like the construction industry.

- *Advanced chain digitisation*. Within this type of interorganisational chain, the available collaboration and the existing technology are both at the same, developed level. Hence, both dimensions are in alignment with each other. Interorganisational chains that concern products or services that have complex specifications but are nevertheless ordered with high or predictable frequency are examples of this type. Examples are the mature e-commerce industries such as travel agencies and multi-media consumer markets.

Although these four situations are intuitive, it should be noted that they do not imply a sequential order of development. Furthermore, the figure may seem to indicate that one type is 'better' than the other, but concluding this would be incorrect. It is clear that there is more chain digitisation in the upper right quadrant than in the lower left, but this does not mean that organisations that are positioned in the latter quadrant are less successful: they might not need to grow to a higher maturity level because of their specific circumstances ('situationality').

In this chapter, we add to the original model the aforementioned distinction between the supply and demand side, and the operationalisation of the levels by means of items for a questionnaire. Distinguishing the maturities at the supply and demand side of an organisation gives a more detailed view of that organisation's collaboration capabilities. In a way it serves as a proxy for backward and forward chain digitisation maturity, i.e. the degree of collaboration with other parties upwards and downwards the chain. The quantification of the model allows for the application of statistical methods, like cluster analysis. Furthermore, we are interested in finding the determinants that influence this maturity.

For the selection of the organisational and technological determinants of chain digitisation maturity, we studied existing literature on the adoption of IOS. A rigorous IOS literature review, concerning research articles that were published in 11 different IS journals between 1990 and 2003, has been performed by Robey, Im, and Wareham (2008). We extend their analysis here, by looking at different determinants coming from other and more recent publications. However, there are two important differences between their research and ours. First, Robey et al. primarily discuss studies describing IOS adoption. Although related, this is not exactly the same as our concept of maturity. Furthermore, in our model we specifically consider two sides (i.e. supply and demand) of the focal organisation.

Bunker, Kautz, and Pyne (2008) state that communication and information sharing are enablers of a collaborative culture, and hence have a positive effect on the adoption of IOS. They also emphasise that trust is required to stimulate adoption. Teo, Lin, and Lai (2009)

add that firm size is positively and significantly associated with the adoption of e-procurement. Larger organisations are considered more capable of adopting innovations, due to larger financial resources and scale advantages. Also, large organisations are more likely to have transactions that suit IOS, at least with some of their trading partners (Geri & Ahituv, 2008). Munkvold (2005) found that challenges in adoption of e-collaboration increase with the level of autonomy in the adoption process. Batenburg and Constantiou (2009) state that e-business adoption is influenced by factors such as the synchronisation of data with suppliers and customers (increasing the compatibility of the e-business solutions) and the complexity of the e-business solutions.

Based on the literature discussed above, we formulate the following six hypotheses:

H1: The ability of an organisation to communicate and collaborate (in terms of not being hindered by legacy systems) is positively related to its chain digitisation maturity.

H2: The level of trust an organisation puts in its value chain partners is positively related to its chain digitisation maturity.

H3: An organisation's autonomy (in terms of not being hindered by dominant players in the value chain) is negatively related to its chain digitisation maturity.

H4: The complexity of an organisation's chain digitisation solutions (in terms of its 'lock-in' with other value chain partners) is negatively related to its chain digitisation maturity.

H5: The importance of synchronisation of data for an organisation is positively related to its chain digitisation maturity.

H6: The size of an organisation is positively related to its chain digitisation maturity.

These hypotheses regarding the determinants of chain digitisation maturity can be summarised in a conceptual model (see Figure 3.2). Some of those determinants are of a purely organisational (e.g. interorganisational trust) or technological nature (e.g. complexity of chain digitisation solutions), whereas others are more mixed (e.g. synchronisation of data). In line with e.g. Robey et al. (2008), many other determinants can be thought of, but in this study we consider these to be the main determinants.

As follows from the conceptual model in Figure 3.2, the independent variables are expected to have an effect on the dependent variable: the level of chain digitisation maturity of an organisation. The chain digitisation maturity level of an organisation is characterised by a technological and an organisational dimension, combined with the organisation's chain position measured at its supply and demand side.

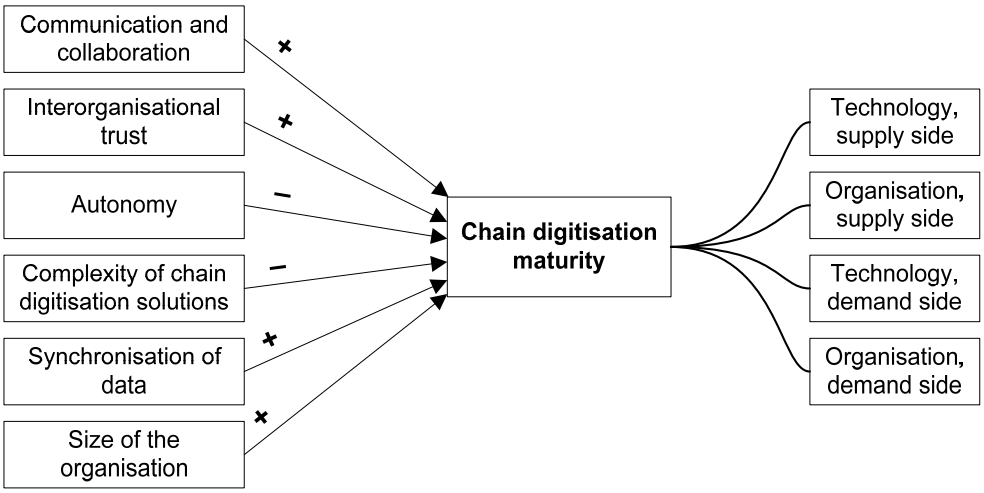

Figure 3.2 The conceptual model

3.3 Data & methods

We used a survey to collect data to test our hypotheses, which were analysed through a cluster and correlation analysis. An online questionnaire has been distributed among 38 Chief Information Officers (CIOs) of Dutch organisations from different industries through the professional and personal network of the authors. This method can be typed as convenience (but controlled) random sampling (cf. Lunsford & Lunsford, 1995). No requirements were applied in the selection process (e.g. with respect to sector), except that the organisations had to be 10 FTE or larger. The CIOs were personally asked to participate in the research and fill in the online questionnaire. If they agreed to participate, the URL of the online questionnaire was sent to them. In the questionnaire, additional instructions and motivation for the CIOs was given. The respondents were free to choose when and where they would complete the questionnaire, as long as the results were submitted before a clearly stated deadline.

Table 3.1 indicates how the independent variables of our conceptual model have been operationalised. The first five determinants have been measured through statements, preceded by the question 'please indicate how the following statements represent your organisation'. The answer options were formed by a 7-point Likert scale ranging from 'strongly agree' to 'strongly disagree'. The factor size was measured through an open question. We looked at the total head-count here, based on the idea that the number of users is of greater importance than the number of FTEs. The measure remains a proxy however, as other factors (e.g. degree of outsourcing, line of business) likely play a role as well.

Table 3.1 Determinants and the survey questions employed to measure them

Determinant	Question used for measuring the determinant
Communication and collaboration	With regard to interorganisational communication, our organisation is strongly limited by our existing / legacy systems.
Interorganisational trust	There is a high level of trust between the parties within our value chain.
Autonomy	There are one or a few dominant players in our value chain who decide all organisational issues on collaboration and agreements.
Complexity of chain digitisation solutions	Our organisation is strongly 'locked in' by the systems and data standards of our value chain partners.
Synchronisation of data	Continuous synchronisation of data (24x7, real time) with our value chain partners is of great importance to our organisation.
Size of the organisation	What is currently the total head-count of your organisation in terms of persons?

Table 3.2 shows how the dependent variable (chain digitisation maturity) in our conceptual model has been operationalised. In total 32 statements about both technological and organisational maturity on both the supply and demand side of the organisation have been used, 7 or 9 per dimension. We 'mirrored' these statements for the supply and demand side, e.g. "receiving e-invoices" versus "sending e-invoices" and "document joint process descriptions with suppliers" versus "document joint process descriptions with customers".

The respondents were asked to express how each statement fits their organisation. Four different answer categories were provided, namely:

- 'Yes, for (almost) all of our [suppliers / customers]',
- 'Yes, for some of our [suppliers / customers]',
- 'Yes, for only one of our [suppliers / customers]', and
- 'No'.

In addition, a 'Do not know / cannot say' option was provided.

In total, we received 33 completed surveys. After data collection, the dataset has been processed to create scales for both the independent and dependent variables. First, variables were constructed based on the questions from Table 3.1 to measure the independent variable: the determinants of chain digitisation. Some questions have been recoded (i.e. reversed), because they were stated in a 'negative way'.

Table 3.2 Maturity dimensions and the survey questions employed to measure them

Maturity dimension	Questions used for measuring the maturity dimension
Technology, supply side	*To support the purchase function, does your organisation use specific IT systems / applications for:* - Ordering goods or services online? - Arranging payments online for ordered products or services? - Receiving e-invoices? - Finding suppliers in the market? - Inviting suppliers to quote prices or submit proposals? - Running online auctions? - Collaborating with suppliers to forecast your demand? - Collaborating with suppliers to design new products or services? - Managing capacity or inventories of suppliers?
Organisation, supply side	*To support the purchase function, does your organisation apply specific (i.e. customised and written) organisational arrangements to:* - Document delivery contracts on the operational level? - Settle strategic alliances? - Share strategic information? - Evaluate supplier performance on contract parameters? - Document joint process descriptions with suppliers? - Govern a joint work team with suppliers? - Align your strategy with your suppliers' strategy?
Technology, demand side	*To support the sales function, does your organisation use specific IT systems / applications for:* - Receiving online orders? - Enabling payments online for ordered products or services? - Sending e-invoices? - Sending offers? - Answering calls after proposals or tenders? - Launching sales auctions, for example on B2B or B2C marketplaces? - Collaborating with customers to forecast their demand? - Collaborating with customers to design new products or services? - Managing capacity or inventories of customers?
Organisation, demand side	*To support the sales function, does your organisation apply specific (i.e. customised and written) organisational arrangements to:* - Document delivery contracts on the operational level? - Settle strategic alliances with your customers? - Share strategic information with customers? - Evaluate your performance on contract parameters? - Document joint process descriptions with customers? - Govern a joint work team with your customers? - Align your strategy with your customers' strategy?

The scales for the dependent variable were constructed from the questions from Table 3.2. A reliability analysis was performed for each dimension, which resulted in Cronbach's alpha scores of .84 (technology, supply side), .96 (organisation, supply side), .86 (technology, demand side) and .94 (organisation, demand side). Finally, when we take these four categories together, we obtain an alpha of .96. These scores imply a good reliability and there-

fore these five scales can be used to measure the dependent variable chain digitisation maturity (Nunnally & Bernstein, 1994).

3.4 Results

3.4.1 Context variables

Before testing our hypotheses, we first present some descriptive statistics. In our sample, profit organisations are dominant: 25 (75.8%) are profit organisations, while 8 (24.2%) are non-profit (by self-classification). With respect to the sector, we learn from Table 3.3 below that our sample is diverse. The manufacturing / producing and professional services sectors are overrepresented, whereas only one governmental organisation has participated.

Table 3.3 Sector distribution of sample (n=33)

Sector	n	%
Construction	2	6.1%
Education	4	12.1%
Government	1	3.0%
Healthcare	2	6.1%
Logistics	3	9.1%
Manufacturing / producing	9	27.3%
Professional services	9	27.3%
Retail / wholesale	3	9.1%

Although all surveyed organisations had to be active in the Netherlands, some of them were active in other geographical areas as well. As can be seen at the left side of Table 3.4, there is a relevant distribution over the different areas of operation, i.e. local, national, continental and global scale.

Table 3.4 Area of operation and organisational age of sample (n=33)

Area of operation	n	%	Age of organisation	n	%
Local / regional	4	12.1%	<10 years	4	12.1%
National (i.e. the Netherlands)	12	36.4%	10-50 years	18	54.5%
Continental (i.e. Europe)	10	30.3%	51-100 years	7	21.2%
Global	7	21.2%	>100 years	4	12.1%

Because of our method of convenience random sampling, it is also useful to check the age distribution of the organisations in our sample (right side of Table 3.4). On average, organisations are active since 53.4 years, with a relatively high standard deviation of 65.2

years. This means that the sample does not merely consist of very recent start-ups, nor just of age-old organisations, but of a relevant mixture instead.

3.4.2 Dependent variables

The main variables to be analysed in this study are summarised in Table 3.5. The dependent variables (the different dimensions of chain digitisation maturity) all range between 1 and 4. The average score on the 'technology, supply side' maturity appears to be the lowest (1.89; SD=0.72), whereas the 'organisation, demand side' maturity is the highest (2.33; SD=1.07). The overall chain digitisation maturity score has a mean of 2.07 (SD=0.79). Only one organisation reached the maximum level of 4.00 for overall chain digitisation maturity, while 18 companies were positioned in the '≥1.00; <2.00' range.

Table 3.5 Descriptive statistics of the chain digitisation maturity dimensions (dependent variables; n=33)

Variable	Mean	SD	Min.	Max.
Technology, supply side	1.89	0.72	1	4
Organisation, supply side	2.09	1.06	1	4
Technology, demand side	2.04	0.84	1	4
Organisation, demand side	2.33	1.07	1	4
Overall chain digitisation maturity	2.07	0.79	1	4

3.4.3 Cluster analysis

In order to find out whether our cases can indeed be differentiated along the dimensions of the model, and to get a better understanding of our dataset, we performed a cluster analysis on our dependent variables. We clustered the organisations in our sample twice: once for the supply side variables and once for the demand side variables. All variables were standardised prior to the cluster analysis procedure, in order to rule out spurious effects due to unequal variances (Kachigan, 1991).

First, we performed a *two-step cluster analysis* for the organisation and technology variables on the *supply side*. We used the log-likelihood distance measure and let the number of clusters be determined automatically. This leads to two clusters: one consisting of 17 cases (technology mean=1.47; organisation mean=1.21) and one consisting of 16 cases (technology mean=2.32; organisation mean=3.03). Applying Akaike's or Schwarz's Bayesian information criterion results in exactly the same clusters.

As with most (statistical) methods, the most prudent course is to use two different techniques to arrive at the clustering results (Kachigan, 1991). Therefore, we performed an additional clustering using the *k-means clustering* method. When fixed on two clusters, this

results in a cluster with 18 members and one with 15 members. These numbers differ by only one compared to our first clustering, and indeed one case has 'switched' to the other cluster. The mean technology and organisation scores of the clusterings are therefore also very similar. The two classifications are also highly correlated with each other: both Kendall's tau-b and Spearman's rho are 0.94 and significant ($p<.01$). This entails that the two different clustering methods lead to very similar results, which makes the clustering more robust.

In Figure 3.3 the clusters are visualised. The 33 cases have been plotted on the chain digitisation maturity model; one dot is bigger as it represents 3 cases with exactly the same scores. The grey areas indicate the two clusters. They overlap for the one case that is part of each cluster, depending on the method that is used. If we look at the two clusters, we see that one clearly represents the organisations that score low on chain digitisation maturity (i.e. all cases fall in the 'basic chain digitisation' quadrant). The other cluster mainly holds cases with medium or high levels of chain digitisation maturity.

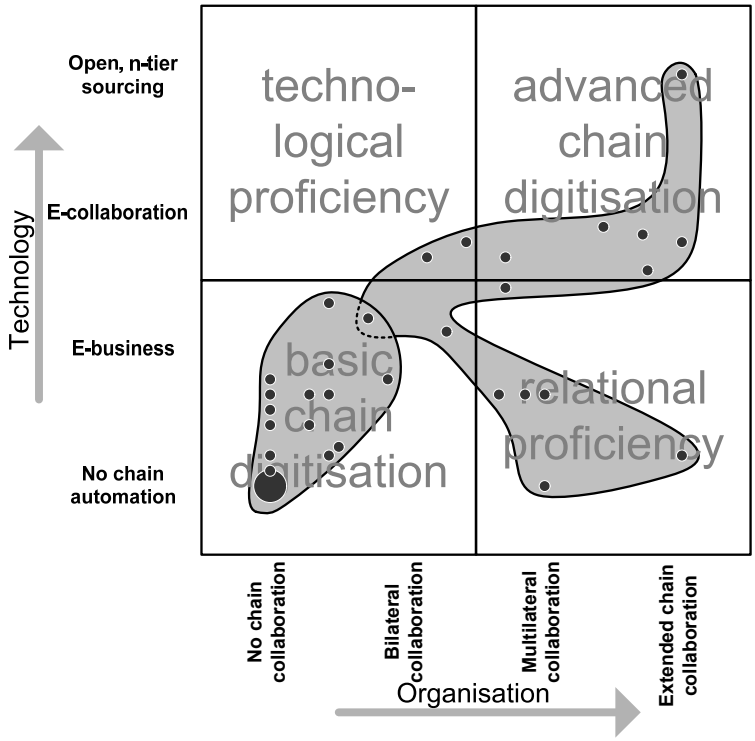

Figure 3.3 Clustering of cases for supply side chain digitisation maturity

Comparing the clusters on background variables, through chi-square tests for both sector and area of operation, and a t-test for age of the organisation, reveals no significant differences (p>.10). For these analyses, the case that is part of both clusters was left out.

We performed a similar *two-step cluster analysis* for the organisation and technology variables on the *demand side*, which results into two clusters as well: one of 19 cases (technology mean=1.46; organisation mean=1.62) and one of 14 cases (technology mean=2.83; organisation mean=3.31). Applying Akaike's or Schwarz's Bayesian information criterion did not lead to different results.

Analogous to our supply side cluster analysis, we conducted a *k-means clustering* here as well. Fixed on two clusters, this leads to one cluster with 20 members and another cluster with 14 members. Once again, these numbers differ by only one compared to the first clustering, caused by one 'switching' case. The mean technology and organisation scores of the two clusterings are also very similar, resulting in the two classifications being highly correlated: Kendall's tau-b and Spearman's rho are again 0.94 and significant (p<.01). This supports the soundness of the demand side clusters.

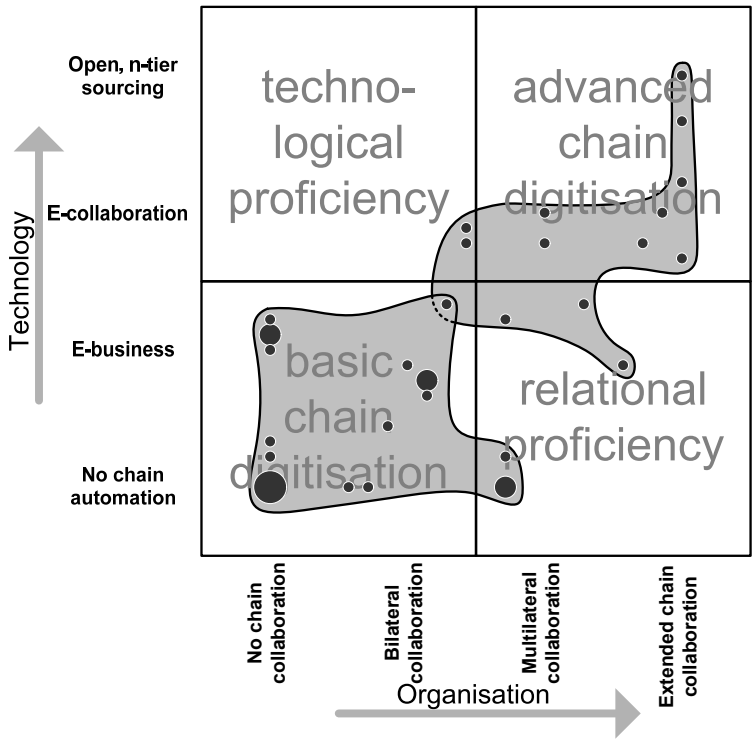

Figure 3.4 Clustering of cases for demand side chain digitisation maturity

Figure 3.4 presents the results of the clustering procedure. Note that some dots are bigger than others, representing two or three organisations that scored exactly the same. If we examine the clusters, we see that also for the demand side, one cluster mainly represents low scores, while the other contains mostly high scoring organisations with regard to chain digitisation maturity.

No significant differences (p>.10) were found when comparing the clusters on background variables sector and area of operation (both chi-square tests), and age of the organisation (t-test). Once again, the case that is a member of both clusters was left out of these analyses.

Based on these analyses, we conclude that the cases in our dataset can be successfully clustered based on their chain digitisation maturity, for both the supply and demand side. In both cases two clusters emerge: one with mainly low maturity scores and one with mainly medium / high scores.

3.4.4 Independent variables

The main statistics of the independent variables are listed in Table 3.6. Most of the independent variables range between 1 and 7, except 'communication and collaboration' and 'interorganisational trust', as no organisation scored a 1 on these variables. No organisation scored 7 on the variable 'interorganisational trust' either. The variable 'synchronisation of data' has a relatively high standard deviation of 2.28, indicating that this is of great importance for some organisations, whereas it is not for others. As the employee size of an organisation is an in principle unbounded variable, its distribution is skewed and standard deviation relatively large (mean=12,300; SD=25,900). Therefore we transformed this variable by taking its logarithm. The characteristics of the log-transformed variable are presented in Table 3.6.

Table 3.6 Descriptive statistics of the chain digitisation maturity determinants (independent variables; n=33)

Variable	Mean	SD	Min.	Max.
Communication and collaboration	4.48	1.58	2	7
Interorganisational trust	4.36	1.22	2	6
Autonomy	4.64	1.45	1	7
Complexity of chain digitisation solutions	4.64	1.69	1	7
Synchronisation of data	4.09	2.28	1	7
Size of the organisation (logarithm)	2.77	1.32	1.08	5.08

3.4.5 Correlation analysis

Next, the relationships between the dependent and independent variables have been assessed using Pearson bivariate correlation analysis. The results are displayed in Table 3.7. We employed one-tailed testing in accordance with the expected direction of the relations shown in Figure 3.2.

Table 3.7 Pearson correlations between chain digitisation maturity and its determinants (1-tailed; n=33); *=significant correlation at the .05 level; **=significant correlation at the .01 level

	Technology, supply side		Organisation, supply side		Technology, demand side		Organisation, demand side		Overall chain digitisation maturity	
Determinant	r	p	r	p	r	p	r	p	r	p
Communication and collaboration	-.06	.38	-.18	.16	-.01	.48	-.10	.28	-.10	.29
Interorganisational trust	-.02	.46	-.19	.15	-.05	.40	-.13	.24	-.11	.28
Autonomy	-.09	.31	-.33*	.03	-.16	.20	-.38*	.01	-.27	.06
Complexity of chain digitisation solutions	-.31*	.04	-.09	.32	-.39*	.01	-.24	.09	-.29*	.05
Synchronisation of data	.44**	.01	.26	.07	.59**	.00	.31*	.04	.46**	.00
Size of the organisation (log.)	.63**	.00	.53**	.00	.44**	.01	.43**	.01	.57**	.00

From this table we learn that the first two variables 'communication and collaboration' and 'interorganisational trust' are not clearly related to the chain digitisation maturity level of an organisation. Both the four maturity dimensions and the overall maturity construct are not significantly correlated with either of these two independent variables.

The variable 'autonomy' is significantly and negatively related to chain digitisation maturity ($p<.05$), but only for the organisational dimension (i.e. both for the supply and demand side). This makes sense, as the content of this variable is related to this particular dimension (refer to Table 3.1). As the overall score contains both the technological and the organisational dimension, there is only a trend correlation ($p<.10$) visible.

The 'complexity of chain digitisation solutions' variable is significantly and negatively related to chain digitisation maturity as well ($p<.05$), but here only on the technological dimension (also for both the supply and demand side). Once again this is understandable, as its measurement includes technical aspects like being 'locked in'. In this case, however, the determinant is also significantly correlated ($p<.05$) with the overall chain digitisation maturity variable.

The determinant 'synchronisation of data' is significantly and positively related to chain digitisation maturity, with three out of the four maturity dimensions, and the overall maturity construct ($p<.01$).

The variable with the strongest correlation however, appears to be the employee size of the organisation. With all four dimensions as well as with the overall chain digitisation maturity measurement, this determinant shows a strong and significant correlation ($p<.01$).

We conclude that complexity of chain digitisation solutions, synchronisation of data, and size of the organisation are the strongest determinants of the chain digitisation maturity of an organisation.

3.5 Conclusion & discussion

In this chapter, we developed a framework for chain digitisation maturity and turned this into a survey, which we applied on 33 (CIOs of) Dutch organisations. Next to defining and operationalising these main dimensions of chain digitisation maturity, the goal was to find and test the main determinants of this construct.

Our results indicate that the determinants of chain digitisation maturity are of a situational nature. Specifically: (i) non-standardised and complex chain digitisation solutions hinder maturity, (ii) large organisations are more mature compared to smaller organisations, and (iii) in situations where continuous synchronisation of data is of critical importance, chain digitisation maturity is higher.

The situational nature of chain digitisation maturity is further underscored by the outcome from the clustering procedures. There we found a distinction between low scoring organisations on the one hand and medium / high scoring organisations on the other. This may point to the need for separate policies or approaches for these two types of organisations / value chains. In terms of these policies, our model – and the specific operationalisation of it in our questionnaire – may prove useful for CIOs. It can help them in identifying the steps they could take in order to achieve the next maturity level. Furthermore, it also underscores the importance of paying attention to both the technological and the organisational dimension in improving an organisation's chain digitisation maturity.

When viewed from a strategic outside-in standpoint, our results seem to indicate that chain digitisation maturity is determined by 'unchangeable' factors of a specific chain constellation. When we take an inside-out perspective however, it can be concluded that every chain eventually achieves 'the maturity it needs'; i.e. the situational factors determine the right degree of chain digitisation. From the current state of several chains we believe that this cannot be fully true, as there are chains in which interorganisational IS / IT can still be significantly improved. We therefore propose that there must be other, more changeable fac-

tors, which influence chain digitisation too. Finding these remains one of our future research objectives.

A major limitation of many studies on IOS, including this one, is that although the relevant information systems span multiple organisations (i.e. an entire value chain), often a single organisation is taken as the unit of analysis (cf. Reimers, Johnston, & Klein, 2010). Here, we tried to (partly) accommodate for this problem by explicitly defining the dependent variables on two sides of the organisation. This way, collaboration with different parties on two sides of the organisation is measured, thereby forming a proxy for assessment of three different organisational levels in the value chain (e.g. supplier, focal organisation and buyer). Clearly, in terms of validity it would have been stronger to pose the same questions to organisations up- and downstream the value chain. Another way of measuring chain digitisation maturity at the chain level is by querying individual organisations of which it may be expected that they have an overview of the interorganisational field. An example is collecting data at the level of trade organisations (Plomp & Batenburg, 2010; chapter 2 of this dissertation). One could also approach this topic in a more qualitative way, through case studies of an entire value chain (e.g. Alt & Smits, 2007; Grijpink, Visser, Dijkman, & Plomp, 2010). We hope to apply these and other innovative methods that deal with the issue of analysing an entire value chain in a cost-effective manner in our future research endeavours.

This study provides several other starting points for further study as well. Most prominently is the concept of (business/IT-) alignment (Chan & Reich, 2007). With the addition of the distinction between the supply and demand sides of an organisation, the interrelation between these concepts becomes more interesting, but also more complex. Future work on this or a similar, preferably larger dataset could shed light on this issue and build upon the 'arcs of integration' concept of Frohlich and Westbrook (2001). Another topic is the special requirements for chain digitisation in the public domain (e.g. Grijpink, 1999). With only 8 cases from this area in our current sample, we did not specifically look into those and considered all cases to be equal. However, in future research it would be interesting to focus specifically on non-profit organisations and determine whether the same and / or other factors come to surface. This fits well with the rising interest in services science (e.g. Chesbrough & Spohrer, 2006), as organisations in the public domain generally provide services, not products.

Part III:
Studies on Interorganisational Information Systems in Retail and Health

4 Determinants of point-of-sale system adoption: A survey among small retailers in the Netherlands[6]

Several threats affect the survival of small, independent retail companies. Adoption and use of point-of-sale (POS) systems may offer important benefits to counter these threats. POS systems are not widely used by these retailers, however. This research investigates the determinants of the adoption of POS systems using a conceptual model based on existing adoption theories. Based on this, a survey has been held among 37 Dutch small, independent retailers, to answer the question what the most important determinants for POS system adoption are. This study furthers theory on IT adoption, specifically for small organisations. The practical relevance is that its findings may help in improving POS system adoption.

4.1 Introduction

The Dutch retail sector consists for 94% of small retail organisations (≤10 employees), altogether employing around 250,000 persons. The retail sector is noticeably present in the trade-driven Dutch economy and acts as an intermediary between industry and consumer. The sector is an important and relevant subject of study from an economical, social and cultural perspective.

In this chapter we focus on in-store retailing. The environment of this type of retail trade is under pressure. Several interacting threats, like globalisation, demanding consumers, increasing administrative burden and an economic recession force the retailers into action. Information and communication technology (ICT) is a double-edged sword in this context (cf. Turban, King, Viehland, & Lee, 2004). On the one hand, it can be a threat to smaller retailers for its disintermediation effects and competition through e-tailing (cf. Chircu & Kauffman, 1999), and by its supply chain management effectuation of the larger (franchise) organisations (cf. David, 2008). On the other hand, ICT likewise provides opportunities to smaller retailers, like opening up new sales channels, reducing administrative tasks and/or enabling strategic management of their enterprise (Turban et al., 2004).

A specific type of retail ICT that can be employed to achieve effective store management is a 'point-of-sale' (POS) system. POS systems are defined in many different ways. On Wikipe-

[6] This work was originally published as: Plomp, M. G. A., Huiden, R. P., & Batenburg, R. S. (2011). Determinants of point-of-sale system adoption: A survey among small independent retailers in the Netherlands. In *Proceedings of the 17th Americas Conference on Information Systems* (Paper 276). Detroit, USA.

dia, a retail POS system is defined as "a computer, monitor, cash drawer, receipt printer, customer display and a barcode scanner". Webopedia.com defines a POS system as "the capturing of data and customer payment information at a physical location when goods or services are bought and sold". YourDictionary.com defines it as: "A comprehensive computerized checkout system that includes a bar-code scanner, receipt printer, cash drawer, credit and debit card scanner, monitor, and inventory management software. A point-of-sale system tracks sales and identifies inventory levels in real time". There are many different types and brands of POS systems available. eBay.com and BuyerZone.com provide a web-based 'Point of Sale System Buying Guide', containing over 4,000 different POS equipments for retailers, and 91 different types of POS software. The POS system market in the Netherlands contains no less than 150 vendors, each offering their own 'unique' software package.

POS systems enable retailers to consult more detailed management information compared to traditional cash registers and Electronic Cash Registers (ECRs). As this management information is based on sales figures, retailers can improve their business by maintaining a better product strategy and pursuing a more efficient replenishment process matching customer demand, alleviating what is often referred to as the 'bullwhip effect' (Lee, Padmanabhan, & Whang, 1997). This enables inventory optimisation, minimising storage space and 'sold-out' situations. Moreover, cash slips can be stored electronically and the results can be brought up in the POS system immediately, both reducing time spent on administrative tasks. This is specifically relevant for the Netherlands, where the administrative burden for SMEs has increased through regulations concerning article pricing, tax regulations for transactions storing and ingredients tracing for food products. It can therefore be expected that POS systems lead to higher performance and support the development of small retailers (cf. Parkan, 2003). Professionalising through ICT may particularly help the small, independent retailers to improve their competitive position against larger retailers and internet based vendors.

Despite their potential benefits and their wide availability on the Dutch market, POS systems are not (yet) widely used by smaller retail organisations. Statistics from the Dutch central industry board for retail trades (HBD, 2009) show that in 2008, 30% of retail organisations actually used a POS system. This adoption level differs per branch, ranging from 57% for supermarkets to 10% for shops for household products. The most recent Sectoral e-Business Watch (European Commission, 2008) confirms that smaller retail companies tend to be less automated than larger ones.

To be able to further stimulate the uptake of POS systems, it is important to understand how retailers value POS systems and which determinants play a role in the decision to adopt such a system. Until now, only limited knowledge on these matters is available. In

this chapter, we therefore investigate how existing theories can be applied to understand the POS adoption by small retailers. We will do this by answering the following research questions:

- *From literature study, what are the main determinants of POS system adoption for small, independent retailers?*
- *From a survey among Dutch small, independent retailers, which determinants of POS system adoption can be found in practice?*

The results of this study are of scientific and practical relevance. Although the field of ICT adoption research is abundant, a preliminary literature study revealed that limited research has been conducted on ICT adoption in the retail sector, especially concerning POS systems. The practical value of this work lies in the input the results may give to policy makers on possibilities to improve POS system adoption among small (Dutch) retailers.

The objective of this research is to identify the key determinants of POS system adoption by small, independent businesses. As much research on IT adoption has been conducted in fields closely related to the adoption of POS systems, the next section provides an overview of these studies. Based on these models, we derive our conceptual model and corresponding hypotheses, which we test through a survey. The final section contains main conclusions and ideas for future work.

4.2 Literature review: Adoption models

In this section we review eight different studies on the adoption of information systems, which were found through (meta) literature study. The meta literature search focused on theories and models concerning IS/IT adoption, more specifically of small businesses, retail and/or POS systems. Below, as a result, we first describe two generic adoption models with regard to IS/IT adoption. Next, we discuss six models that address adoption within the retail or small business domain.

4.2.1 Generic models

The first generic adoption model we refer to here is that of Rogers (2003). His Diffusion of Innovations (DOI) theory describes the adoption of innovations over time. He ascribes the dynamics of adoption behaviour in terms of different groups of people, like innovators and laggards. His theory also indicates how an individual or organisation (i.e. any decision-making unit) decides to adopt (or not) an innovation. This adoption process consists of five different stages: knowledge acquisition, persuasion, adoption, implementation and confirmation. Rogers specifies three groups of determinants that influence this process: characteristics of the decision-making unit, characteristics of the innovation and information

channels. Based on DOI theory, factors concerning the decision-making unit that positively influence adoption are e.g. high social status, low age and financial flexibility. According to DOI, important characteristics of an innovation include: relative advantage, compatibility, complexity, trialability (the degree to which it can be experimented with), and observability (the visibility of its results). Information channels (personal and mass communication channels) are required to spread knowledge of an innovation.

The second generic adoption model is based on Venkatesh, Morris, Davis, and Davis (2003), who reviewed technology acceptance models, among which the Technology Acceptance Model (Davis, 1986) and the Theory of Planned Behaviour (Ajzen, 1985). They used elements of each model for a new unified model, called the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Contrary to Rogers' model, UTAUT concentrates on the adoption behaviour of individuals. In this model, four constructs are defined as determinants of a user's acceptance and behaviour. Performance expectancy relates to the degree to which the technology is expected to improve job performance. Effort expectancy concerns the ease of use associated with the technology. Social influence is defined as "[t]he degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003). Finally, the construct facilitating conditions deals with the degree to which a support infrastructure for the technology is believed to exist. In addition, these four constructs are modelled to be influenced by four so-called moderators, i.e. gender, age, experience and voluntariness.

4.2.2 Retail and SME-specific models

We will discuss six main studies and their adoption models below.

First, the study by Julien and Raymond (1994) can be mentioned. Their technology adoption model for the retail sector proposes eight organisational aspects as determinants of technology adoption: centralisation, complexity, size, status (i.e. independent/affiliated), sector, and assertiveness, rationality, and interaction of the organisational strategy.

These determinants were identified in earlier research on technology adoption in small organisations. Technology adoption in this case concerned the use of hardware (business computing, POS systems and telecomputing) and software. In the study 79 firms in food, hardware and clothing were assessed through questionnaires and semi-structured interviews. Clothing firms and large firms were less apt to use POS systems, while firms that had a longer organisational planning horizon used POS systems more often.

Secondly, Chau (1995) researched which factors are important for small businesses in software selection. His research focused on packaged software, as small organisations usually do not buy custom developed software, due to their limited resources. Chau argues

that owners/managers of small organisations are less focused on budgeting techniques like 'net present value' or 'internal rate of return' to make decisions on software investments. Instead, they focus more on criteria aimed at the functionalities and popularity of the software. Also, opinions of vendors, employees, consultants or acquaintances are believed to influence decision making. Based on empirical research among 122 small businesses, he found that the importance of selection criteria varied between owners and managers. In general, owners seem to focus more on technical aspects, while managers focus more on non-technical aspects.

Third, Thong and Yap (1995) developed a model based on the notion that the adoption process of small businesses differs from that of large firms. One of their main assumptions is that characteristics of the CEO are critical for IT adoption decisions. CEOs play a major role in small firms as they are the primary decisions makers. In their research, the authors developed a causal model, which assumes that the following factors are positively correlated with the likeliness of IT adoption for small firms: business size, competitiveness of the business environment, information intensity, innovativeness, and attitude towards adoption of IT and IT knowledge.

A survey among 166 Singaporean small organisations in the manufacturing, commerce and service industry was used to validate these assumptions. Results showed that firm size, the CEO's innovativeness, attitude towards IT adoption and IT knowledge were indeed positively correlated with IT adoption. Although competitiveness and information intensity were both not correlated with IT adoption, they were positively correlated with the CEO's attitude towards IT adoption.

Fourth, Iacovou, Benbasat, and Dexter (1995) studied the adoption and impact of Electronic Data Interchange (EDI) in small organisations. Their research was driven by the fact that small organisations are often related to value chains that use EDI and so their potential resistance to adopt EDI could hinder the overall adoption of the technology. Three major factors were identified with regard to EDI adoption: perceived benefits, organisational readiness, and external pressure.

Using data from 7 small organisations, these three determinants were measured through multiple variables. The factor perceived benefits is measured as direct and indirect benefits, organisational readiness through financial and technological resources, and external pressure by the competitive pressure and imposition by trading partners. The analysis showed that the strongest determinant of EDI adoption was the imposition by (large) trading partners. In addition, it was found that sales volume also determined EDI adoption. Another finding was that perceived benefits were congruent with the adoption decision. Non-EDI adopters primarily focused on direct benefits, while EDI adopters mainly focused on the indirect and strategic benefits, like improving interorganisational communication and en-

try on new and remote markets. Barriers to adoption were costs and lack of technical knowledge within the organisation, and technical and financial assistance by the government.

The fifth study is by Van Akkeren and Cavaye (1999), who reviewed various IT diffusion and adoption models applicable to SMEs. They found that some had overlapping factors, but most models either focused on organisational or individual adoption. Van Akkeren and Cavaye proposed a new model, capturing and summarising all factors identified in the literature as 'the' IT adoption factors for SMEs. The factors identified were divided in three categories:

- owner-manager characteristics: perceived benefits, computer literacy, assertiveness (also identified in earlier discussed models), perceived control and their subjective norm,
- firm characteristics: organisational readiness, external pressure to adopt, structural sophistication of the firm, sector, status (also identified in earlier discussed models), and customer/supplier dependency,
- return on investment.

Finally, the more recent economic/financial oriented study by Ekanem (2005) can be mentioned. He identified the phases and influential factors during investment decisions for durable products (like machinery) in small firms. Ekanem argues that in small organisations the owner-manager has a more dominant role in the decision-making process compared to large firms. The results are based on a longitudinal study among 8 small manufacturing companies, and their non-routine investments in e.g. new computerised printing machines. Based on the case studies, Ekanem developed a model consisting of five steps: identifying need, collecting information, evaluating alternatives, choosing alternatives and financing. Furthermore, there are key players whose information or opinions play a significant role in some phases. Ekanem acknowledges the influence of the external environment in which the organisation operates. Examples of this are the demand of customers or the presence of specific equipment that may influence the outcome of the phases.

4.3 Synthesis: Conceptual model & hypotheses

In the previous section, a total of eight models for adoption have been discussed. Most models view the (retail) organisation and/or its owner as the decision-making unit. In small organisations, the owner-manager/CEO almost by definition determines IT investments and the IT strategy. Thong and Yap (1995), Ekanem (2005) and Chau (1995) all point out this phenomenon. Therefore, we consider personal variables of the owner (like age and gender) as key determinants of POS adoption by retailers. In addition, organisational char-

acteristics (like size and competition) can be considered as additional, contextual determinants of the IT adoption decision. This idea is framed into a conceptual model for this study (Figure 4.1).

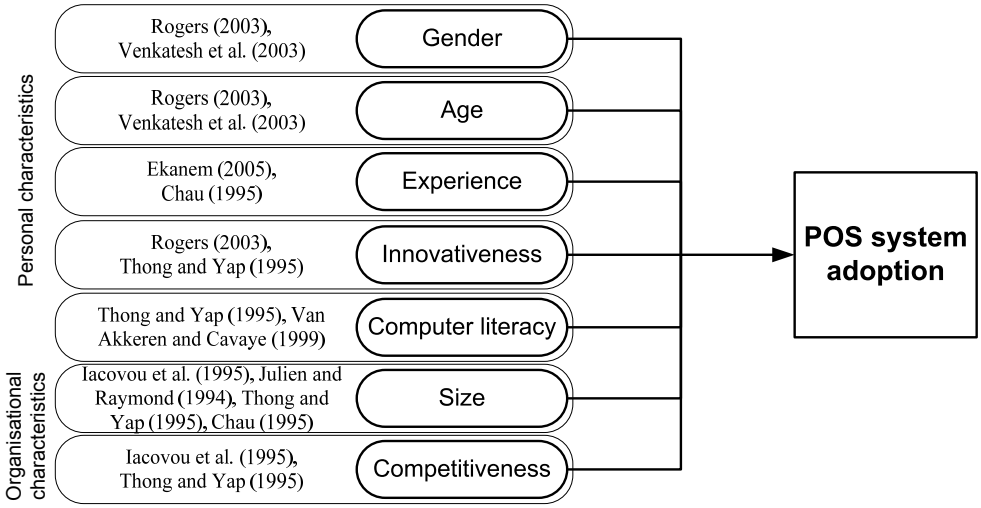

Figure 4.1 Conceptual model

From this conceptual model we derive the hypotheses on how the seven determinants potentially influence the probability that independent entrepreneurs of a small retail organisation adopt a POS system. Doing so, differences between adopters and non-adopters of POS systems can be found and validated. Through identifying these differences, stimulation of POS system adoption could possibly be concentrated on or tailored to specific groups.

With regard to the personal characteristics and POS adoption, the following five hypotheses can be formulated:

H1: Male retailers are more likely to adopt a POS system than female retailers.

H2: The age of retailers is negatively related to their adoption of a POS system.

For these hypotheses, we follow Rogers (2003), who acknowledges the influence of gender and age on adoption of innovations. Venkatesh et al. (2003) found that men and younger people have a higher performance expectancy of IT systems than women or older people. This performance expectancy in turn positively influences the attitude towards adoption.

H3: The experience of retailers is negatively related to their adoption of a POS system.

This hypothesis is mainly based on Ekanem (2005), who underpins the importance of the owner-managers' ability to learn from their experience and decisions while managing their organisation. Hence, we expect that starting retailers will have a greater need for a POS sys-

tem to support them in decision-making, while more experienced retailers (as well as managers of small businesses) are more likely to rely on their 'gut feeling'. Note that 'experience' here refers to the profession of being an owner of a retail store (cf. Chau, 1995).

H4: The innovativeness of retailers is positively related to their adoption of a POS system.

H5: The computer literacy of retailers is positively related to their adoption of a POS system.

These two hypotheses are derived from the study by Thong and Yap (1995), who found that CEOs of organisations that adopt IT are generally more innovative and more computer literate than CEOs of organisations that do not adopt IT. H4 is also supported by the theory of Rogers; H5 by the study of Van Akkeren and Cavaye (1999). The same relations are therefore expected to be found when it comes to POS system adoption by retailers.

Finally, addressing the organisational determinants of the conceptual model, two POS system adoption hypotheses are formulated:

H6: The size of retail organisations is positively related to their adoption of a POS system.

This hypothesis is based on Iacovou et al. (1995) and Thong and Yap (1995), who found that larger organisations (measured by respectively turnover and employees) are more likely to adopt IT. On the contrary, Julien and Raymond (1994) found that retail organisations with a POS system were generally smaller. Based on the positive relationship between organisational size and innovation (Damanpour, 1992) and the findings of both Iacovou et al. and Thong and Yap, we hypothesise that larger retail organisations are more likely to have a POS system than their smaller counterparts.

H7: The competitiveness of the environment of retail organisations is positively related to their adoption of a POS system.

It should be noted that the relation between competition and innovation is far from clear-cut (Carlin, Schaffer, & Seabright, 2004). More competition likely leads to more innovation, but this relationship may be in the form of an inverted U-shape (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005). Thong and Yap (1995) however, found that organisations in a more competitive environment have a more positive attitude towards adoption. Iacovou et al. (1995) also mention competitive pressure as an aspect that positively influences adoption. We therefore assume that retail organisations which experience more competition are more likely to have a POS system.

4.4 Method: A survey among retailers

The data collected for this research are based on a written questionnaire among Dutch small, independent retailers. The survey has been discussed and adapted through multiple iterations, after which it was presented for expert review to a technology and innovation

expert of the Dutch central industry board for retail trades (HBD). After evaluation of comments, one retailer was asked to fill out the questionnaire as a pilot and comment on it. Following some final adjustments based on this, the questionnaire was distributed.

The target population encloses retailers in all branches of the Dutch retail trade. To set out the survey in the most random and practical manner (i.e. through convenience – but controlled – random sampling, cf. Lunsford & Lunsford, 1995), retail organisations in two Dutch municipalities (one large city and one large town) have been personally visited. Beforehand, it was not known if retailers used POS systems, electronic cash registers or no cash register at all. In all stores the owner was handed the questionnaire in person, to be picked up a week later. This meant that the survey could be introduced personally and that the retailer could indicate directly whether s/he would participate. Returning to retrieve the questionnaire furthermore serves as a reminder for those who did not complete the questionnaire yet. A practical disadvantage of this distribution method is that it is very time consuming, especially when multiple visits are required until a questionnaire is completed.

In order to avoid complicated routing, two versions of the same questionnaire have been used. Some questions' phrasing or relevance depended on whether the respondent has a POS system or not. Both questionnaires consisted of three sets of questions, related to:

- the organisational characteristics of the retail organisation,
- the usage of the cash register/POS system,
- the personal characteristics of the respondent.

In total 61 retailers have been approached to participate in the research. Finally 37 questionnaires were completed which entails a response rate of 61%. We explored whether the sample of 37 respondents mirrors the population of small Dutch retailers, by comparing it with a study that was conducted by the Dutch central industry board for retail trades (HBD, 2009) among 2,500 small (1-10 employees) retailers in 2008. With regard to POS system adoption, our sample holds 41% adopters, whereas the HBD sample holds 30%. Concerning branch diversity, the distribution within our sample is approximately equal to that of the HBD study. Furthermore, our sample contains somewhat more males (68%) than the retailers that participated in the HBD survey (58%), while the age distribution of our sample is slightly younger on average: 43 versus 45 years in the HBD sample. All in all, we conclude that our sample of 37 responding retailers is relatively small, but holds a good variety of relevant background characteristics. This is important, as our aim is to test our conceptual model and the relationship between a number of variables that are addressed by our hypotheses. Therefore, the 'full' representation of the sample is of less importance, compared to the suitability of the sample to allow (deductive) hypothesis testing and analysis.

4.5 Results

A basic result is that 41% of our response group used a POS system. Through the questionnaire, we also informed about the year that they adopted their POS system. We classified this into three categories, following Rogers, as: innovators (i.e. the frontrunners that adopted their POS system 4 or more years ago), early adopters (adopted 2-3 years ago) and late adopters (adopted less than 2 years ago). The remainder of our sample (59%), which does not own a POS system (yet), is labelled laggards. Figure 4.2 shows the composition of the sample by these classes.

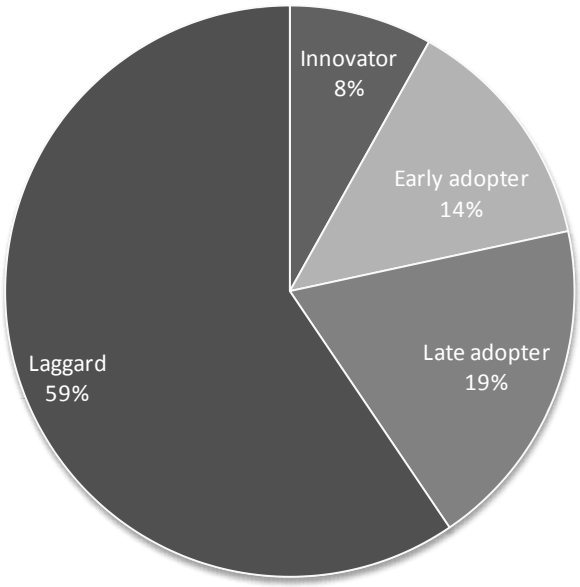

Figure 4.2 Classification of POS adopters in our sample

Turning to our conceptual model, we tested the hypotheses on the potential determinants of POS adoption, through bivariate analysis of the data. Table 4.1 gives an overview of the independent samples t-test results. Some variables may require additional explanation on how they were measured. For the concept of experience, retailers were asked how many years of experience they have as entrepreneur in the retail trade. Innovativeness was measured through a Likert-scale question asking whether the respondent generally is one of the first in his/her social environment to adopt new technologies. The measurement of computer literacy is based on a set of questions on the (perceived) interest in IT-related developments. The size of the organisations was measured in number of employees. Finally, perceived competition was measured as the degree to which internal rivalry among small,

independent retail stores is experienced by the respondents. The Likert-scale answer options were: no, little, moderate, high, or very high competition.

Table 4.1 T-test results on the influence of individual/organisational characteristics on POS system adoption (*=significant at the .05 level)

H	Determinant	POS adopters (mean; n=15)	Non-adopters (mean; n=22)	Difference	t-value	p-value (1-sided testing)
Personal						
1	Gender (proportion male retailers)	0.53	0.77	–0.24	–1.48	0.08
2	Age (years)	42.50	43.52	–1.02	–0.34	0.37
3	Entrepreneurial experience (years)	10.98	15.75	–4.76	–1.26	0.11
4	Innovativeness (Likert-scale: 1-5)	2.93	2.24	0.70	1.81	0.04*
5	Computer literacy: interest in IT (Likert-scale: 1-5)	3.60	2.67	0.93	2.37	0.01*
Organisational						
6	Size (number of employees)	4.85	3.73	1.12	0.77	0.22
7	Competition: internal rivalry among small retailers (Likert-scale: 1-5)	2.33	2.05	0.29	1.07	0.15

The results support two hypotheses related to personal characteristics: H4 and H5. This implies that retailers who have adopted a POS system are innovative and computer literate. The p-values smaller than .05 indicate that the differences found are 'significant', i.e. fall within confidence 5/95%-intervals. The other personal determinants (gender, age and entrepreneurial experience) are not related to the likeliness of POS system adoption, neither are the determinants on the organisational level (size and competition), based on the t-test results (p-values are above .05). Still, we need to take into account that we apply t-tests on a relatively small sample.

4.6 Conclusion & discussion

In this study we examined a specific adoption problem, namely that of point-of-sale (POS) systems in small retail firms. This is interesting from a scientific perspective, because to the best of our knowledge, this has not been done previously and thus provides an extension of the theory on adoption of innovations. However, it is also of practical value. The retail in-

dustry, and especially the small retailer, is currently suffering from various interacting threats, for which POS systems could possibly be an antidote.

Based on literature study of existing models and theories, we formulated a conceptual model and seven corresponding hypotheses. We tested these hypotheses in the Dutch retail sector, specifically targeting small, independent retailers. A questionnaire was used to survey 37 respondents from diverse store types, both with and without a POS system.

In our model we distinguish several personal and organisational determinants related to the decision-making unit (i.e. the retailer). Of these, only the retailer's innovativeness and computer literacy proved to be significantly related to POS adoption. Gender, age, entrepreneurial experience, organisational size and the competitiveness of the environment were not found to differ between adopters and non-adopters. With these results, our theoretical model seems only partly accurate in practice.

In terms of policy for POS system stimulation, computer literacy seems to have a positive effect, so it may proof worthwhile to try and interest people in general for the benefits of IT.

An obvious limitation of our research is that the model is applied to only one sector (although with many different branches), one country, and only a limited number of cases. It would still be interesting to see if the same results would be found for other countries, other sectors, and other technologies. Different technology is almost a necessity when one starts looking at other sectors, because POS systems seem to be retail specific software. Obviously, it would also be valuable to test the hypotheses on a larger sample as well, to see if the results are representative for the Dutch retail sector as a whole. In addition, it would be useful to conduct case study research to explore the concept of our model in more depth. This may help in formulating policies to stimulate POS system uptake.

Future studies could take into account the specificity of POS systems: benefits may very well be contingent on the specific situation of the retailer. In supply chain simulations for instance the benefits of sharing POS information were found to be dependent on the nature of the demand pattern (Steckel, Gupta, and Banerji, 2004). This implies that POS systems are possibly more beneficial for one retail branch than for the other. This would explain the current differences in POS system uptake between different branches. Future research could also focus on the role of software suppliers in the adoption process. What different software packages do they offer? I.e., is there really something to choose between, or are all systems similar? Finally, if we view a POS system as the starting point of retailers' automation, it would be of interest to study their further digitisation, e.g. by looking at the information systems and their interconnections with other parties in the value chain.

5 Chain digitisation support by point-of-sale systems: An analysis of the Dutch product software market[7]

Point-of-sale (POS) systems increasingly support more retail processes than just the basic cash functionality. But to what extent do they support chain digitisation, i.e., interorganisational processes as the exchange of order and sales information? We develop a two-dimensional maturity model for categorising POS systems by their level of backward and forward chain digitisation support. Both dimensions have the same maturity scale, cumulating from internal isolated, internal integrated, external linked to external integrated. We operationalise and apply this model to the Dutch POS system market by assessing 86 different POS solutions of 79 POS vendors. It appears that about a third of all POS systems support backward chain digitisation to the external integrated level, and forward chain digitisation to the external linked level. In some branches, chain digitisation enabling initiatives are successfully deployed, e.g., in the fashion and furniture branches where EDI initiatives are established by industry boards.

5.1 Introduction

Point-of-sale (POS) systems are computerised cash registers which are traditionally used by retailers to ring up customers' purchases. There are several advantages to POS systems. Besides the use of sales data from a POS system for marketing purposes, time consuming administrative activities like ordering, customer management, stock control, order tracking, and satisfying regulations can also be reduced. Recently, newly developed POS systems also provide the ability to connect to other systems across company boundaries, thereby enabling what we call chain digitisation. With these POS systems, automatic information exchange with wholesalers and suppliers for the exchange of, e.g., sales, order, product, and customer information is possible. By making use of this information from retailers, product suppliers can adapt production and supply of goods to the actual demand, thereby reducing the bullwhip effect (Lee, Padmanabhan, & Whang, 1997). It is also possible to better take specific preferences of customers into account.

As in any value chain, collaboration between actors in the retail value chain (i.e., the retailers, the suppliers, and the customers) is inevitable – especially for independent retailers – to survive in the modern retail market (e.g., Daft, 2001). Due to current changes in the retail

[7] This work is a forthcoming journal publication: Plomp, M. G. A., Van Rijn, G., & Batenburg, R. S. (in press). Chain digitisation support by point-of-sale systems: An analysis of the Dutch product software market. Accepted for publication in: *International Journal of Information Technology and Management*.

sector and in consumer behaviour, retailers are forced to collaborate more intensively with other parties (Berger, Möslein, Piller, & Reichwald, 2005). Supply chains tend to transform from push models into pull models where customers play a major role. This transformation requires extensive collaboration between value chain partners, likely supported with IT. The adoption of POS systems and the urgency for interorganisational collaboration and alignment in the retail sector, presents the societal relevance of this study.

While much literature exists on supply chain management and retailing in general, little research has been performed on POS systems and their role in this field. As a POS system can be considered to be the electronic backbone of a retail company, it is an important last node for chain digitisation in a value chain. At this time, little seems to be known about how POS systems support chain digitisation in practice, and what POS vendors do to innovate their software to support chain digitisation. By researching POS systems from an empirical and software vendor perspective, this chapter fills an important knowledge gap.

This study concentrates on the chain digitisation enabling functionalities of POS systems. These include use of electronic product catalogues, electronic ordering, e-invoicing, and automatic payments. Since these functionalities cover different processes and the exchange of different business documents between individual organisations and customers, it is likely POS systems also differ. There exist various options to enable chain digitisation, which result in different degrees of integration with the other parties in the value chain. The concept of maturity can be used to model these differences in functionality.

The aim of this research is to develop a maturity model that indicates different levels of chain digitisation support of POS systems. We present the ingredients of this model in the following two sections. First, we discuss the characteristics of a retail value chain and the specific position of the retailer in this (Section 2). Second, we describe the results of a literature study on maturity models in Section 3, and present a specific POS maturity model in Section 4. Next, we apply this model to the Dutch product software vendor market, in order to determine to what degree the existing systems actually support chain digitisation. We study POS systems as a result of product development of software vendors, including how they innovate their systems. This can be considered as a typical product software supply network (Xu & Brinkkemper, 2007; Jansen, Finkelstein, & Brinkkemper, 2009). The methods used for the empirical application of the model are presented in Section 5, and the results in Section 6. The final section of this chapter contains the conclusions, limitations, and some suggestions for future research.

5.2 Retail processes and POS systems

Many different processes take place within retail firms, and the value chain(s) they are part of. One model that tries to categorise and visualise various activities of a retailer, is the Re-

tail H-model, introduced by Becker and Schütte (1996). Its name stems from the fact that in the model, the primary processes of a retailing company are portrayed as an 'H' (Figure 5.1). The H-model consists of three parts. The 'roof' contains the control and decision functions. The foundation of the H-model is formed by the business administrative tasks. Core business processes consist of procurement, storage, and distribution of goods.

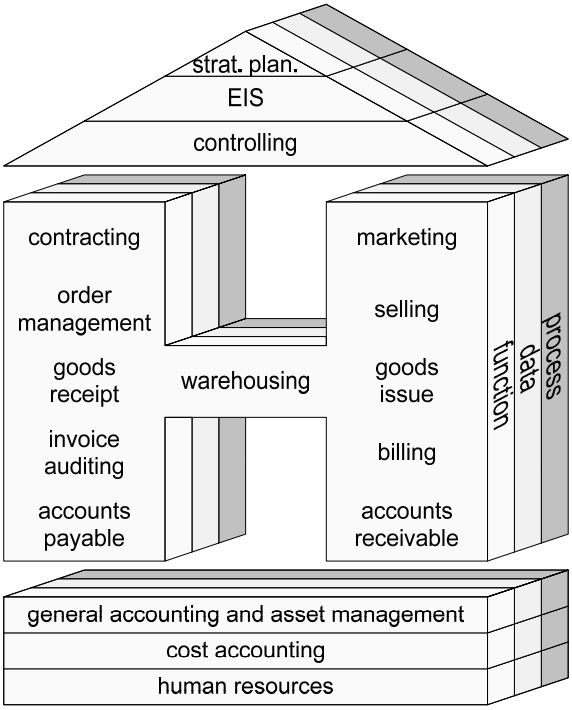

Figure 5.1 The Retail H-model (Becker & Schütte, 2004)

The customer side of the model (marketing, sales, goods issuing, billing, and accounts receivable) can, together with the warehousing part, be automated with a POS system. All activities can be performed at the pay desk in the store, even with an isolated (stand-alone operating) POS system. The procurement tasks can also be implemented in POS systems. To perform procurement activities, interaction is required with other companies. Traditionally, this interaction is performed by telephone, fax or mail. Nowadays, when both parties have automated their internal business processes with IT, this can also be achieved digitally. E-mail is a very basic example, automated information exchange by using EDI or XML are specific technologies for intercompany exchange. In the latter case, data is generated and interpreted automatically. For both messaging services, systems have to be connected to each other, typically via the internet or another network.

Activities at the top of the model (strategic planning, enterprise/executive information systems, and controlling) can be performed through business administrative systems and/or executive information systems (Stair & Reynolds, 2003). Most POS systems are able to register accounts receivable to some degree and some POS systems can also register and manage the accounts payable. However, they lack functionalities that support accounting tasks. Specific administrative systems that cover accounting functions can in most cases be linked to or integrated with POS systems.

If we now want to measure chain digitisation supporting functionalities of POS systems, we need to look at the integrated level of interorganisational relations, i.e., retailers collaborating in their value chain(s). A value chain consists of all parties that are related to the fulfilment of a customer's request (Chopra & Meindl, 2004). The retailer takes a special place in the chain from raw materials provider to the end-customer (see Figure 5.2). From the retail point-of-view, important value chain partners are at the one side suppliers (e.g., wholesalers) and at the other side customers. This entails that retailers have to engage in both business-to-business (B2B) and business-to-consumer (B2C) collaboration. To make automatic B2B electronic information exchange possible, collaborating organisations need to adopt similar standards and use collaborative applications. We term this *backward chain digitisation*. This often requires an investment in information systems for both (or more) parties, as suppliers frequently own advanced information systems. For B2C collaboration in retail, which we label *forward chain digitisation*, e-business joint action and investments are often not required (Subramani & Walden, 2000). A retailer's customer often is a private person with limited or no information technology at all. In our view, these differences in terms of both existing infrastructure and required capabilities, justifies the two separate dimensions.

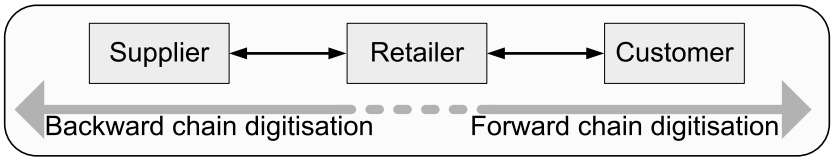

Figure 5.2 The retailer's position in the supply chain and the scope of backward and forward chain digitisation (CD)

The next question is how both types of chain digitisation can be measured, in terms of indicators and maturity.

5.3 Maturity models for chain digitisation

Maturity models are common in IS/IT to define different – distinct – maturity levels of a process or activity (Nolan, 1979). A maturity model describes the stages through which a system, process or organisation can progress or evolve. Each level is used to characterise

the state of a system, process or organisation (Clark & Jones, 1999). Two principles are often expressed by maturity models. First, maturity models assume that states evolve in a cumulative way. This means that by achieving *level x*, *level x–1* is also fulfilled. Adherence to the requirements of all levels below a certain level is a necessary condition for achieving a higher level (Nolan, 1979). A second principle is that maturity models have an ordinal, not a ratio scale: levels are described in words, not through strict measurements/requirements. This entails that differences between the different levels are therefore often not objective.

Maturity models have been subjected to criticism for a long time (e.g., Benbasat, Dexter, Drury, & Goldstein, 1984; Alonso-Mendo, Fitzgerald, & Frias-Martinez, 2009). They are criticised for being too generic, not adequately describing the development path, and lacking empirical validation (Alonso-Mendo et al., 2009). In addition, measuring maturity through a questionnaire would preclude researchers from "examining the richness of anecdotal data" (Benbasat et al., 1984). We believe however, that the different types of POS-systems (i.e., ranging from standalone systems to systems that are completely integrated with external parties, both in the direction of the supplier and in the direction of the consumer) very well fit the characteristics of a typical maturity ladder. Not claiming that every retailer's system will progress through all those different stages, we do argue that each higher stage is more mature (in terms of functionality) than its predecessor. Furthermore, we attempt to avoid some of the typical pitfalls of maturity model studies in our research method, e.g., through applying the model in practice and by conducting company visits in addition to a questionnaire.

In the academic literature, numerous maturity models regarding chain digitisation can be found (Plomp & Batenburg, 2010; chapter 2 of this dissertation). For this research, we select five chain digitisation maturity models, based on three criteria. First, the models define maturity levels regarding value chain integration or automation through IT or can be directly related to the use of IT. Second, the selected models describe different levels of interaction and (electronic) collaboration between value chain partners. The third selection criterion is that they all start with an internal view and for higher levels expand to value chain partners – an external view. This selection process results in five models: Folinas, Manthou, Sigala, and Vlachopoulou (2004), Wang, Chang, and Heng (2004), McLaren (2006), Williamson (2007), and Schoenfeldt (2008). As presented in Table 5.1, these maturity models identify three to five different stages of chain digitisation maturity and corresponding IT support.

Table 5.1 Comparison of five chain digitisation maturity models

	Level 1	Level 2	Level 3	Level 4	Level 5
Folinas et al. (2004)	Core logistics activities efficiency	Coordination of internal organisational processes	Inter-enterprise business exchanges	Establishment of dynamic networks between virtual organisations	
Wang et al. (2004)	Essential functions	Single department/ operation process	Cross department/ multi-process integration	Enterprise integration process	B2B integration/ collaborative business
McLaren (2006)	Functional focus	Internal integration	Linked network	Integrated network	Optimised network
Williamson (2007)	Elementary IOS	Intermediate IOS	Advanced IOS		
Schoenfeldt (2008)	Siloed company	Internal integration	One level of integration/ partnership	Two levels of integration	Entire chain integration

If we compare the five models to discover a common pattern of maturity, we claim that four basic levels can be distinguished:

1. Internal isolated;
2. Internal integrated;
3. External linked;
4. External integrated.

In the next section, we use this common pattern to shape our own maturity model.

5.4 A maturity model for chain digitisation support of POS systems

The aim of this chapter is to compare different POS systems for the Dutch retail sector with regard to the chain digitisation functionalities they offer. The four maturity levels presented above can be used to this end. We develop a maturity model, based on the existing models, that specifically looks at the different integration areas of the POS system, i.e., backward and forward chain digitisation. With this model, we can measure the chain digitisation functionalities of a POS system, and categorise and hence distinguish POS systems on their level of chain digitisation support. A graphical overview of this model is presented in Figure 5.3.

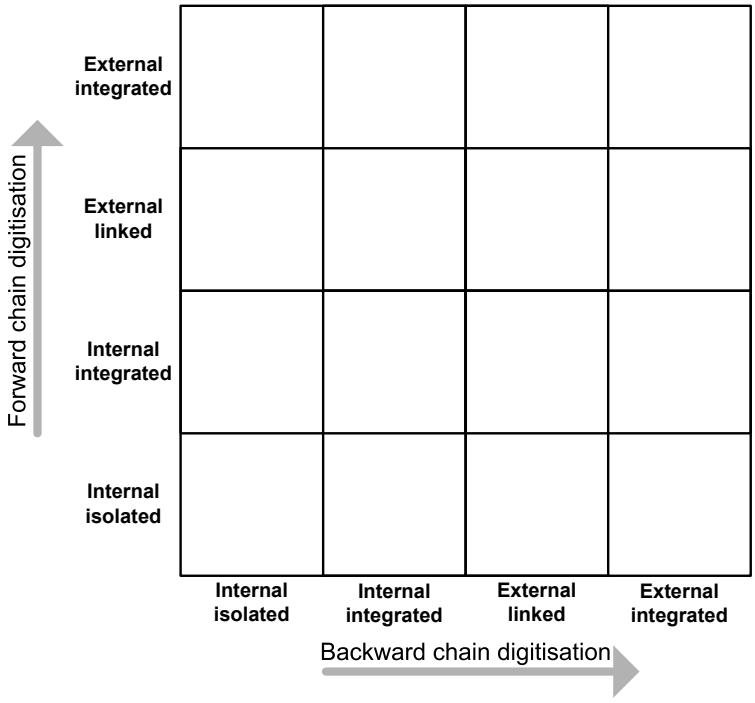

Figure 5.3 Maturity model for chain digitisation support of POS systems

We distinguish two dimensions in the maturity model: a backward (towards the wholesaler/supplier) and a forward (towards the customer) dimension of chain digitisation. Both dimensions of the model have similar maturity levels. The first two levels are aimed at internal automation of processes. Those levels are included in the model because it can be argued that retailers first automate their own store before they focus on chain digitisation. They can for example automate their sales processes by implementing a POS system. Subsequently, those sales systems can be expanded with other back-office systems. Finally, the company borders can be crossed with digital connections to suppliers or consumers. This development is also described by Chen, Themistocleous, and Chiu (2004). The last two levels of the maturity model focus on the integration of systems from value chain partners. As the POS system is the point of departure, a 'minimalistic' POS system that is only capable of registering sales and/or customer orders is the first level of chain digitisation for both dimensions.

To turn our model into a measuring instrument we define the following. *Backward chain digitisation* covers the degree of chain digitisation support by a POS system for processes taking place between a retailer and its suppliers. Four levels of maturity are distinguished for this dimension:

- *Level 1: Internal isolated.* At this lowest level, the POS system is capable of ringing up sales and/or registering customer orders. All data (e.g., product information) are processed and entered manually into the system, which makes the system laborious, inaccurate, and maintenance demanding (Williamson, 2007). Each function and department within the company operates as an individual unit. The information systems used within those departments operate isolated as well, which is aptly termed 'isolated islands of IT' (Folinas et al., 2004).

- *Level 2: Internal integrated.* At this level, the POS system is directly connected to a system that can be used for managing purchases from suppliers. It is also possible that both functions are integrated in one information system. This information system covers multiple departments and processes in an organisation. The POS system is not only capable of ringing up sales or registering customer orders; it is able to generate purchase order advices based on sales and/or stock levels. When the order is received, it is also possible to update stock levels using the purchase order. The system is able to print, fax or e-mail order documents towards suppliers. However, suppliers are not able to enter those orders automatically into their system; the system still lacks support for data exchange with business partners.

- *Level 3: External linked.* In this case, there are semi-automatic connections with information systems of value chain partners. There is some collaboration with partners (McLaren, 2006) and the information system supports communication with them (Williamson, 2007). There is no automatic data exchange: human effort is still required for exchanging data between information systems of value chain partners. A retailer can for example receive a spreadsheet with product information from a supplier per e-mail. This product database can then be imported into the POS system. Likewise, a retailer can send an e-mail to a supplier with a purchase order generated by the POS system, which can then be imported into the supplier's information system.

- *Level 4: External integrated.* Systems of value chain partners are integrated with the POS system, or there are direct connections available that enable automatic and direct data exchange between the information systems of value chain partners (Williamson, 2007). No human effort is required for data exchange regarding product information, orders and order responses, and electronic packing slips or invoices.

Forward chain digitisation covers the relation between a retailer and its customers: the consumers or end-users. Here, four distinct maturity levels can be distinguished as well:

- *Level 1: Internal isolated*. As starting point, this maturity level is equal to the first level of backward chain digitisation. The POS system is only capable of ringing up sales or registering customer orders. While it is possible that there are also separate information systems for managing customer contacts or maintaining a web shop, those systems are not connected to the POS system. The system lacks support for electronic data exchange with customers or external information systems.
- *Level 2: Internal integrated.* Internal integrated refers to integration of processes and systems within an organisation. The POS system is directly connected to a system that can be used for customer relationship management (CRM). It is also possible that both functions are integrated in one information system. Payne (2002) describes that integrating CRM systems with enterprise information systems can enhance customer service. Integration of organisational processes including customer processes significantly reduces transaction costs. An internal integrated system, for example, connects the enterprise resource planning to CRM (Pant & Ravichandran, 2001). Finally, sales can be registered on a per-customer basis.
- *Level 3: External linked.* At this level, there are semi-automatic connections for performing B2C e-business transactions. A POS system with CRM functionalities is primarily focused on recording customer information and offline (in-store) business transactions with customers. The POS system crosses the company border to perform electronic transactions with customers. An integrated web shop is an example of a functionality which matches this maturity level. Human effort at the consumer side is required, while the web shop catalogue can be build from the POS system, and customer orders can be automatically imported from the web shop into the POS system.
- *Level 4: External integrated.* Here, systems of consumers are integrated with the POS system or direct connections are available that enable automatic and direct data exchange between the information systems of the retailer and the customer. This is sometimes termed silent commerce, with the typical example being an 'intelligent fridge', that automatically orders products over the internet without human intervention (Röcker, 2010).

In the next section, we show how this model was applied to the POS systems that are available on the Dutch vendor market.

5.5 Applying the POS maturity model to the Dutch vendor market

5.5.1 Data collection

Our aim was to collect data that is representative for the whole Dutch POS system market. It was therefore imperative to collect names and contact information of as many software vendors as possible. In collaboration with the portal http://www.softwarepakketten.nl and the Dutch central industry board for retail trades (HBD) we gathered the information of many software firms. This resulted in a list of 144 POS-system suppliers. We believe that this is a virtually complete list, because the portal has already been existing for many years and functions as a meeting point for software companies and a place to promote themselves. Furthermore, the HBD also has many contacts in the retail software world. Still, the research was broadly 'advertised' in the media and relevant professional magazines, so firms that were not listed could participate as well.

The primary form of data collection was a questionnaire. In total, the field research period lasted six months. At the start, we organised an event for which all software vendors were invited, where we asked them to complete this survey. In addition, all companies were contacted by e-mail with a request for participation. We performed numerous activities in order to maximise the response. Vendors were called to remind them, and we sent out a letter by post signed by the director of the HBD.

Questionnaires were formatted using Microsoft Word and XML, and were sent by e-mail to the suppliers. They were requested to complete the survey digitally; however, paper-based completion was also possible. Depending on the branches supported by the POS system, the questionnaire was 75-102 pages long including four pages cover and introduction. The questionnaire contained around 1,000 till 1,200 possible POS system functionalities. Not only functionalities related to sales are part of the questionnaire. Also functionalities concerning procurement, stock management, CRM and web shops are assessed. Groups of (related) functionalities were categorised and presented as separate chunks, in order to facilitate quick completion. Respondents had to indicate for each functionality whether their system supports it or not, using six different answer options. The different options were: standard supported, partly supported, optionally supported (i.e., at a premium), supported through other software solution, not supported, and expected.

Despite the size of the questionnaire, 79 different POS suppliers filled in questionnaires for 86 different POS systems. Based on the number of suppliers – as it is unknown exactly how many software solutions there are – this amounts to a response rate of 55%.

Of those 79 suppliers, 75 were visited by one of the researchers in the first half of 2009. During these company visits, a predefined protocol was completed. The protocol dealt with

general questions about the POS system, and a demonstration of the software by the supplier. This demonstration was performed to check the validity of the answers given in the questionnaire. The demonstration was guided by a selection of functionalities from the questionnaire.

5.5.2 Model operationalisation

We operationalised the maturity levels of the model through 21 functionalities from the questionnaire that was sent out to the POS software vendors and the company visit protocol. We limited our use of the data to generic chain digitisation functionalities, while the original survey included many functionalities that were branch-specific or related to other functional domains. Functionalities were only judged to be supported when the related question was answered by the vendor with 'standard supported' or 'optionally supported'. When the supplier answered 'partly supported', 'supported through other software solution' or 'expected', the functionality was considered not to be present in the POS system.

The operationalisation rules used to determine the distinct maturity levels are shown in Table 5.2. The rules imply that the proposed maturity model is cumulative. The first level (internal isolated) is the same for both forward and backward chain digitisation support. In our view, this basic functionality is the litmus test for whether a software product should be considered a POS system.

In order to illustrate how the rules have been applied to determine the maturity level of a POS system, we provide a – fictitious – example. Suppose a POS system supports registering customer sales (the first level requirement for both dimensions), transforming purchase advices into purchase orders, registering goods using a purchase order and e-mailing purchase orders. It also supports a flexible import format, but electronically sending orders towards suppliers is not supported. Then, this POS system is rated as 'internal integrated' (Level 2) on backwards chain digitisation, as it supports all functionalities of this level, but not all of the 'external linked' level (Level 3). With regard to forward chain digitisation, the system allows for the exchange of product data to a web shop only and no further functionalities. Its maturity is therefore coded as 'internal isolated' (Level 1).

Table 5.2 POS chain digitisation maturity levels and their corresponding functionalities

Functionalities
Backward chain digitisation maturity
Level 1: Internal isolated • Register customer orders / register customer sales
Level 2: Internal integrated • All functionalities of Level 1 supported • Transform purchase advice into purchase order • Registering goods using purchase order • Printing purchase orders from the system / faxing purchase orders from the system / e-mailing purchase orders from the system
Level 3: External linked • All functionalities of Level 2 supported • Electronic order sending towards suppliers • Processing separate supplier product database / flexible import format
Level 4: External integrated • All functionalities of Level 3 supported • Enforcing electronic orders to supplier systems • Importing electronic product updates from suppliers • Registering goods using an electronic packing slip / registering goods using an electronic invoice
Forward chain digitisation maturity
Level 1: Internal isolated • Register customer orders / register customer sales
Level 2: Internal integrated • All functionalities of Level 1 supported • Looking up customer database using attributes / selecting customer at the point of sale • Sales directly connected to the customer in the system / sales history visible per customer
Level 3: External linked • All functionalities of Level 2 supported • Exchange product data to web shop • Importing web shop sales in back office
Level 4: External integrated • All functionalities of Level 3 supported • Near real-time automated ordering

5.6 Results

Based on the rules defined in the previous section, all 86 POS systems were positioned into our maturity model. This is visualised in Figure 5.4.

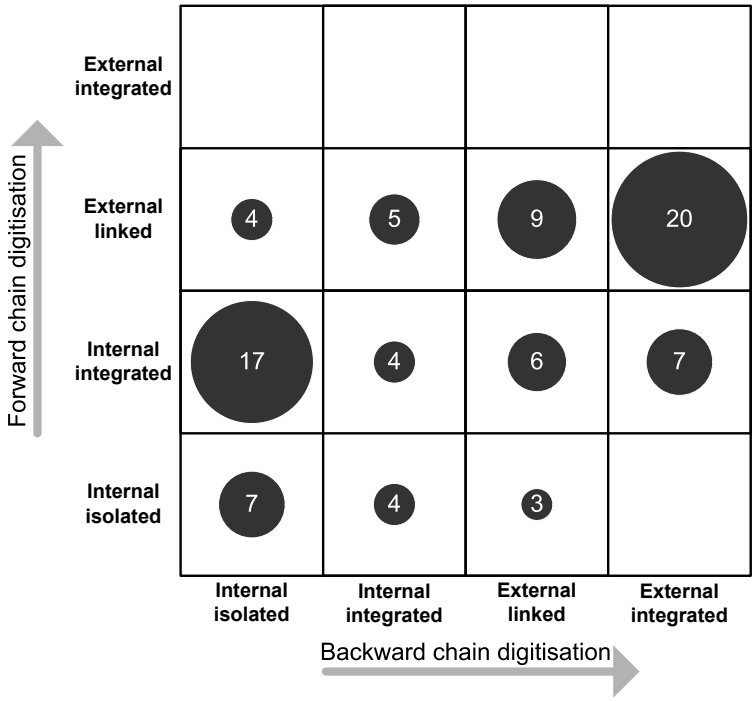

Figure 5.4 Position of POS systems available on the Dutch market in terms of forward and backward chain digitisation maturity

The figure shows that 32 POS systems (37%) are internally focussed only, meaning that these systems offer all functionalities up to 'internal isolated' or 'internal integrated' chain digitisation on both dimensions, but not (all) on the next 'external linked' or 'external integrated' levels. 29 POS systems (34%) offer functionalities for linking consumers, and linking or integrating external systems from suppliers. A notable result is that none of the surveyed POS systems are on the 'external integrated' level of forward chain digitisation. Another finding is that none of the systems are 'internal isolated' only with respect to the forward chain digitisation dimension, and backward 'external integrated' at the same time. Apparently, this is a combination that is not very likely.

Although the two dimensions are not equal to ratio scale variables, we can calculate the median maturity level to get an idea of how the software packages are distributed, as the dimensions are on the ordinal level. Doing so, we see that the median score of all POS systems on backward chain digitisation is 3 or 'external linked', and on forward chain digitisation 2 or 'internal integrated'. The largest group of POS systems (23%) is positioned at the level of 'backward external integrated' combined with 'forward external linked'. This is closely followed by 20% of the software solutions that are positioned on the 'internal isolated' backward level and 'internal integrated' forward level. Despite the lower maturity

with regard to forward chain digitisation, the systems in our sample are quite diverse in terms of their chain digitisation maturity.

Next we take a more detailed perspective on our data. We made a division into two equal groups: 41 POS systems (48%) that match the 'internal isolated' or 'internal integrated' level of backward chain digitisation, and 45 POS systems (52%) that are 'external linked' or 'external integrated' regarding their backward chain digitisation support. Further inspection learns that the first group of POS systems consists of:

- Generic solutions that can be used by retailers in all branches;
- Solutions that are specifically suitable for the fresh food branch; and
- Solutions for large retail organisations or 'POS only' solutions. POS systems for large retail organisations only cover point-of-sale activities. For logistical flows and other store management functionalities, they depend on applications that can be connected or integrated with the POS solution (e.g., an ERP system).

The second group of POS systems consists of solutions that enable connections with external organisations. We found specific backward chain digitisation initiatives for this group, such as:

- An EDI standard set up for electronic data exchange in the fashion branch.
- An EDI standard for the furniture branch, together with an e-business portal.
- Supplier specific connections, such as for retailers in the bicycle, books, drugs, animal and DIY/ironware branches.
- Tailor-made chain digitisation initiatives, that are customer and supplier specific and established on customer's demand, designed for use in multi-store retail organisations.
- Connection to ERP systems for chain digitisation enabling functionalities, often designed for use in large retail organisations.

In addition, further statistical investigation of the POS systems' variety shows that in general, systems that support a small number of retail branches score higher on backward chain digitisation maturity (Kendall's τ_b=-0.19, $p<.05$). This seems to imply that systems that are designed for a specific retail branch provide more 'depth' in terms of chain digitisation functionalities. Furthermore, POS systems customised for retailers in food have on average a lower backward chain digitisation maturity (i.e., a median of 2 on a scale from Levels 1-4), while for POS systems designed for the fashion branch this average maturity is higher (i.e., a median of 3.5). Finally, we found two characteristics of the vendor to be of

influence on the chain digitisation maturity of the POS systems they offer. Systems supplied by POS vendors that exist longer are more mature in terms of backward chain digitisation when compared to those of 'young' POS vendors (Kendall's τ_B =0.22; p<.05). Similarly, POS vendor companies that have a larger number of employees also tend to offer more mature systems with regard to forward chain digitisation (Kendall's τ_B =0.24; p<.05).

5.7 Conclusion & discussion

In this chapter, we developed a maturity model for chain digitisation support of POS systems. The model is based on a literature study of existing maturity models, combined with the specific characteristics of the retail sector and its value chain(s). Our model consists of two dimensions – backward and forward chain digitisation – that hold four similar maturity levels: internal isolated, internal integrated, external linked and external integrated.

We operationalised our model through a set of functionality items and assessment rules, by which we can categorise POS systems on their level of chain digitisation. In practice, this operationalisation (and validation) of the model was conducted through a questionnaire and additional company visits of 79 Dutch vendors who market 86 different POS systems.

A main result of our analysis is that there is a great diversity among POS systems if they are assessed on the level of support for chain digitisation. Chain digitisation functionalities differ greatly. Another finding is that no POS system was found that supports external integrated forward chain digitisation. Apparently, this type of functionality is still very much 'something of the future'. This result indicates an interesting market opportunity for POS software developers. We conclude by stating that it is important that retailers have something to choose from. They should seriously consider what chain digitisation functionalities they will need and which POS system best fits those needs.

Comparing these results with related work is difficult, since we did not find many similar research efforts, as already indicated in the introduction of this chapter. The scarce related studies that have been performed, often focus on the actual benefits of sharing POS data throughout the supply chain; see for instance, the simulation study of Croson and Donohue (2003). Also related are the results of a study on the actual chain digitisation maturity of the Dutch retail sector (Plomp & Batenburg, 2010; chapter 2 of this dissertation). There it was found that in general, this maturity is above the sector average for the clothing branch, whereas the food branches lag behind. This corresponds with the results of the present study, which shows similar maturity levels for the available POS systems for these sectors. This leads to the interesting – albeit tentative – finding that a relation exists between the maturity of what software is offered by vendors for a certain market and the maturity of that market itself. In order to substantiate this relationship and determine its causality, further research is needed.

Two important limitations of our model should be mentioned here. First, as the model has been specifically designed for the retail sector, it is not necessarily applicable to POS systems outside of this sector. Although it can be argued that most POS systems are used within the retail sector, they are also being used in the catering/hospitality industry. In that industry there are POS systems with particular peripherals available, for instance, wireless pagers and electronic signature capture devices. It may prove difficult to position these POS systems within our maturity model. A clear second limitation of the present study is that we only looked at the Dutch vendor market, whereas the situation could be different in other countries.

A point of discussion is the maturity assessment of the evaluated POS systems. This can be illustrated by two examples. First, there is one system that offers backward 'external integrated' functionalities, but is categorised at the 'external linked' level. The reason for this is that the system lacks support for automatic product updates. However, product updates are highly unusual in the specific branch this POS system was developed for. Because other business documents can be exchanged automatically through this specific POS system, its maturity can be considered as 'incomplete' 'external integrated'. A second example of a maturity assessment issue is formed by most POS systems that connect to the chain digitisation initiative of the furniture branch. These are at the level of 'external linked' backward chain digitisation according to the maturity model. The initiative enables retailers to import product information and order automatically, but does not support electronic packing slips at this time. Therefore, POS systems are categorised at the third level of backward chain digitisation support, while they can also be considered as 'incomplete' 'external integrated'. Following these examples, it can be concluded that the rules for the fourth level of backward chain digitisation are strictly defined. For some specific cases, it could be argued that they are too strict. This would call for a concept of 'situational maturity', meaning that the 'best' level of maturity may be contingent on the specific situation, e.g., the branch the retailer is in. This could be a subject for further research.

Other future research endeavours could focus on extending the maturity model developed here to other POS system functionalities, e.g., administration, loyalty features or support of peripherals. With regard to the current model, both studies in other locations (i.e., an international comparison) and studies over time (i.e., a longitudinal study of the same POS vendors) would be of interest, to see whether there are differences between countries, and whether the POS system market matures over time in terms of chain digitisation enabling functionalities. If this research could find its way into practise, it could stimulate software suppliers to innovate their solutions, in turn leading to better POS systems for retailers. In our view, further exploring the role of software vendors in innovating value chains would be of great value.

6 Adoption of interorganisational ICT in primary care[8]

Efficient and effective collaboration among health care providers is of great importance. Interorganisational ICT can enable and facilitate this collaboration, but the adoption of such information systems is still sparsely analysed. In this chapter we describe the results of a survey among 49 GP practices in the Netherlands held in 2009 and 2010, which were queried on their adoption of different types of interorganisational ICT, such as the exchange with out-of-hours services and with other primary and secondary care providers. It appears that the adoption of interorganisational ICT is not significantly related to personal or organisational characteristics of the GP practice, nor to characteristics of their patient population. What is related, is the type of GP software package the practice uses.

6.1 Introduction

As is the case in many developed countries, the Netherlands will face a sharp increase in demand for health care services in the coming years, whereas supply is becoming limited at the same time (OECD, 2010a; Bodenheimer, Chen, & Bennett, 2009; Margolius & Bodenheimer, 2010). Efficient and effective collaboration among health care providers is one way of limiting the consequences of these two trends. Collaboration and information sharing in health care services are of great importance (Pirnejad, Bal, Stoop, & Berg, 2007) and a trend in many countries, especially in the Netherlands (Schäfer et al., 2010; Minkman, Ahaus, & Huijsman, 2009; Kringos et al., 2010). ICT can facilitate this (e.g. Daft, 2001; Mannan, Murphy, & Jones, 2006; Mann, Lloyd-Puryear, & Linzer, 2006; Hillestad et al., 2005), and many initiatives are undertaken in the health care sector (OECD, 2010b; Fontaine, Ross, Zink, & Schilling, 2010). Especially interorganisational ICT (also termed 'chain digitisation'; Plomp & Batenburg, 2010; chapter 2 of this dissertation) is relevant in this respect. In a meta-study on exchanging health information of primary care practices, Fontaine et al. (2010) reviewed over 60 studies on this topic, showing that the main benefits are more efficient workflow, improved quality of care, cost savings and increased revenue. Likewise, the OECD indicates that ICT implementation in health care leads to benefits in four, interrelated categories (OECD, 2010b): (1) increased quality of care (and efficiency), (2) reduced costs of clinical services, (3) reduced administrative costs, and (4) enabling entirely new modes of care. The OECD also describes however, that reaping these benefits is not

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straightforward, as there is a lack of commonly defined and consistently implemented standards and concerns about privacy and confidentiality.

General practitioners (GPs; family doctors) play a central role in the Dutch health care system, being the gatekeeper for health services (Schäfer et al., 2010; Van Riet-Paap, Boerma, & Kringos, 2010). As the medical and administrative tasks of GP practices increase in number, variety and complexity, ICT has become more and more important for GPs to execute the required patient care and to comply with the requirements of health care insurers, governments and other stakeholders. The Netherlands is a frontrunner in the use of electronic patient records (EMR) in GP practices in comparison with other European countries (Schäfer et al., 2010; Van Riet-Paap et al., 2010). Next to this, other types of ICT are emerging in the GP practice. For example, there are e-mail consultations, internet-based health applications, websites of GP practices, e-mail communications with other health care organisations and laboratories, and so on.

Despite all these developments, the adoption of (new) interorganisational ICT in primary care appears to diffuse slowly and is confronted with many problems (Minkman et al., 2009; Anderson, 2007; Barjis, 2010). Barriers often mentioned are costs, security and privacy issues, but also liability, political leadership, sceptics, and technical barriers (Fontaine et al., 2010). Adoption barriers and problems are generally assumed to be more prominent in smaller primary care practices (Reardon & Davidson, 2007).

The starting point of this chapter is to increase the understanding of interorganisational ICT adoption in primary care, in particular GP practices, building upon existing ICT adoption studies. Within the medical domain, there are not many empirical studies performed so far in primary care (Fontaine et al., 2010). Both Fontaine et al. (2010) and Chismar and Wiley-Patton (2003) explicitly call for additional research on the effects of physicians' characteristics on information technology adoption "across specialties, disciplines, geographic boundaries, and cultures" (Chismar & Wiley-Patton, 2003). By having more insight into how ICT can contribute to the much-needed benefits in the health care sector, managers and policy makers can be supported in their search for 'buttons and levers' that can improve the successful uptake of ICT and innovations in this sector.

The main research question of this chapter is twofold: *(1) what is the level of interorganisational ICT adoption of GP practices in the Netherlands, and (2) what are the determinants of this level of adoption?* The structure of the remainder of this chapter is as follows. First, through reviewing earlier studies, we classify and define a number of factors that potentially influence the adoption of interorganisational ICT by GPs. Next, we describe how we measure both this adoption and its (potential) determinants, through the survey dataset available. In the results section, we first describe the level of interorganisational ICT adoption among the sample of GPs, and consequently test if the factors are indeed related to the adoption level.

To conclude the chapter, limitations of this work are discussed and suggestions for future research endeavours are given.

6.2 Theory

The existing studies on GPs and their adoption (and use) of interorganisational ICT define different groups of characteristics/determinants. Most studies are based on literature or cases (also see Chiasson, Reddy, Kaplan, & Davidson, 2007 for an overview). A number of studies that can be mentioned are:

- Wainwright and Waring (2006), who focused on innovation, task, individual, environmental, and organisational factors;
- Topacan, Basoglu, and Daim (2009) studied the influence of user characteristics, service characteristics, ease of use, social factors, usefulness, and facilitating conditions;
- Schaper and Pervan (2007) addressed the importance of the technological, individual, and implementation context;
- MacGregor, Hyland, and Harvie (2009) studied whether organisational characteristics could explain the differences between rural and urban practices;
- Evans et al. (2008) looked at practice characteristics, in particular the number of diabetes-educated staff;
- Tsiknakis and Kouroubali (2009) applied a specific framework to study "socio-organisational-technical factors that influence IT adoption in the healthcare domain", including the 'fit' between task, technology and individual factors;
- In a multi-site case study on the introduction of shared electronic records, Greenhalgh et al. (2008) identified explanatory determinants on the micro level ("material properties of the technology, individuals' attitudes and concerns, and interpersonal influence"), the meso level (organisational antecedents, readiness, and operational aspects of implementation), and the macro level (institutional and socio-political forces influence the course of the introduction process).

If we look at the more general literature on ICT adoption and use by organisations, there are many studies as well that address different types of determinants and conditions (Daft, 2001; Wainwright & Waring, 2006; Bouwman, Van den Hooff, Van de Wijngaert, & Van Dijk, 2005). In order to overcome the lengthy debate on which determinants are in fact the most important, or which general factors can be 'transferred' or 'translated' to the domain of GP practices and interorganisational ICT, for this research we propose a more general

approach. We start from the framework by Tornatzky and Fleischer (1990), which can be considered as a generic and commonly accepted model to, first, classify ICT adoption determinants of organisations. Following this classification, we then define a number of determinants that can be assumed to be of importance for the adoption of interorganisational ICT in GP practices. This approach enables us to link it with the specific survey dataset available on Dutch GPs – which will be described in the next section.

In the 1990s, Tornatzky and Fleischer developed their generic framework for the adoption and implementation process of technological innovations (Tornatzky & Fleischer, 1990). They describe three groups of determinants (or: explanatory variables) that influence this process:

1. the technological context,
2. the organisational context, and
3. the environmental context.

This classification of determinants has become commonplace in IS research (e.g. Daft, 2001; Scott Morton, 1991; Turban, McLean, & Wetherbe, 2001; Luftman & Kempaiah, 2007; Zhu & Kraemer, 2002) and is also in concordance with Atkinson, Eldabi, Paul, and Pouloudi (2001) and Berg, Aarts, and Van der Lei (2003) who indicate the importance of an integrated socio-technical approach for a health informatics initiative to be effective. This threefold classification also matches Fleuren, Wiefferink, and Paulussen (2004), who developed a theoretical framework representing the main stages of innovation processes, based on several theories and models. In total, they identified 50 determinants of innovations in health care, based on a systematic review of the literature. These were classified in four categories: (1) characteristics of the socio-political context, (2) characteristics of the organisation, (3) characteristics of the adopting person (user), and (4) characteristics of the innovation. These four categories can be well mapped on the three context types of Tornatzky and Fleischer: the technological context being similar to the characteristics of the innovation, the environmental context resembling the characteristics of the socio-political context, and the organisational context matching with both the characteristics of the organisation and the person, as the majority of GP practices are very small (micro) organisations consisting of one or two persons.

In the next section, we describe how the classification of Tornatzky and Fleischer can be applied to variables in a dataset based on a repeated survey among Dutch GP practices in 2009 and 2010.

6.3 Data & measurements

6.3.1 The LINH survey

In this study we use data from practices participating in the Netherlands Information Network of General Practices (LINH). This network consists of a representative panel of around 80 GP practices in the Netherlands, evenly distributed across the country. The network and panel have been set up by the Netherlands Institute for Health Services Research (NIVEL) and IQ Healthcare. It is funded by the Ministry of Health, Welfare and Sports (VWS). In 2009, 84 GP practices participated; for other years this number is more or less the same; panel drop-out is kept to a minimum to safeguard the possibility to conduct longitudinal studies at patient level.

LINH started in 1992, recording only referrals of GPs and then gradually developed into a system recording all patient contacts and all interventions within the connected practices, including diagnoses. Currently the LINH database holds (cumulative) information about more than three million patient years, and longitudinal data on morbidity, prescribing, laboratory measurements, and referrals of about 350,000 individuals. This patient data is the key source of LINH, to develop and maintain a high quality longitudinal database on morbidity and GP care in the Netherlands, and to use this database for health services research and quality of care research. Data are extracted twice a year from the electronic medical records (EMR) used in the practices to file patient information. This extraction is approved by the GP and is executed by a custom-made application. Participating GPs receive feedback reports, comparing their own practice with the LINH average. They also receive a modest financial compensation.

Next to the patient data extractions, all LINH practices are surveyed on a yearly basis. The aim of this survey is to monitor the use of the feedback information provided, registration and EMR issues, whether data exchanges with other health care providers occur and digital linkages with pharmacists exist, and other items that are relevant in a certain year.

6.3.2 Measurement of the dependent variables: Adoption of interorganisational ICT by GPs

In the 2009 and 2010 survey, the respondents were asked to answer a number of questions regarding their interorganisational ICT adoption, the focus of this study. Although the number of items within the survey was limited, they cover different types of interorganisational ICT that GP practices can use within the Dutch primary care system.

The selected survey items (verbatim question quoted) and their answer categories are coded as a 'cumulative' ICT maturity scale (from 'low' to 'high') and can be considered as ordinal

(rank) but not interval variables. They are summarised in Table 6.1, including their frequencies.

Table 6.1 Descriptives of the 3 items measuring interorganisational ICT adoption by GPs in 2009, 2010 and the answers in 2009 and 2010 compared

Item	Answer in 2009	Answer in 2010	Answer in 2010 compared to 2009
1. Next to the LINH module, do you also use the 'Zorgdomein' application to register referrals to secondary care? (yes=1, no=0)	• No: 67.3% • Yes: 32.7%	• No: 57.1% • Yes: 42.9%	• No in 2009 and in 2010: 57.1% • No in 2009, yes in 2010: 10.2% • Yes in 2009 and 2010: 32.7%
2. Can the out-of-hours service employees retrieve patient information from your EMR system? (yes=1, no=0)	• No: 79.6% • Yes: 20.4%	• No: 63.3% • Yes: 36.7%	• No in 2009 and 2010: 63.3% • No in 2009, yes in 2010: 14.3% • Yes in 2009 and 2010: 20.4%
3. How are consultations recorded that are separately reimbursed in disease management programmes? (in a chain information system=2, in our GP information system=1, not=0)	• Not: 26.5% • In our GP information system: 57.1% • In a chain information system: 16.3%	• Not: 20.4% • In our GP information system: 51.0% • In a chain information system: 28.6%	• Not in 2009 and 2010: 20.4% • In our GP information system in 2009 and 2010: 42.9% • In a chain information system in 2009 and 2010: 16.3% • Not (i.e. not or only in GP IS) in 2009, in a chain information system in 2010: 12.2%

In both years, about 75% of the practices approached completed the questionnaire (n=62 in 2009, n=69 in 2010). In total, 49 practices completed the questionnaire in 2009 as well as in 2010. To maximise our base for analysis, we perform cross-sectional analyses using the 2009 and 2010 dataset in parallel, i.e. using the dataset that contains the same 49 practices in 2009 and 2010. Doing so, we are also able to analyse the change scores of the 49 practices between 2009 and 2010.

From Table 6.1 we can derive that for all three items, GP practices hold proportionally 'higher' scores in 2010 compared to 2009.

As a next step we explore if the item scores are intercorrelated, as they can be seen as indicators of a common latent factor, i.e. the level of interorganisational ICT adoption by (Dutch) GP practices. Below (Table 6.2) are the results of Spearman's rho correlations (as

all three variables are measured at an ordinal level) calculated between the 3 items, both for the 2009 and 2010 dataset.

Table 6.2 Results of Spearman's rho correlation analysis between the 3 items measuring interorganisational ICT adoption by GPs in 2009 and 2010

Item[a]	Correlation with item 2	Correlation with item 3
1. Next to the LINH module, do you also use the 'Zorgdomein' application to register referrals to secondary care?	2009: –.03 2010: +.20	2009: +.04 2010: +.02
2. Can the out-of-hours service employees retrieve patient information from your EMR system?		2009: +.08 2010: +.16
3. How are consultations recorded that are separately reimbursed in disease management programmes?		

[a] The value coding is presented in Table 6.1.

The results show that the items are mostly positively correlated, but for no pair of items is the Spearman's rho correlation significant (p>.10). This indicates that the items probably address different aspects of (interorganisational) ICT systems and functionality. Given these results, we chose not to add or aggregate them into one factor or scale. At the same time, we have no specific reason to exclude one of the items. The fact that the items are not intercorrelated does not imply that they are invalid or unreliable as indicators. Hence for further analysis, each item is used as a separate dependent variable.

6.3.3 Measurement of the independent variables: Determinants of interorganisational ICT adoption by GPs

In this section we present the data and measurements to measure the potential determinants of interorganisational ICT adoption by GP practices through our dataset available, applying the three dimensions of the Tornatzky and Fleischer model presented earlier.

With regard to the *technological context* we define the type of EMR system used by the GP practice as the main determinant. EMR systems are a typical example of product software, which is provided by a limited number of vendors and used by many users/organisations (Xu & Brinkkemper, 2007). Although EMR systems for GP practices basically aim to support the same primary processes of patient recording, diagnosing, prescribing, referring and billing, they do differ in their functionalities, in particular with regard to external communication and interaction with other systems (i.e. their interorganisational functionalities, cf. Plomp & Batenburg, 2010; chapter 2 of this dissertation), making it a potential determinant.

The *organisational context* is defined in this study by four characteristics of the practice and its GPs. First, we define age and gender as potentially important, following the propositions

set and validated by Rogers (2003) and Venkatesh, Morris, Davis, and Davis (2003). In case there were several GPs, the average age and the proportion of women within the GP practice were used, which are identified in other studies among health practitioners as well (Parekh, Nazarian, & Lim, 2004; Simon, Rundall, & Shortell, 2005). Next, we select the GP practice size as indicator by the number of GPs employed (including GP self-employed), as the scale of processes and activities is naturally of relevance for the extent to which practices actually need to exchange information with other organisations (cf. Iacovou, Benbasat, & Dexter, 1995). This includes if a GP practice is part of a health centre or not, which can typically influence decisions with regard to supporting and facilitating functions such as ICT. The fourth characteristic we take into account is the amount of practice experience of the GP (measured in years). It should be noted that we only assessed the experience of the responding GP here.

Third and final, the *environmental context* in this study is defined by the patient population of the practice in terms of their size and their age distribution. This context is expected to determine the relative workload a GP practice is dealing with. The average patient age is potentially important, as elderly care is mostly chronic care, which in the Netherlands is organised in chains, which drives the need for interorganisational ICT (Minkman et al., 2009).

The descriptive statistics of the determinants as present in the 2009 and 2010 dataset are presented in Table 6.3. With regard to the technological and organisational context variables, no changes have been reported between 2009 and 2010.

Table 6.3 Descriptives of the defined determinants of interorganisational ICT adoption by GPs, based on Tornatzky and Fleischer (1990) and the LINH dataset available

	Mean	Standard deviation	Minimum	Maximum	n
Technological context[a]					
Using EMR / GP software package A (%)	18.37				9
Using EMR / GP software package B (%)	12.24				6
Using EMR / GP software package C (%)	28.57				14
Using EMR / GP software package D (%)	30.61				15
Using EMR / GP software package E (%)	10.20				5
Organisational context					
Length of practice experience of the responding GP (in years)	15.27	9.78	0	33	49
Proportion of female GPs in the practice (%)	34.48	29.23	0	100	49
Average age of all GPs in the practice (years)	48.12	6.08	33	59	49
Size of the practice (1 GP=1, 2 GPs=2, 3 GPs or more=3, part of a health centre=4)	1.65	0.93	1	4	49
Environmental context					
Practice size (number of patients in 2009, 2010)	2009: 4,081 2010: 4,147	2009: 2,313 2010: 2,457	2009: 1,870 2010: 1,892	2009: 10,680 2010: 12,894	49
Average age of the patients (in 2009, 2010 in years)	2009: 48.65 2010: 48.71	2009: 4.75 2010: 4.69	2009: 36 2010: 36	2009: 56 2010: 57	49

[a] Names of the EMR / GP software packages are anonymised.

6.4 Results

In this section we test the expectations that were formulated in the previous section, i.e. that the defined determinants are related to the different types of interorganisational ICT adopted by the GP practices. The basic test is performed by calculating Spearman's rho correlations between the dependent and independent variables, recognising the ordinal scale of the ICT adoption variables. To investigate the relationship between the type of EMR used by the GP practice and the adoption variables an ANOVA-test is applied. Table 6.4 shows the results.

Table 6.4 Correlation and ANOVA-test results, testing the relationship between the defined determinants and 3 items measuring interorganisational ICT adoption by GPs

Determinant	Interorganisational ICT adoption item[a]		
	Next to the LINH module, do you also use the 'Zorgdomein' application to register referrals to secondary care?	*Can the out-of-hours service employees retrieve patient information from your EMR system?*	*How are consultations recorded that are separately reimbursed in disease management programmes?*
Technological context (ANOVA-test, F-value, df=4)			
Using EMR / GP software package A-E (%)	2009: 1.50 2010: 2.47*	2009: 2.55* 2010: 4.63**	2009: 1.84 2010: 1.41
Organisational context (Spearman's rho correlation)			
Length of practice experience of the responding GP (in years)	2009: +.16 2010: +.08	2009: –.08 2010: –.02	2009: –.19 2010: –.08
Proportion of female GPs in the practice (%)	2009: –.08 2010: –.15	2009: –.04 2010: –.17	2009: –.09 2010: –.16
Average age of all GPs in the practice (years)	2009: –.07 2010: +.05	2009: +.09 2010: +.20	2009: –.21 2010: –.19
Size of the practice (1 GP=1, 2 GPs=2, 3 GPs or more=3, part of a health centre=4)	2009: +.24 2010: +.20	2009: –.09 2010: +.10	2009: +.06 2010: +.04
Environmental context (Spearman's rho correlation)			
Practice size (number of patients)	2009: +.25 2010: +.23	2009: +.03 2010: –.01	2009: +.03 2010: +.07
Average age of the patients (in years)	2009: +.00 2010: +.01	2009: +.00 2010: –.07	2009: +.04 2010: +.08

[a] The value coding is presented in Table 6.1.
*: p<.05; **: p<.01.

The results clearly indicate that none of the organisational (including person characteristics) or environmental context variables is related to the level of interorganisational ICT adoption by the GP practices. The Spearman's rho correlations are non-significant. However, the ANOVA-tests performed on the differences between the EMR systems (GP software packages) show some significant results. In particular, the item on whether out-of-hours service employees can retrieve patient information from the GP's EMR system does significantly differ between the EMR systems, both in 2009 and 2010. In 2010, the use of the special referral module 'Zorgdomein' significantly differs between the different GP systems.

6.5 Conclusion & discussion

In this chapter we started from the notion that the adoption of interorganisational ICT in primary care is considered as important and is advocated by different stakeholders. At the

same time, the potential determinants for the uptake of ICT-based information exchange between GP practices are hardly investigated empirically. In this chapter we present and use data collected among a sample of 49 GP practices in the Netherlands that participated in a survey in 2009 and in 2010. The data provide a unique opportunity to perform empirical analysis on the level of adoption of interorganisational ICT by GP practices and its potential determinants.

The survey data firstly show that GPs, between 2009 and 2010, have become more advanced in their exchange of information with GP posts, in using referral modules and chain digitisation applications or software. Then, based on the classification framework of Tornatzky and Fleischer (1990), three types of determinants were investigated that are expected to have influence on interorganisational ICT adoption by GP practices. Most determinants appear to be not significantly correlated with the adoption variables, however. Both the 2009 and 2010 data show that gender, age and experience of GPs in a practice are not related to the level of interorganisational ICT adoption, nor is the size of their practice. Also, we did not find a relationship for the number of patients or their average age. Adoption levels did differ between the types of EMR systems the GPs have in place. Some GP practices are significantly better connected to out-of-hours service employees, who can retrieve patient information from the GP's EMR system, than other. Also, certain types of EMR systems used by the GP practices are significantly more involved in the use of special modules for referral to secondary care.

These results obviously trigger several new questions. If GPs that use certain types of EMR are more mature with regard to their external information exchange through ICT than others, it is obviously relevant to explore the exact reasons behind this result. This implies a more in-depth and comparative analysis of the functionalities of EMRs, which has not been performed on a scientific basis until now. Also, a hypothesis worth testing is whether GP practices – with certain characteristics in combination with a certain EMR system – are frontrunners in the level of interorganisational ICT adoption. To test this hypothesis however, a larger sample size (number of GPs) is needed. Further data collection can enable this. Successive measurements among the current group of 49 practices can also be used to perform longitudinal data analysis. This enables a further exploration of the determinants behind interorganisational ICT adoption in GP practices, as clearly more and other variables may be of influence. This extended analysis could also include the matter of causality for the relationship between characteristics and adoption of interorganisational ICT adoption by GP practices.

Part IV:
Policy Studies on Interorganisational Information Systems

7 Towards an information strategy for combating identity fraud in the public domain: Cases from healthcare and criminal justice[9]

Two trends are present in both the private and public domain: increasing inter-organisational co-operation and increasing digitisation. More and more processes within and between organisations take place electronically, on local, national and European scale. The technological and organisational issues related to this prove to be difficult on a local scale and barely manageable on national and European scales. We introduce the theoretical framework of Chain-computerisation, which explains large-scale chain co-operation as an answer to a dominant chain problem. Identity fraud proves to be the dominant chain problem in many chain co-operation situations. Therefore, our main research question is: how to arrive at a successful information strategy to combat identity fraud in the large-scale processes that constitute the public domain? We demonstrate the problem of identity fraud on the basis of two Dutch cases, from the criminal justice chain and the healthcare sector. These cases are taken from our chain research programme in which we test empirical findings against the theoretical framework of Chain-computerisation to derive a successful chain-specific information strategy. In both cases, the problem of identity fraud presents a threat to the chain co-operation. Identity fraud has to be tackled with an approach focused on large-scale processes and with specific person-oriented security procedures and instruments preventing identity fraud from happening undetected. This study forms an important contribution to information science and to the security realm that still pivots only on traditional authentication frameworks that cannot cope with 'wrong person' identity fraud. In large-scale situations, therefore, additional safeguards will be necessary. Taking into account that the problem of identity fraud rises in many other domains and countries as well, we conclude that it is a major threat to the European society. Finally, we argue that chain-specific information systems with random identity verification enable combating identity fraud.

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7.1 Introduction

Interorganisational co-operation is becoming increasingly important, as organisations are more and more interdependent. ICT can support the development of interorganisational relations through cost reduction and/or increasing possibilities for communication and coordination (Williams, 1997). Since the internet has become mainstream, many organisations communicate with each other through this channel. This can be in the form of basic means like e-mail messaging, but nowadays also often takes place using advanced ICT applications like chain information systems. These developments are visible on local, national and European scales.

Research, strategy and policy often focus only on technological issues, like standards for interorganisational information exchange. Organisational issues however, like who co-operates with whom, shares which information and why, are complex and important as well. It can therefore be argued that attention should be given to both dimensions (Plomp & Batenburg, 2010; chapter 2 of this dissertation). Both technological and organisational issues prove to be difficult on a local scale and barely manageable on national and European scales, because the number of parties increases greatly and because of differences in culture, legislation and ICT infrastructure. These factors explain the difficulties and sensibilities that are encountered in large-scale interorganisational chain information infrastructures. Even when these large-scale communication initiatives are successfully deployed, there are many potential problems in their use that need to be taken into account. As interorganisational co-operation in the information age is becoming increasingly important, everyone working in (e-)government should be aware of its inherent risks. In this chapter, we present those risks using two cases from the vital domains of criminal justice and healthcare. We argue that one of the main threats in these domains is identity fraud, and show the potential danger if this problem is not properly handled.

In this chapter, we introduce the theoretical framework of Chain-computerisation that explains large-scale chain co-operation as an answer to a dominant chain problem (see §2). Identity fraud proves to be the dominant chain problem in many chain co-operation situations. Many people think that through further securing the authentication process, the risk of identity fraud can be reduced (e.g. Drogkaris, Geneiatakis, Gritzalis, Lambrinoudakis, & Mitrou, 2008). This basic security is necessary, but we claim that this is only sufficient for small-scale situations. In large-scale chain co-operation situations, traditional authentication systems and procedures prove to be unable to cope with 'wrong person' identity fraud. Identity fraud proves to be hard to prevent in these situations. Therefore, our main research question is:

> *How to arrive at a successful information strategy to combat identity fraud in the large-scale processes that constitute the public domain?*

In order to provide an answer to this question, the remainder of this chapter is structured as follows. First, we present the theory of Chain-computerisation and the three components of its chain perspective. This provides the background against which we formulate our approach for combating identity fraud. We describe our research method and pay specific attention to the process of conducting a chain analysis and deriving an information strategy from that. Next, we present our two cases in which identity fraud plays a central role, and indicate how this phenomenon can be countered. We conclude with our main findings and suggest some topics for future research.

7.2 Chain-computerisation and its specific chain perspective

Chain-computerisation (Grijpink, 1999; 2010) is a theoretical framework which explicitly focuses on large-scale social chains, not on logistic chains (the process of handling goods), nor on information chains (closely linked information systems). Examples of social chains are social security, criminal law enforcement or drug addicts' healthcare: large-scale inter-organisational processes that yield a social product such as income support, safety or survival.

Central to the theory of Chain-computerisation is a specific chain perspective to better understand large-scale chain co-operation processes and chain communication systems. This chain perspective consists of three components. The first component is the concept of a *dominant chain problem*; a problem that no party in the chain can solve on its own. The second component is the idea that a chain should be seen as a *multi-level phenomenon*, enabling a distinction between automation at the 'base level' and the 'chain level'. The third component is the *acknowledgement of irrational decision making at the collective chain level*. The rationale of this chain perspective is recognising *fallacies of the wrong level*. They lead to invalid assumptions and unjustifiable expectations causing large-scale communication systems to fail or sometimes even backfire. We will now discuss these four central elements.

7.2.1 The dominant chain problem as the trigger of chain communication

In a social chain, thousands of organisations and professionals work together without a clear relationship of authority, in ever-changing combinations depending upon the actual case. However, co-operating with other organisations and professionals takes a great deal of effort, time and money. There must be a cast-iron reason for doing so. Chain partners only co-operate if they are forced to do so by a dominant chain problem. A dominant chain problem is one that none of the partners can solve on its own. It is only by effectively co-operating that chain partners can prevent the systematic failure of their own organisation and the entire chain. Because common interests are less pronounced than people usually think – and are also often unclear – the badly needed cohesion can only be provided by a

pressing dominant chain problem. Only such a barely-manageable problem can create an interplay of forces which triggers large-scale co-operation of so many organisations and individuals and promotes the development and maintenance of a large-scale chain communication system focused on the dominant chain problem. In a chain analysis, the dominant chain problem – if any – is uncovered, defined, examined and tested against the theoretical requirements that must be fulfilled to qualify as a trigger for large-scale chain co-operation. If in a specific chain a dominant chain problem cannot be found or – upon examination – does not seem to be vigorous or tenacious enough, a large-scale ICT-project for this chain will predictably fail or falter. Thus, the dominant chain problem determines to a large extent the feasibility of a large-scale chain communication system.

7.2.2 The chain as a multi-level phenomenon

The theoretical framework of Chain-computerisation sees a chain as a multi-level concept (see Figure 7.1). It makes a distinction between interorganisational (or chain) information systems at 'chain level' on the one hand, and *intra*-organisational information systems (or source registers) at the 'base level' of the chain, that can be linked to a chain information system, on the other hand. A chain information system automatically detects in which intra-organisational system relevant information can be found or, for instance, which organisation should be informed depending on the actual dominant chain problem that the chain co-operation is focusing on. The dominant chain problem determines the content of the necessary chain communication. This chain communication is brought about even when chain partners themselves do not know which organisations are involved in the case at hand.

This distinction is meant to analytically enable separating information collection and storage in source registers from communicating essential details throughout the chain using chain information systems. It directs our attention to two notions:

- According to the theory of Chain-computerisation, only the critical details that are absolutely necessary for preventing the dominant chain problem should be available at the chain level.
- Irrational decision making takes place at the chain level, as will be explained next.

This way, large-scale chain communication systems have only minor influence on the chain partners' autonomy; projects meet less resistance, so the critical mass of participating organisations is reached as soon as possible.

This multi-level scheme – for a better understanding of the problems inherent in large-scale chain co-operation and communication – can be applied to any large-scale phenomenon.

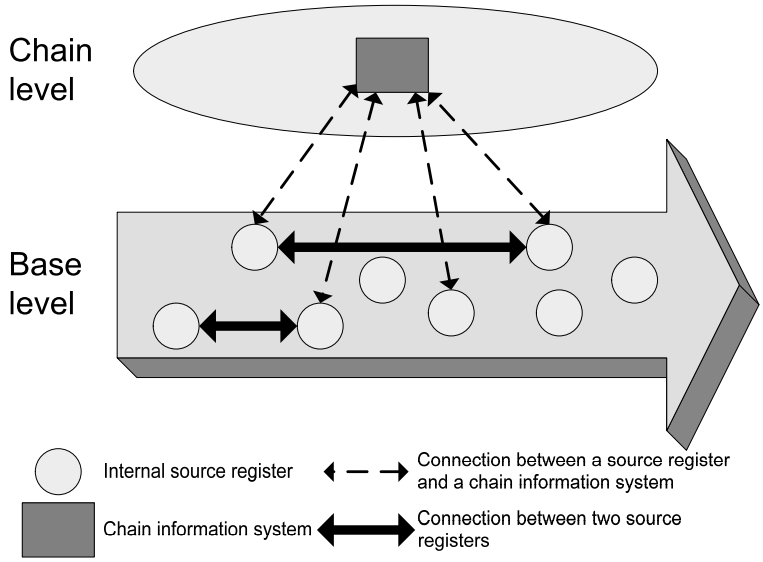

Figure 7.1 Two distinct levels of analysis, with different types of information systems

7.2.3 Acknowledgement of irrational decision making at the collective chain level

Because overall leadership or authority is absent, the chain is a difficult administrative domain in which decision making and information exchange proceed differently than *within* organisations. Rationality and efficiency are often hard to find at the collective chain level and, as a consequence, unpredictability and lack of control are the order of the day. A model of irrational decision making that fits well with the processes that take place at the chain level is the garbage can model of Cohen, March, and Olsen (1972; March & Olsen, 1976). This model states that the outcome of decision processes results from combining a random selection of problems, solutions and decision makers. Often this concept of irrationality at the chain level is hard to grasp. The crux is that – as there is no single party in command – group processes at the chain level are not rational, even if every individual professional and organisation acts rationally. The theoretical framework of Chain-computerisation takes this lack of an overall co-ordinating and enforcing authority as its starting point. Large databases containing substantive data to be used by many independent organisations call for more authority and willingness to co-operate and pool resources than are usually present in chains. Collective decision making is chaotic and unpredictable. Therefore, chain solutions should be basic and non-complex. A simple alert mechanism using a chain information system at the chain level is often the maximum result that can be attained.

The significance of a decision model as a component of our chain approach is that it creates awareness of the inherent complexities of any large-scale situation and warns against expecting clear objectives, ample support or well-articulated decisions. At the chain level, these ideal conditions will not be found. Instead, the model teaches us to expect setbacks and to develop chain communication systems only in a very gradual way.

7.2.4 Fallacies of the wrong level

In information science – as well as in management – we usually derive insights from small-scale situations such as a local information system, a small group experiment or a regional pilot. Thus, we have gained insights into the power of recording data and in management tools such as time schedules and budgets. If we transpose such insights to large-scale situations without checking the validity of underlying assumptions at that level, we often make a 'fallacy of the wrong level' (cf. Galtung, 1969). This might partly explain why so many policy measures and large-scale systems unexpectedly produce poor results, fail or falter – and sometimes even backfire.

The concept elaborated upon in the previous subsection provides a good example of such a fallacy of the wrong level. Expecting that chain decision making takes place in a rational and well-articulated manner seems logical, as individual organisations use to behave rationally. At the collective chain level, however, this cannot be the case because essential preconditions for rational decision making are not fulfilled. Another example is providing a single sign-on e-government architecture, as discussed by Drogkaris et al. (2008) for the Greek situation. Although this may seem convenient from the perspective of an individual user, it also means that once a malevolent person obtains the possibility to fraudulently sign on, (s)he has access to all e-government services. The notion that a person who provides the right credentials (e.g. username and password) does not necessarily imply that this is also the right *person*, is important in this respect. In small-scale situations, the focus is often only on optimising the authentication procedure. In large-scale situations, the focus should also be on preventing malicious use of these authentication means by someone other than the authorised person.

The theoretical framework of Chain-computerisation suggests several remedies against making fallacies of the wrong level, while taking into account the needs and preconditions of large-scale chain co-operation. One such remedy could be, for instance, taking a gradual approach to the development and implementation of large-scale systems. Most of all, we must stop treating large-scale communication systems as intra-organisational information systems with a somewhat larger group of users. This is a classic fallacy of the wrong level. Chain-computerisation features a chain approach with its three pillars (§2.1-§2.3) which – taken together – provide professionals and researchers with a compass that is better suited

for a working environment without a co-ordinating and enforcing authority, thus preventing from making fallacies of the wrong level that cause projects and systems to fail or falter.

7.3 Chain-computerisation and its method of chain analysis

Apart from the chain perspective, the theoretical framework of Chain-computerisation offers a specific method for chain analysis, to better assess the feasibility of large ICT-projects and information systems. The examples that we present in the following two sections are case studies taken from our chain research programme at Utrecht University based upon this method. This programme has an exploratory, empirical character and mainly consists of conducting chain analyses. A chain analysis tests empirical findings against the theoretical framework of Chain-computerisation, to derive a suitable chain-specific information strategy to cope with the dominant chain problem.

By now, we have performed over 25 analyses of Dutch and international chains (Plomp, 2011). For each chain analysis, desk and field research have been performed. Data collection took place from 2005 till 2010. By interviewing a number of stakeholders within a chain, we try to obtain an accurate picture of it, estimating the value of the variables used in the chain analysis. Each chain analysis consists of constructing the four assessment profiles provided by the theory of Chain-computerisation: the mission, coordination, information, and co-operation profile. Completing these profiles entails, among other things, determining what the dominant chain problem is and what critical details are necessary to prevent the dominant chain problem from spoiling the result of the chain co-operation effort, assessing the required coordination forms in this specific chain and gauging the current level of chain-wide co-operation. An example of constructed assessment profiles for the chain analysis of the manic-depressive disorder chain-of-care can be found in a recent article in the Journal of Chain-computerisation (Grijpink, Visser, Dijkman, & Plomp, 2010, pp. 5-6). The results of this chain analysis, together with other input from the interviews, make it possible to formulate a successful information strategy (Grijpink et al., 2010, p. 7).

Generic, recurring results of the more than 25 conducted chain analyses thus far have bearing on the dominant chain problem, fallacies of the wrong level and identity fraud (Plomp, 2011). We have already seen the dominant chain problem and fallacies of the wrong level. In practice, identity fraud is poorly understood causing many social chains to dysfunction or be disrupted. Therefore, before turning to our two examples, we briefly explain the peculiar character of identity fraud. Identity fraud – using or stealing somebody else's identity with malicious intent – is becoming a major issue in our information society. The real problem is that if an identity fraud succeeds, all clues and traces lead to the victim instead of the culprit. Afterwards, the culprit cannot be found and the victim subsequently has

much difficulty proving his/her innocence. Identity fraud is difficult to detect while it is taking place unless special preventive tools and procedures are installed. This is usually not the case. Thus, identity fraud goes by unnoticed. A major challenge, indeed.

The phenomenon of identity fraud leaves us with difficult puzzles. Identity checking as a process is greatly predictable and observable because it takes place in public spaces. Making identity checking less predictable is a major challenge, but rewarding because identity fraudsters do not want to be caught. Usually, we check identities with only one ID-instrument, which makes the process vulnerable because checks with one ID-instrument can easily be manipulated. But how can we check identities with two or three independent ID-instruments at the same time? That requires a careful situational design of the process, which has to be variable in order to diminish the predictability of the process. Another difficult characteristic of identity fraud is that its magnitude is very hard (if not impossible) to measure. Every statistic is useless, as it only indicates how often the fraud has been detected: successful identity fraud goes by unnoticed. With this realisation in mind, news items stating that "the incidence of fraud has gone down" suddenly become much less positive.

The chain perspective provides a better understanding of the problem of identity fraud by revealing that its real damage will ultimately be the disruption of important large-scale communication systems. Moreover, once a person has fraudulently changed his/her identity in one chain, the new 'identity' can affect other chains as well in which it is no longer possible to see through the preceding fraudulent identity change. Thus, our chain research programme has resulted in a more realistic view of our interorganisational world and will in turn lead to better information strategies for successful large-scale information infrastructures for national or international chain co-operation.

7.4 Case 1: Identity fraud in the Dutch criminal justice chain

7.4.1 The criminal justice chain at the national level

Because successful identity fraud cannot easily be detected and mostly goes unnoticed, only rarely can a successful fraudster be detected because (s)he is still there. One such situation where this *is* possible, is the prison cell. If a criminal finds someone willing to sit out his/her sentence in his/her place, we find his/her stand-in person in the cell. Alternatively, if the criminal has been successful in using the identity of someone else, we find the right person in the cell but with an identity that is not his/her own. If this identity fraud goes undetected, the criminal is untraceable after his/her release because the administrative details of the verdict – stored in the criminal registry for later use – point to someone else. This

scenario could explain how a criminal sometimes succeeds in pursuing his/her career with a clean slate without links to his/her previous aliases.

In 2004, more than 100,000 sets of criminal fingerprints linked to more than one administrative identity had been registered in the Dutch national forensic biometrics system HAVANK (Grijpink, 2011). The cleverest criminals had succeeded in using more than 50 aliases, implying that they had managed to get their criminal verdicts spread to as many criminal records of other persons (who may not be aware of this). Note that this volume of identity fraud may be even bigger because a fingerprint set linked to a single name does not guarantee that this name actually belongs to the criminal. This volume of aliases was the result of only fifteen years of automatic biometric fingerprint checking in only a limited number of criminal cases, because until October 2010, the Criminal Procedure Law allowed the use of forensic biometrics only if necessary to prove someone's involvement in the criminal case at hand. An immediate confession thus prevented biometric identity checking. If the criminal retracted his confession in court, he could be pretty sure that fingerprint checking would not be done in this stage of the prosecution. Since January 2011 however, the Dutch Criminal Procedure Law provides for compulsory biometrical identity checking for every serious crime.

Apart from the HAVANK system, which is positioned at the base level of the chain, the criminal justice chain also has a chain information system at the chain level, a reference index for persons called VIP. This chain information system contains for every registered criminal a personal criminal number (the VIP-number) and a set of references pointing to criminal law enforcement agencies actually involved in this person's criminal justice procedures. The VIP-number is issued to a criminal when (s)he is registered in the information system of one of the chain partners for the first time; it will never be re-issued to another person and will be used at every new contact with one of the chain partners during the rest of his/her life. By 2004 however, the VIP system had already administered more than 1.2 million VIP-numbers since the introduction of the system in 1993. In 2004, this huge amount of VIP-numbers issued to first offenders suggested a large volume of identity fraud, because the Dutch population could not possibly account for so many criminals.

The above two systems, HAVANK and VIP, illustrate the apparent pollution that is present in the information systems of the Dutch criminal justice chain, as a consequence of successful identity fraud. In the future, this can be prevented or at least reduced by improving identity checking of criminals (i) by the police and (ii) in prisons:

(i) The police perform identity checking at the beginning of the chain. They used to do this by asking for an identity document or for name and address which are then checked against the residents' register of the relevant municipality. However, if name and address go together but belong to another person, this checking causes a wrong name mentioned in the

official report as well as in the subsequent summons and criminal verdict. This way the criminal will leave the chain with a clean slate when using his real identity. In the new procedure since January 2011, the police have to perform a biometric identity check first together with high resolution photographs, both taken simultaneously at the start of the procedure. If more than one trustworthy identity comes up, a thorough identity investigation is required by law with the possibility of special detention.

(ii) Until recently, the detention process was only supported by an administrative information system. Nowadays, prison management also uses biometric details in order to check at every internal movement or leave whether there is a biometric match.

If the above is done properly by the police and the prison, the value of trying to use another name or sending somebody else to serve a sentence is greatly diminished. Still, we are left with the challenge of verifying that older verdicts have been booked under the right name.

7.4.2 Fading borders: The criminal justice chain at EU-level

As criminals more frequently operate internationally, criminal justice will also need to operate across national borders more often. Let us now see how extending this national scale to an international scale complicates our national approach. The difficulties that make national chain processes barely manageable hold even more for the European situation.

An example of this increased complexity is the case of Michel Fourniret. This Frenchman was sentenced in France to long-term imprisonment having raped and murdered several young women. By moving to Belgium, he was able to start with a clean slate and even work at a school there. Apparently, the Belgian police never questioned the French criminal registry. The Belgian education chain might have questioned the Belgian criminal registry because, in many EU member states, Fourniret's job was considered sensitive enough to ask a job candidate for a so-called declaration of good conduct. However, consulting the Belgium criminal registry would wrongly have produced a clean slate, as his criminal past was only registered in France. To avoid this from happening in the future, criminal record information must be exchanged between EU-member states at the moment of a sensitive appointment of a person with another nationality. This communication will only be correct if two conditions are met:

- The national criminal law enforcement chain in every member state prevents identity fraud in its own criminal procedures.
- Each member state sends every criminal verdict to the convict's member state of nationality while preventing identity fraud during this transfer.

This implies a close co-operation among police forces within the EU, focused on the identity of their nationals in other EU-countries using the forensic biometrics procedures of the home country (i.e. the country of origin, not the country were the crime was committed). Chain-computerisation theory tells us that a physically centralised EU registry for criminal justice cannot be expected to work adequately at this enormous scale. Fortunately, at the moment, the efforts are being aimed at a bilateral exchange of criminal verdicts regarding member states' nationals based on a central access system and the use of the national biometric identities. In line with the theory of Chain-computerisation, this will eventually lead to a distributed EU criminal registry based on biometric identities that might be able to prevent criminal cases such as Fourniret's from happening again. At the moment, we are very far from this ideal situation, but much will already be gained if every criminal verdict that is to be exchanged between EU-member states is accompanied by fingerprints and photographs, similar to the Dutch national solution.

7.5 Case 2: The importance of identity in Dutch medical chains

We now shift our attention to another vital domain of our society where identity plays an important role: the healthcare sector. In the Netherlands, the government aims at introducing a national system of medical information exchange based on the national personal number as the sole identifier for recognition of persons and linking of data. Recently, there has been much debate about the implementation of this Electronic Patient Record (Schäfer et al., 2010). With the chain perspective of Chain-computerisation in mind, it is clear that the usual small-scale concept of the doctor-patient relationship does not adequately reflect the large-scale field of forces in healthcare between more than half a billion EU-patients and the EU's hundreds of thousands of medical service providers. A simple risk assessment might reveal, for instance, that some patients have a clear interest in using somebody else's personal number to be treated in cases (s)he is not insured for healthcare, to hide his/her illness from other persons or from his/her life insurance company. This identity fraud can take many forms but inevitably contaminates the medical record of the patient and of his/her victim. Identity fraud will probably surface in many large-scale healthcare chains as the dominant chain problem to be countered. This problem proves to be barely manageable on a regional scale. On a national scale, many preventive measures are needed; on an international scale, even more. At the moment, adequate preventive measures are generally absent.

Consider the large-scale nation-wide electronic patient record on the one hand, and the small-scale doctor-patient situation on the other. In the Netherlands, even national policy makers usually think about healthcare with the small-scale situation in mind. It is the situation they are most familiar with. When someone ('patient X') receives treatment in a hospital and enrols with the health identification number of someone else ('patient Y'), the vic-

tim (Y) usually will not suffer much from this as long as the geographical distance between the treatment locations of X and Y is large enough. Both doctors – trapped in their small-scale thinking – believe they know their own patient Y very well. But if all medical data would be combined in a nation-wide information infrastructure – now we are in the realm of large-scale information systems – the data of patient X would also be part of the virtual medical file of patient Y. None of both physicians would notice, as both name and number of their patient are correct. So, in most cases identity fraud goes by unnoticed, as the data point to their own patient for both doctors. It should be clear that these situations can easily lead to medical errors.

We are very far from an ideal situation, but much will already be gained if any national linking of medical records would not be based on the patient's personal number alone and – additionally – would also automatically present a high resolution photograph of the patient on the doctor's computer screen. In the near future, research should also establish which infrastructural elements and which additional safeguards are needed for the safe exchange of medical information on a European scale.

One such infrastructural element – that is also relevant to computerisation on national level – is the consideration that not all medical chains are similar, and thus may benefit from different information infrastructures. In our chain research we have found differences between for example the diabetes control chain and the manic-depressive disorder chain-of-care (Grijpink et al., 2010). These two diseases require fundamentally different medical data in order to provide adequate treatment. Furthermore, for diabetes it is usually sufficient to share patient data regionally, whereas manic-depressive people tend to be less 'sedentary', so it may be wise to share their data on a larger scale. And there are more relevant variables that vary across medical chains: differences in speed required, differences in the role of the patient (active/passive) and differences in the nature of the process (e.g. monitoring an illness, discovering an illness). For instance, the aforementioned illnesses are both chronic, but it is not hard to see that the acute medical care chain has other requirements.

Similar to the criminal justice example, we again see that a central – be it national or European – database for healthcare records is undesirable, as this facilitates identity fraud, makes it harder to keep all information up to date, and is more difficult from a privacy perspective.

7.6 Conclusion & discussion

Identity fraud/theft is easy and very profitable. In both cases discussed above, the dominant chain problem of identity fraud presents a threat to the relevant chain co-operation that has to be tackled with a large-scale approach and with person-oriented security procedures and

instruments that are indeed able to prevent identity fraud from happening undetected. Taking into account that this problem exists in many other domains as well, we conclude that identity fraud is a major threat to our society. The main reason is that our social systems are not designed to prevent or detect identity fraud. Because committing identity fraud is not a seriously sanctioned criminal offence, the culprit can effectively evade such unpleasant consequences as long-term imprisonment. Often, the cost-benefit relationship is in his/her favour. Moreover, the interests and motivations of the target persons in a chain process vary greatly, depending on the dominant chain problem. We have seen that only preventive measures can protect against identity fraud.

Our examples illustrate that the chain concept is a powerful tool in understanding how large-scale public information infrastructures can effectively tackle identity fraud, even on an enormous scale. The chain perspective and chain analysis have proven useful to uncover hidden aspects of large-scale social systems and to develop and deploy successful chain information systems geared to the dominant chain problem at hand. Therefore, we argue that basic, but chain-specific information systems, combined with random identity verification procedures enable combating identity fraud.

An important contribution of this chapter is that we have shown how the chain analysis method (Grijpink, 2010) is tuned towards the peculiarities of large-scale chain co-operation and the corresponding chain information infrastructures. The impact of a dominant chain problem and of irrational decision making at the collective chain level bring about that simply scaling up the usual authentication procedures and traditional defence measures is not good enough. They do not take into account identity fraud of the 'wrong person'-type that cannot easily be detected within large-scale systems and surreptitiously spreads from chain to chain.

Future research could focus on how identity fraud differs across social chains as for severity of the consequences, ease of detection and available prevention methods. We have already seen in this chapter that there are similarities but also great differences between identity fraud in the context of serving a sentence in a prison cell and receiving medical treatment at a hospital. Another possible future stream of research could focus on the relationship between the identity fraud problems covered in this chapter and the processes occurring in 'for-profit chains', e.g. online ordering in web shops.

Politicians and public managers like to simplify complicated interdependencies between and within large-scale systems and preferably produce simple measures. Our chain research has taught us that this is fruitless in the real world; we had better deal with the world as it really is. This does not exclude a simple solution, as these two examples show. The example of the criminal law enforcement chain also applies to many other large systems at EU scale. If it proves to be that easy to use other people's identity under the watchful eyes of

the criminal law enforcement officials, we must not delude ourselves about the future of identity fraud in less well-guarded public information infrastructures, such as employment, education or travel. If, in the future, we are not able to adequately counteract identity fraud – even, for example, in large-scale EU co-operation in the vital fields of identity management and healthcare – governments will ultimately lose much of their legitimacy.

8 ICT policy to foster interorganisational ICT adoption by SMEs: The Netherlands Goes Digital case[10]

SMEs are of vital importance for our economy and society. However, they lag behind in their adoption of ICT, particularly interorganisational ICT. Many countries have put policy programmes in place to improve SMEs on this aspect. Previous research provides unclear evidence on the effectiveness of these programs. With this study we aim to provide new insight into the impact of such policy choices on ICT adoption. Through a survey among a relatively large sample of SME participants (n=516) and a matched control group (n=124) of non-participating SMEs, we assess a policy programme that ran in the Netherlands from 2002-2007. Participants are found to use significantly more interorganisational ICT and also more often find that ICT has enhanced their firm's performance compared to the control group. However, pre-selection effects cannot be ruled out. Based on our results, we suggest basic, awareness-focused policy programmes, as opposed to complex, government supported implementation processes.

8.1 Introduction

It is widely acknowledged that SMEs are of vital importance for economy and society. The vast majority (99.8%) of all enterprises in the European Union are small or medium (i.e. employ less than 250), and 92% of the companies even employ less than 10 persons. SMEs provide over two thirds (67.4%) of all jobs in Europe and are estimated to be responsible for 58% of the total turnover in 2008 (EIM, 2010).

In any value chain, collaboration between its actors has become critical and so has the linkage of ICT of its partners (cf. Barrett & Konsynski, 1982; Meier & Sprague, 1991; Daft, 2001; Morrel & Ezingeard, 2002; Shapiro, 2009). ICT potentially improves the effectiveness and efficiency of value chains through cost reduction and increasing possibilities for interorganisational communication, coordination and information exchange (Williams, 1997). As Papazoglou and Ribbers (2006, p. 280) put it: "*Interorganisational information systems (IOSs) are a specific class of information systems that automate the flow of information across organizational*

[10] This work has been submitted for journal publication.

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boundaries and enterprise information systems, and link an organization to suppliers, customers and possibly other organizations". On both organisational and chain level, the adoption, implementation and usage of interorganisational information systems and ICT is intensively studied (Zhu & Kraemer, 2002; Nelson, 2003). Within this ICT domain, SMEs are traditionally less mature and innovative than their larger counterparts (cf. Premkumar, Ramamurthy, & Nilakanta, 1992; Damanpour, 1992) as they lag behind in the uptake of these systems (European Commission, 2008; 2010).

To address this backlog, various policy instruments are being applied in different countries (European Commission, 2008; 2010). Internationally there is (and has been) a wide mix of policy instruments and programmes on SME-oriented ICT adoption. It has been identified that in almost thirty OECD countries such policy is currently developed or deployed. The OECD Information Technology Outlook 2010 presents a typology of 24 types of ICT policies that they divide in five main categories: 'fostering ICT innovation' (including government procurement policy), 'increasing diffusion/use', 'maintaining a healthy ICT business environment', 'enhancing the infrastructure' and 'promoting trust online' (OECD, 2010c).

A prominent example for the Netherlands is the policy programme "the Netherlands Goes Digital" (*Nederland Gaat Digitaal*, abbreviated to NGD) that was in place between 2002 and 2007. With this programme, a budget of € 33.5 million was spent to promote and support the adoption and use of ICT by SMEs; including interorganisational ICT such as e-business applications. SMEs could participate in the programme and receive free or sponsored workshops, seminars, consultancy advice and information materials. Initially in 2002, SMEs that are 'technology followers' were the target group of the NGD programme, but since 2004 the focus was on SMEs that are 'technology leading'. The NGD programme was, for the Netherlands, a comprehensive and ambitious programme. It is estimated that some 27,000 SMEs (about 8%) have been reached by the various components of the programme. In addition, the programme has reached 85 industry organisations in the SME sector that actively contributed to its activities and events.

In this chapter we present the results of an evaluation study of the NGD programme, which was initiated by its sponsor (the Dutch Ministry of Economic Affairs) near the end of the programme in 2006. At that time, the first notion was that the programme as such was successful in terms of its reach and publicity. It was unknown however, if the targeted SMEs actually set the next step in their ICT maturity and additionally became more aware about the added value of ICT. As argued above, ICT for interorganisational exchange can be considered as the most lacking, and yet most promising area for SMEs to innovate and boost their performance. The main question is therefore whether the NGD policy programme reached this far reaching goal and supported SMEs to become what is often called an 'extended enterprise' (cf. Bovet & Martha, 2000; Davis & Spekman, 2004). The related ques-

tion is about situationality of the potential effect of the programme, i.e. did it differ between types of SMEs and/or types of interorganisational ICT?

This chapter is driven by these two questions and structured as follows. In the next section we review related work on SMEs, policy and interorganisational ICT, which feed our conceptual model. We then discuss the data collection, being the surveys that were done after the policy programme was finished among participating and non-participating Dutch SMEs. Section four contains the results of comparative analyses and in the concluding section we reflect on the implications of the results, including some critical reflection.

8.2 Theory & conceptual model

8.2.1 Related work

Chau and Turner (2002) find through 34 case studies of Australian SMEs that government support only played a minor role in the adoption and utilisation of web-based electronic commerce. They state that: *"[e]ducation and awareness programs for breaking down the barriers of misinformation and EC adoption fears [...] helped a number of the small and micro enterprises"*. Using the technology-organisation-environment framework, Kuan and Chau (2001) look at the adoption of EDI in SMEs. They identify government policy as one of the relevant factors, however, only as a 'stick' (government pressure), whereas we are interested in the effects of a 'carrot' here, namely an innovation programme. Earlier, Iacovou, Benbasat, and Dexter (1995) performed similar work on EDI adoption, through seven case studies. They also include the government in their analysis, but then look at the concept of dependency, as all seven organisations were trading partners of the government. Another example of a study in which the government is only viewed from a 'push'-factor perspective, is the work of Salleh, Rohde, and Green (2006) on the adoption of a government e-procurement system by Malaysian SMEs. They take this mainly as a given, as they focus primarily on other factors in their study.

Prananto, McKay, and Marshall (2004) do include policy/initiatives as one of the possible drivers in their model of e-business progression among SMEs. They mention that this is considered the least influential driver by their sample of 104 survey respondents, but unfortunately do not elaborate on this. Through analysing 50 cases in the UK using network actor theory, Beckinsale, Levy, and Powell (2006) also find that the government has no influence on the adoption of internet by SMEs. This could be related to the fact that none of the SMEs is aware of government schemes to support e-business adoption. In their survey among 378 UK-based SMEs, Harindranath, Dyerson, and Barnes (2008) also find ignorance of policy initiatives. Their results clearly show that this ignorance is significant, al-

though it is unclear whether this is due to a lack of awareness or a lack of use of these initiatives.

In an extensive analysis of 54 Pakistani cases, Seyal, Awais, Shamail, and Abbas (2004) find that government support is a significant factor in determining the adoption of e-commerce by SMEs. Wymer and Regan (2005) also conclude that government rules and regulations are a significant factor in the adoption decision of e-commerce/e-business internet technologies, based on a survey of 102 USA SMEs. In addition, they state that this factor has not received much attention in prior studies, possibly unjustified.

Although perhaps not complete, the above review gives an impression of the *status quo*. Overall, we can say that 'government' is not regularly included as a factor in adoption studies. If so, it often is in the form of a push (external pressure) instead of a pull factor, like NGD is. The general outcome of the studies we found that *did* analyse government policy is unclear. Some scholars say it is highly relevant, others indicate minor or no relevance at all. Already in 1994, in their European Journal of Information Systems paper on the effect of government incentives on computerisation of small businesses, Yap, Thong, and Raman (1994) report on this apparent duality: "[…] *participation in a government computerisation programme does not result in more effective information systems. However,* […] *government incentives, in the form of subsidies, low-interest loans, seminars and technical expertise, lower the barriers to computerisation and make it more attractive*". It is this second type of effect (not more effective information systems per se, just a higher degree of interorganisational ICT) that we will discuss in the remainder of this chapter. We think that our study into the *effect* (i.e. not just the awareness) of a major government policy programme, using a large sample and control group, forms a valuable contribution to this field.

8.2.2 SME-focused ICT policy & the productivity paradox

In general, ICT solutions for most SMEs are not ready-made packages. The successful realisation of ICT applications and the actual utilisation of ICT, involves lengthy and expensive learning and it is not possible to determine in advance that entrepreneurs will obtain all benefits of ICT. For many SMEs markets lack transparency. Combined with the fact that there are insufficient knowledgeable demanders (asymmetric information), this forms a relevant theoretical argument for promoting ICT application and use in SMEs. Especially considering the economy-wide positive impact of the application of ICT, this provides an argument to support the implementation of ICT, provoke ICT investments and improve the utilisation of ICT for SMEs.

However, a government intervention in industry is always accompanied by questions about its efficiency and effectiveness, as well as more fundamental questions about the rationale and legitimacy. In fact, this concerns the type of governance role a government should take

in the economy. There are divergent views about this, which are partly ideologically determined. When a government plans to 'repair' market failures through policy interventions, there is the possible risk that these market failures get *replaced* by government failure. Policy also involves costs and the (sometimes limited) market could be hindered by government intervention. For that reason, one should prevent too far-reaching and too specific ICT policy. In the Netherlands, Raes, Gelauff, Klomp, and Roelandt (2004, pp. 317-318) advocate generic policies for ICT and policies that stimulate co-operation between firms and knowledge institutions, but also warn: "*However, the risk of government failure in such volatile markets is more than imaginary. Again, a careful approach by governments in designing and implementing such schemes is necessary.*" It should be noted that this mainly seems to refer to promoting technological progress in ICT and less about policy focused on ICT diffusion.

Still, there are many arguments to initiate and execute an ICT policy that focuses upon SMEs. These arguments have been collected in a series of OECD-reports in 2004 ("ICT diffusion to business: peer review"; OECD, 2004) which included country studies on Denmark, Finland, Italy, (South) Korea, Norway, and Switzerland. It appeared that in most countries, similar arguments are at stake for stimulating SMEs in their ICT uptake by the specific development of ICT policy. Examples of such arguments in those countries are:

- *Contribution of ICT to productivity growth and economic performances in combination with the dominant presence of SMEs.* Almost all countries point to recent OECD studies on the significant contribution of ICT to productivity and economic performances. This is often confirmed by national studies that sometimes are even specifically aimed at SMEs. The Danish ministry of Science, Technology and Innovation has for example calculated that there exists a positive correlation between ICT usage and added value per employee for companies in the range of 10-49 employees. In addition, it is determined that SMEs play a very large role in the national economy and that there is much space to improve the utilisation of ICT.

- *ICT backlog of SMEs.* It is found for many countries of the peer review that SMEs have a significant backlog compared to large enterprises with regard to use and actual utilisation of ICT. Most countries view this as an argument for having ICT policy aimed at SMEs. In doing so however, boundaries are encountered. With some ICT applications that backlog of SMEs will never change, because not all ICT applications are relevant for all organisations (this is for instance one of the conclusions in the Danish peer review). In addition, the large differences between sectors and regions are often pointed out (e.g. Italy).

- *Market failure.* There are examples of countries (e.g. Denmark and Finland) where taking out market failures and realising attractive conditions for companies to use

ICT are indicated as argument in favour of governmental intervention. SMEs would suffer most from market failures in the ICT domain. An example of a market failure is the lack of transparency of the ICT services and applications that are on offer in the market.

- *Connection between SMEs and the knowledge infrastructure is insufficient.* In most countries, SMEs collaborate less with knowledge institutions on ICT R&D compared to large organisations (e.g. Denmark and Italy). On average SMEs are less innovative than large companies, while according to policy makers it is of great importance to have competitive and knowledge intensive SMEs that stimulate future economic development. Overall, countries differ in the degree to which the themes of ICT and innovation are being coupled.
- *Alleviating a number of concrete problems of SMEs in the application of ICT.* In the peer review several SME-specific problems are presented that are used as arguments for an SME-specific ICT policy. Examples of these problems are:
    - SME management is insufficiently aware of the potential advantages of usage of ICT (Denmark, South Korea).
    - Opportunities are not being pursued because SMEs lack sufficient ICT skills (Denmark, South Korea, Switzerland).
    - SMEs are insufficiently able to determine their ICT needs and find suitable ICT solutions (Denmark).
    - SME customers have different demands for ICT applications and that problem is aggravated by a lack of standardisation (Denmark, Finland, Norway).
    - SMEs are uncertain about protection of privacy and consumer interests in the ICT era (Finland, Switzerland).

From the OECD study, it was also argued that international rankings (e.g. the e-readiness index of The Economist) constitute a trigger for the development of ICT policy by countries. If a country holds low scores in these rankings, this is used as an argument to use ICT policies to catch up (Italy). Likewise, leader countries use these rankings as an argument to (continue to) invest in ICT policy (Finland).

Although there is strong policy interest in the usage of ICT by SMEs, the question remains if ICT is indeed the performance driver for these organisations. This goes back to the 'productivity paradox': "*we see the computer age everywhere but in the productivity statistics*" (Solow, 1987, p. 36). Solow observed that ICT investment levels were not positively related to productivity levels of countries and sectors. Currently, the consensus is that this phenomenon was indeed a paradox at that time and supported by that type of analysis, but now this has

changed. Van Ark and De Jong (2004, pp. 42-43) show that on a macro level, in the Netherlands, a quarter of the growth of labour productivity between 1979 and 2001 was caused by an increase in computers (and other ICT assets). For 1995-2001 this was more than 50 percent of the productivity growth. In addition, it has been shown that on organisational and individual levels ICT *does* increase productivity (e.g. Brynjolfsson & Hitt, 2000; Donselaar, Erken, & Klomp, 2004; European Commission, 2010). For interorganisational ICT, this relationship is less certain and more research is needed.

8.2.3 A conceptual model to investigate policy effects

In this study we design a conceptual model to investigate the effect of the Dutch NGD policy programme to improve the uptake of interorganisational ICT by SMEs. The model, which is depicted in Figure 8.1, consists of two parts that are assumed to be dependent upon participation in the NGD programme. The first part entails the question if participation by SMEs in the NGD programme has led to higher usage of interorganisational ICT systems and applications. The second part of the conceptual model is about the question if the participating SMEs, through the NGD programme, experienced a higher added value from ICT. Specification of the programme's activities, the indicators of use of interorganisational ICT systems and the perceived added value of ICT are listed in Figure 8.1 as well. Finally, the conceptual model illustrates that the potential effect of the policy programme is also investigated by controlling for contingencies, being the employee size, sector and level of participation of SMEs. In the next section, it is described how in practice these measurements were conducted in an extensive field study among participants and non-participants of the NGD policy programme.

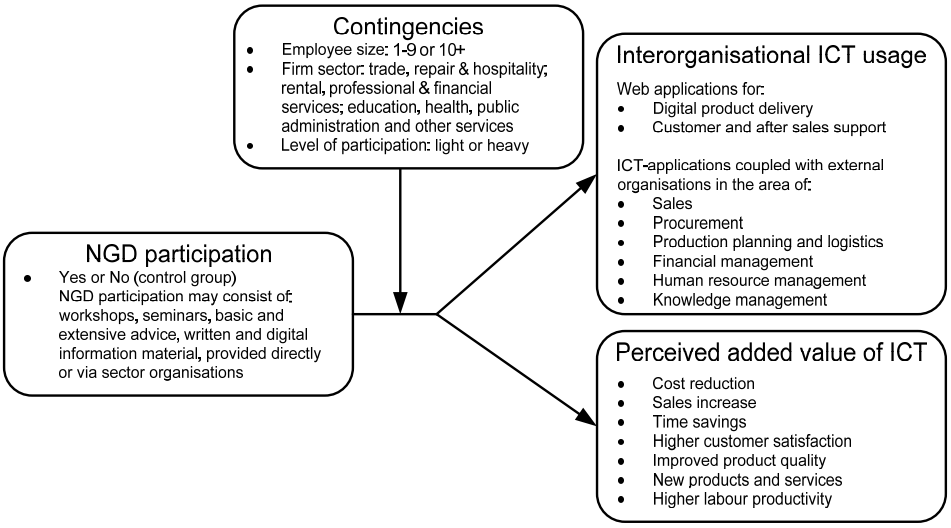

Figure 8.1 The conceptual model for this study

8.3 Data & methods

Initiated by the Dutch Ministry of Economic Affairs a field research was executed in 2006, which resulted in a number of evaluation activities, including two extended surveys conducted by telephone and the internet. The advantage of employing the survey method here is that we were able to query a substantial amount of participants of the programme, and do so in exactly the same way. Two target groups were approached to complete a tailor-made survey: a sample of the SME participants of the NGD programme (n=516), and a control group consisting of SME organisations comparable to the NGD participants, but who did not took part in the NGD programme (n=124).

The first group was selected by a (stratified) sample from the database of the NGD programme organisation. An e-mail with a request to complete a web survey was sent to 2,482 participants. This e-mail was preceded by an explanatory letter from the Ministry of Economic Affairs. The questionnaire includes – among other things – components on ICT usage and ICT impact on business. After about one week and again after another two weeks a reminder was sent via e-mail to those that did not respond (yet). After three weeks, 516 respondents completed the questionnaire in its entirety. This is a response rate of 21%. It should be noted that the response was reduced a priori because many e-mail addresses were shown to be outdated: 434 e-mails (17.5%) were undeliverable. Controlling for this matter results in a net response rate of 25.2% of fully completed questionnaires. Comparative survey studies among SMEs (e.g. the E-Busines W@tch survey; European Commission, 2008) reach similar or lower response rates.

The second group can be considered a control group of SMEs (n=124). This group was selected from an address database that was available for surveying through a Dutch market research company. The composition of this control group was matched with the response group of the web survey among the NGD SME participants. For each SME respondent to the web survey, a 'counterpart' SME (according to size and industry) was selected, to ensure a 'fair' and unbiased comparison as good as possible. The control group of SMEs was surveyed by telephone, immediately after the completed web surveys of the SME participants were received. Within two weeks, 124 telephone interviews were realised according to a stratified sampling matrix. An abridged version of the web survey was used, including similar questions about interorganisational ICT use and perceived added value of ICT to the SME. In achieving the response of 124, refusals (do not want to participate, too busy to participate, not available) were obviously encountered; a net response rate of 26.7% was achieved.

Due to this sampling design, it is possible to compare NGD participants with non participating SMEs, on the different aspects of interorganisational ICT usage and the perceived added value of ICT. Although selection bias cannot be excluded, it is at least reduced, which

improves the measurement of the contribution of the policy programme to the interorganisational ICT use and perceived added value of ICT by Dutch SMEs.

8.4 Results

8.4.1 Do participating SMEs have higher usage of interorganisational ICT?

In this section we analyse the differences (and their statistical significance) in use of interorganisational ICT between participants and non-participants of the NGD programme. We deliberately consider the differences on a number of indicators for interorganisational ICT, as it is a broad concept that covers several distinct business domains. In addition, the NGD programme was set up to improve adoption of ICT in general, so we can expect effects on all types. Also, this gives us the opportunity to see whether participants in the NGD programme favoured specific types of interorganisational ICT above others.

Table 8.1 shows that the participants in the NGD programme scored higher than non-participants on all interorganisational ICT indicators. The differences between participants and non-participants are the largest for interorganisational ICT applications in the sales domain (36%), followed by those for financial management (32%). For digital product delivery (18%), knowledge management (14%) and human resource management (11%) the differences are smaller, compared to the other indicators. However, all differences are statistically significant.

Table 8.1 Differences in ICT usage between participants and non-participants; '*' indicates significant difference (t-test; p<.01)

SME uses:	Non-participants (n=124)	Participants (n=516)	t-value	p (2-tailed)
A web application for:	**Mean %**	**Mean %**		
Digital product delivery	7.3	25.6	-5.98	.00*
Customer and after sales support	16.9	42.1	-6.19	.00*
ICT applications coupled with external organisations in the area of:				
Sales	4.9	41.1	-12.42	.00*
Procurement	6.8	31.8	-8.15	.00*
Production planning and logistics	4.6	29.8	-9.13	.00*
Financial management	10.3	42.1	-9.05	.00*
Human resource management	12.8	23.5	-2.90	.00*
Knowledge management	9.7	23.8	-4.26	.00*

An important question is whether the observed differences still exist when we take into account company size and industry, two characteristics that have a 'proven' effect on the

level of ICT development of organisations. Table 8.2 provides an overview of some analyses performed for this purpose. We determined whether the above significant differences between participants and non-participants are still statistically significant when we isolate the following groups:

- Organisations with 1 to 9 employees (column '10-' in the tables);
- Organisations with 10 to 250 employees ('10+');
- Organisations in trade, repair and hospitality ('TRH');
- Organisations in rental, professional and financial services (column 'RPF');
- Organisations in education, health, public administration and other services ('EHP').

Table 8.2 Differences between participants and non-participants: subgroups; '*' indicates significant difference (2-tailed t-test; p<.01)

	Employee size		Sector		
SME uses:	10-	10+	TRH	RPF	EHP
A web application for:					
Digital product delivery	*	*		*	
Customer and after sales support	*		*	*	*
ICT applications coupled with external organisations in the area of:					
Sales	*	*	*	*	*
Procurement	*	*	*	*	
Production planning and logistics	*	*			
Financial management	*	*	*		
Human resource management		*			
Knowledge management	*	*			

We need to define these fairly coarse subcategories, because of the number of observations. When defining too specific subclasses, the number of respondents may become so small that no reliable averages can be calculated. Here we use the rule of thumb that analyses should be performed on categories with 15 or more respondents. We combined organisational sectors based on similarity of industry. An '*' in Table 8.2 indicates that the difference between participants and non-participants is statistically significant, based on the t-test conditions (significance level is .01 or less, two-tailed testing).

These results partly support the idea that all participants within the NGD programme use more interorganisational ICT. Both the relatively small and relatively large businesses score

higher on almost all different interorganisational ICT applications when compared to their non-participating peers. For the three sectors that we distinguished, the results are more mixed: the differences are only significant for four (TRH, RPF) or two (EHP) out of eight indicators. A possible explanation for this result is that some of the interorganisational ICT application domains are not very relevant for the sector (e.g. digital product delivery for trade, repair and hospitality organisations, and production planning and logistics for all three sectors).

Finally, we analyse the impact of the programme by comparing differences *between* participants. To do so, we make a distinction between light and heavy users, based on a major dividing aspect within the programme: whether or not use has been made of the 'extensive advice'. This activity can be considered the most complex and far-reaching for the organisation based on its contents. It is also distinctive because SMEs had to invest themselves, while other programme activities were provided at little or no cost. The expectation here is that heavy users of the programme have developed further in their use of interorganisational ICT compared to light users. The results are listed in Table 8.3.

Table 8.3 Differences between light and heavy users; '*' indicates significant difference (2-tailed t-test; p<.01)

SME uses:	Light users (n=286)	Heavy users (n=230)
A web application for:	**Mean %**	**Mean %**
Digital product delivery*	16	29
Customer and after sales support	23	29
ICT applications coupled with external organisations in the area of:		
Sales*	34	50
Procurement*	27	38
Production planning and logistics*	22	40
Financial management	38	47
Human resource management	21	27
Knowledge management*	19	30

On all indicators, heavy users score higher than light users. Obviously, the absolute differences are smaller than those between participants and the control group, but still five out of eight are statistically significant.

8.4.2 Do participating SMEs perceive higher added value of (interorganisational) ICT?

We now move to the second part of our analysis: whether SMEs that participate in the NGD programme perceive higher added value of ICT for their organisations. Here we need to

make the important reservation that assessing the direct economic impact of instruments such as NGD is not easy. There are indeed many non-policy factors that determine the state of corporate performance (in conjunction with the use of ICT). We measure the *perceived* added value of ICT on several indicators, as a proxy to the real added value. This entails a subjective evaluation of the respondent, but is therefore not of less value. This method of measuring ICT revenues has been used more often in IS research (cf. Tallon, Kraemer, & Gurbaxani, 2000). It should also be noted that these measurements cover both *intra-* and *inter*organisational ICT, so we cannot completely attribute the experienced benefits to the latter category. However, in selecting these types of added value, we chose items that are generally considered to be benefits of interorganisational ICT.

Table 8.4 shows the results of this measurement, compared between participants and non-participants. Respondents could score the indicators on a scale from 1 = almost nil, 2 = little, 3 = neither small/great, 4 = fairly high, 5 = high.

Table 8.4 Differences in perceived added value of ICT (5-point scale) between participants and non-participants; '*' indicates significant difference (t-test; p<.01)

SME has experienced added value of ICT through:	Non-participants (n=124)		Participants (n=516)		t-value	p (2-tailed)
	Mean	SD	Mean	SD		
Cost reduction	2.0	1.2	2.8	1.4	-5.85	.00*
Sales increase	1.9	1.2	2.9	1.3	-7.02	.00*
Time savings	2.8	1.5	3.5	1.3	-4.97	.00*
Higher customer satisfaction	2.2	1.4	3.2	1.3	-6.81	.00*
Improved product quality	2.0	1.4	2.8	1.5	-5.55	.00*
New products and services	1.9	1.3	2.9	1.5	-7.80	.00*
Higher labour productivity	2.1	1.4	3.0	1.4	-6.36	.00*

All differences are in favour of the participating organisations, and are statistically significant. On the economic-related performance indicators (such as cost reduction, time savings and labour productivity) the NGD participants hold significantly higher scores compared to the non-participants. This is in favour of the expectation that for SMEs in general, time and money are prerequisites for entrepreneurship, and ICT can improve these key conditions.

The next step in the analysis again aims to determine whether the above conclusion is robust when the data are broken down with regard to industry and size of the SMEs. The results of this step are listed in Table 8.5.

Table 8.5 Differences between participants and non-participants: subgroups; '*' indicates significant difference (2-tailed t-test; p<.01)

SME has experienced added value of ICT through:	Employee size		Sector		
	10-	10+	TRH	RPF	EHP
Cost reduction	*	*	*	*	*
Sales increase	*	*	*	*	*
Time savings	*	*	*		
Higher customer satisfaction	*	*	*	*	*
Improved product quality	*	*	*	*	
New products and services	*	*	*	*	*
Higher labour productivity	*	*	*	*	*

Compared with the earlier analysis on ICT usage, Table 8.5 quite clearly shows that the participants significantly differ from the non-participants in a consistent way (i.e. for almost all industries and sizes). We therefore conclude that a robust difference can be found in comparing both datasets.

Finally, we examine whether these clear differences remain when we distinguish between light and heavy users. Table 8.6 contains the results of this comparison.

Table 8.6 Differences in perceived added value of ICT (5-point scale) between light and heavy users; '*' indicates significant difference (2-tailed t-test; p<.01)

SME has experienced added value of ICT through:	Light users (n=286)	Heavy users (n=230)
	Mean	Mean
Cost reduction	2.9	2.7
Sales increase*	2.7	3.1
Time savings	3.5	3.6
Higher customer satisfaction*	3.0	3.4
Improved product quality	2.7	2.9
New products and services	2.8	3.0
Higher labour productivity	3.0	3.0

On almost all indicators, the differences in added value are in favour of the heavy users. These differences are statistically significant for two types of added value, however. While in the previous analysis participants scored systematically above the non-participants, within the group of participants there is only a significant difference in terms of increasing turnover and customer satisfaction. These results show that the programme participants are fairly consistently positive about the contribution of ICT to their business performance.

The contribution they experience of ICT does not differ between different degrees of programme usage. Apparently light users are also already in a relatively 'satisfied' situation.

8.5 Conclusion & discussion

In this chapter, we discussed theoretical arguments for an ICT policy that focuses upon SMEs, like the bewildering array of ICT solutions available on the market, combined with SMEs that are insufficiently informed (asymmetrical information). This does not justify any far-reaching measures, but does justify promoting awareness-raising and transparency in the marketplace. In addition, the shortcomings in a variety of other systems can serve to substantiate an ICT policy that is directed towards SMEs.

We set out to evaluate NGD, a substantial ICT policy programme in the Netherlands, aimed at increasing adoption and use of (interorganisational) ICT by SMEs. Based upon our results, we arrive at the following conclusions. NGD participants are people (or organisations) who, in comparison to the control group:

- Use significantly more interorganisational ICT, and
- State considerably more frequently that ICT has enhanced their company's performance.

These outcomes fit within the aims of the programme. When subgroups are defined, these results are consistent for firm size (employees). The results are less clear when a division is made into sectors, but this could be related to the irrelevance of certain types of interorganisational ICT for certain sectors. Within the group of NGD participants, heavy users do not differ from light users on all indicators, especially regarding the perceived added value of ICT.

Participants in NGD are relatively high performing SMEs. This could be the effect of taking part in the programme, (self-)selection or a combination of both. Two possible selection effects could play a role. First of all, not all SMEs have ever been invited – directly and individually – to take part in the NGD programme. We can therefore expect that SMEs that did participate already possessed a certain awareness of and familiarity with interorganisational ICT. Secondly, self-selection may take place, with the result that better-achieving organisations are more likely to take part in web surveys such as those used in this study.

The above results are very favourable for the NGD programme. They support the conclusion that it gave these SMEs a major incentive to become 'ICT mature' sooner, and to reap the benefits of these ICT investments sooner and better. However, forms of self-selection that could weaken this conclusion should seriously be considered. The selection effect relies on a number of phenomena that are hard to operationalise:

- Programmes as NGD typically attract those organisations that are already (pro-)actively engaged with ICT and internet, if not professionally then out of personal interest of the company's employees;
- Programmes as NGD typically attract those organisations that are already (pro-)actively engaged with their environment, including campaigns and schemes from industry associations and governments.
- Organisations that are already in a favourable stage of development are typically better able to make use of programmes such as NGD and reap additional benefits from it.

The basis of these phenomena is in principle supported by the research of Van der Veen (2004) among NGD participants. In her conclusion, she stressed that government should aim to encourage conventional ICT as much as 'renewed entrepreneurship'. The intended effect is that entrepreneurial SMEs receive the right incentives this way, the unintended effect is that the position of less attentive SMEs becomes harder and harder to improve.

In our study, it appears from the comparative analyses that taking part in the programme plays a more decisive role in the use of interorganisational ICT and perceived added value than the nature/intensity of participation. In terms of policy recommendations, this could be interpreted as a plea for basic, awareness-focused programmes, instead of complex, government supported implementation processes. Based on our results, reach seems to be more important and cost-effective than very intensive measures. Taking this into account, it would be important for government bodies to design policy programmes that are as undemanding and simple to understand for SMEs as possible, as Harindranath et al. (2008) found that these programmes are often perceived as "bureaucratic and cumbersome".

An important limitation of this study is that we analysed the added value of ICT in general. Although we investigated factors of which it can reasonably be expected that they are influenced by *interorganisational* ICT, future research should explicitly focus on these effects. It would be interesting if we could then also surpass the level of *perceived* benefits and assess the *real* added value of interorganisational ICT. This is no easy task, and perhaps longitudinal, in-depth case studies are better suited to this kind of research.

As our data collection took place a few years ago, more recent types of interorganisational ICT were not included. Examples of this would be service-oriented architectures (SOA) and web services, which are known to be insufficiently considered in IOS research (Löhe & Legner, 2010). It would be good if future studies included these more novel applications as well.

A final shortcoming of our current work is that it focuses only on the Dutch situation. Although the OECD (2004) peer reviews present results from some other countries, it would be valuable to replicate our current study in other countries with a specific focus on interorganisational systems. However, if the exact same study were to be replicated, that would require a similar policy instrument to be in place in the countries to be studied. But, the conceptual model could also be broadened. Here, we only looked at the influence of ICT policy (i.e. NGD participation) on adoption and the added value of (interorganisational) ICT, moderated by several contingencies. If we would also take other factors in consideration, e.g. technological and organisational characteristics, we could create a more general framework of the determinants influencing adoption of interorganisational ICT by SMEs. This is important, as Ramdani, Kawalek, and Lorenzo (2009) found that the adoption factors for enterprise systems (e.g. SCM and e-procurement) differ from those of other information systems.

Part V:
Main Conclusions
&
Outlook

9 Main conclusions & outlook

In this final chapter, we present the main findings of the research – i.e. the answers to the research questions formulated in chapter 1 – and discuss their implications. Moreover, we reflect on this dissertation research as a whole, identifying limitations, and different perspectives on the results, in particular on the level of analysis, on maturity models, and on a comparison between retail and health care. Finally, we present some suggestions for a research agenda for interorganisational information systems, following up on this study and incorporating future challenges.

9.1 Main findings

The work in this dissertation concentrates on the following main research question:

> *MRQ: How can the maturing of interorganisational information systems be furthered through the development of theoretical models, empirical measurements, and practical policies?*

Below we recap our answers to this research question, by answering the three sub-questions. The sub-questions correspond with the three main parts of this dissertation.

9.1.1 Developing a maturity model for chain digitisation

The research question related to the first part of the dissertation is:

> *SQ1: What are the technological and organisational levels of chain digitisation and how can these levels be measured?*

We developed a framework and typology for chain digitisation at the level of interorganisational chains in chapter 2. In order to create this framework, we first conducted an extensive literature study to identify existing maturity models of chain digitisation, and analysed these. Then we developed our framework by defining two dimensions of chain digitisation: technology and organisation, derived as a common ground of the existing models. We designed both dimensions based on the same concept of maturity accumulation, and in such a way that they cover a realistic, measurable, and equal number of levels. Combining the two dimensions leads to our *maturity model* for chain digitisation.

From our maturity model, it is possible to distinguish four basic quadrants, which can be interpreted as a *typology* for chain digitisation. This is depicted in Figure 9.1. The four types are actually distinctive situations, in which both the organisational and the technological maturity can be high or low, and the two dimensions can be in alignment or not. The typology also brings about different 'routes' towards maturity growth, i.e. directly from basic to advanced chain digitisation ('following the diagonal'), or indirectly, from basic to advanced

chain digitisation through technological or relational proficiency. In line with Henderson and Venkatraman (1993), we do not claim which route towards maturity and alignment is dominant or 'best', as this is situational.

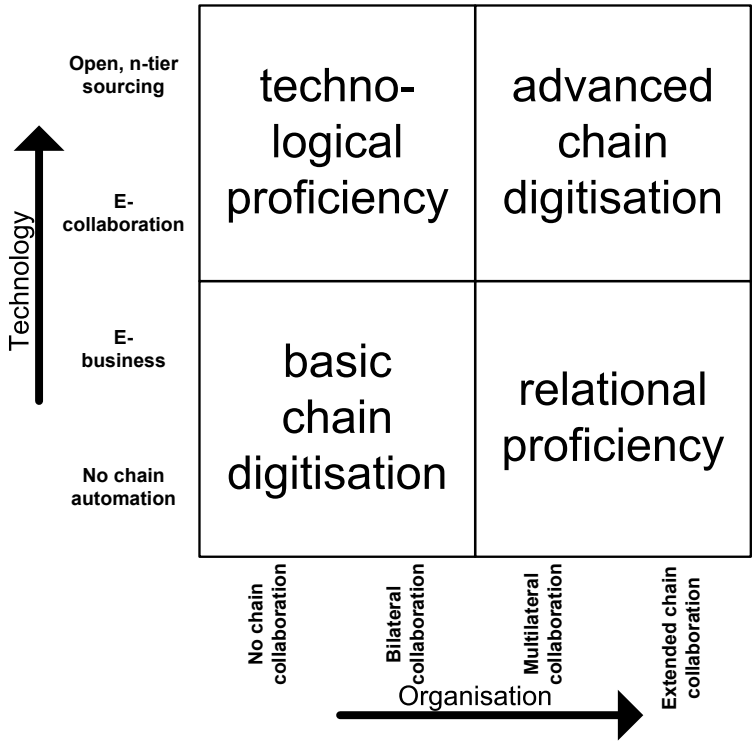

Figure 9.1 A typology for chain digitisation

In order to test the validity of the framework, we applied it to the Dutch retail sector. We were able to measure the technological and organisational maturity of 24 different retail branches. As the framework proves to be applicable for measurement and benchmarking at the level of interorganisational chains, it can be used to support different branches in their ambition to improve their level of chain digitisation, both by measuring their current situation and using it as a roadmap towards the future. It can also be used as a benchmarking instrument, not only by individual organisations in chains, but also by chain policy makers and advisors.

We further applied and developed our framework in chapter 3. We operationalised the measurements into maturity statements measurable through a survey, which was then completed by 33 (CIOs of) Dutch organisations. In this study, we measured chain digitisation maturity at the level of individual organisations, and introduced the important concept of measuring this maturity at both the supply and demand side of a focal organisation. We

performed a cluster analysis on our 33 cases and visualised this by plotting the cases and the clusters onto our framework. The clustering procedure empirically revealed two distinctive groups: low versus medium/high scoring organisations. This operationalisation of our model, i.e. maturity statements formulated for both sides of a focal organisation's chain, proved useful for CIOs in determining their chain digitisation strategy. It can also help them identifying the steps they could take in order to achieve the next maturity level.

9.1.2 Studies on interorganisational information systems in retail and health

The research question related to the second part of the dissertation is:

SQ2: How can these concepts be empirically applied to the Dutch retail and health care sector?

Already in chapter 2, we applied our framework to measure the chain digitisation maturity – in both organisational and technological respect – of 24 Dutch retail branches. The results show that, as of 2007, the interorganisational chains within the Dutch retail sector are generally immature in their organisational and technological levels of chain digitisation. Exceptions are retail chains within the perfume, tobacco, clothing, books, and furniture branches that show moderate levels of chain digitisation. It appears hard to discover specific patterns underlying these maturity differences between the 24 retail branches.

The study described in chapter 4 is related to a specific adoption problem, namely that of point-of-sale (POS) systems in small retail firms. After a literature review of existing models and theories, we formulated seven hypotheses, related to several personal and organisational determinants. We tested these in the Dutch retail sector using a pencil-and-paper questionnaire, specifically targeting small, independent retailers. We received data from 37 respondents, both with and without a POS system. Of the studied determinants, only the retailer's innovativeness and computer literacy proved to be significantly related to POS adoption. Thus, our hypotheses are only partly confirmed by our empirical data.

In terms of policy for POS system stimulation, computer literacy seems to have a positive effect, so it may prove worthwhile to try and interest people for the benefits of ICT in general.

We again studied POS systems in chapter 5, but this time from a different angle. We developed a specific maturity model for assessing the chain digitisation support level of these systems. This model is based on existing maturity models; a subset of the models identified in the literature review described in chapter 2. Our POS maturity model consists of two dimensions: backward and forward chain digitisation. Both dimensions are constructed by defining four similar maturity levels, namely internal isolated, internal integrated, external linked and external integrated. Similar to our earlier maturity model, both dimensions are

constructed to be cumulative and mutually aligned. Figure 9.2 shows a visual representation of our POS maturity model.

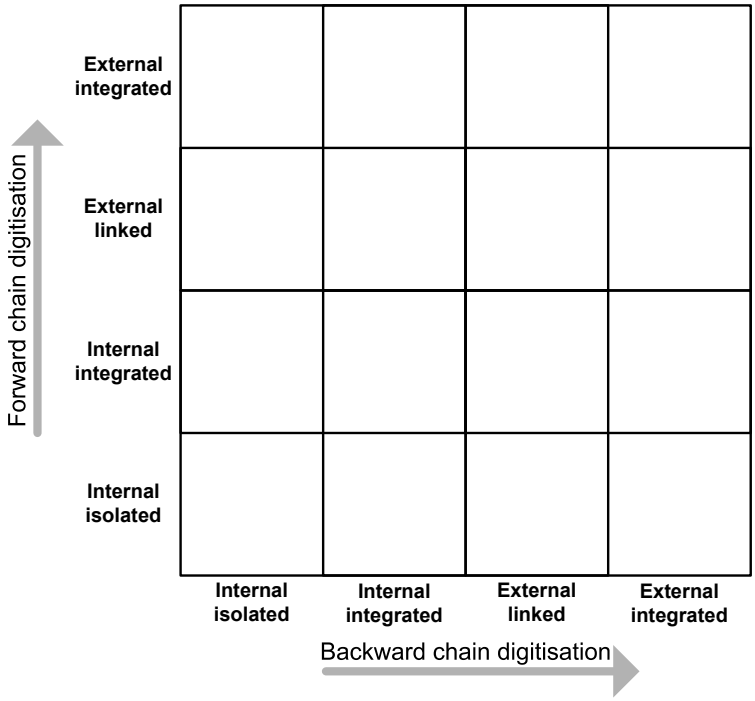

Figure 9.2 Maturity model for chain digitisation support of POS systems

The practical operationalisation of this model consists of a set of functionality items and assessment rules, through which we can categorise POS systems (i.e. *not* user organisations or chains) on their (enabling) level of chain digitisation. We applied the maturity model to 86 different POS systems (from 79 software vendors) that are available on the Dutch market. We collected data from POS vendors in the Netherlands and Belgium, through a questionnaire and subsequent company visit. In analysing our results, we found great diversity among the POS systems in terms of their level of enabling and support of chain digitisation. Interestingly, no POS system appeared to enable or support the highest maturity level for one dimension of the model, i.e. external integrated forward chain digitisation. Apparently, this type of POS system is still very much 'something of the future'.

Next, we shifted our attention to the health care sector (chapter 6). We started from the notion that the adoption of interorganisational ICT in primary care is important, but that its determinants have hardly been empirically investigated, especially for GP practices. In this study, we used unique data from a (longitudinal) survey in 2009 and 2010, conducted

among a representative sample of 49 Dutch GP practices, to both describe and explain their level of chain digitisation.

A first result from this study is that GPs have – between 2009 and 2010 – become more advanced in their exchange of information with GP posts and hospitals, in using referral modules and chain digitisation applications or software. Secondly, we investigated three types of determinants (based on the framework of Tornatzky & Fleischer, 1990), that were expected to influence this type of interorganisational ICT adoption. It appeared that the type of EMR system the GP practice has in place is correlated with adoption levels, specifically registering referrals to secondary care and letting out-of-hours service employees retrieve patient information from their EMR system. Other determinants – gender, age, experience of GPs, size of the practice, number of patients, and their average age – appeared to be not significantly correlated with the adoption variables. This is a result that demands further investigation.

9.1.3 Policy studies on interorganisational information systems

The research question related to the third part of the dissertation is:

> *SQ3: How can policies to improve the use of interorganisational information systems be formulated and evaluated?*

We employed the theory of Chain-computerisation in chapter 7, in order to formulate a future-proof information strategy that takes into account identity fraud. Through two cases, on criminal justice and health, we saw that identity fraud indeed poses a significant threat to our information society. Because of fallacies of the wrong level – i.e. means and strategies that work on the (intra)organisational level that are falsely applied to interorganisational situations – problems are far from being solved. Identity fraud influences the entire chain.

The examples illustrate that the theory of Chain-computerisation is a powerful tool in understanding how large-scale public information infrastructures can effectively tackle identity fraud, even on an enormous scale. We showed how the chain analysis method derived from this theory can be used to understand the peculiarities of large-scale chain cooperation and the corresponding chain information infrastructures.

Finally, we studied the evaluation of governmental policy to enhance the adoption of interorganisational information systems in chapter 8. Specifically, the effects of a substantial ICT policy programme in the Netherlands (*Nederland Gaat Digitaal*; NGD) is evaluated in this chapter, a policy programme that was aimed at increasing adoption and use of (interorganisational) ICT by SMEs.

In this chapter, we first discussed the theoretical arguments for such an ICT policy, specifically aimed at SMEs. Next, we evaluated the effects of the policy programme through an online survey among participants (n=516) and a telephonic survey among a matched control group of non-participating SMEs (n=124). We found that the participating organisations – compared to the control group – use significantly more types of interorganisational information systems, and state considerably more frequently that this has enhanced their company's performance. To test the robustness of this finding, we performed similar analyses on subgroups of our sample. It appeared that results are consistent for firm size (number of employees) and most sectors.

In terms of policy recommendations, the results of this study could be interpreted as a plea for basic, awareness-focused programmes. Reaching awareness among a broad audience seems to be more important and cost-effective than very intensive measures.

9.2 Reflection & implications

In this section we reflect on the dissertation as a whole, and elaborate on some of the key concepts, like levels of analysis and maturity models in interorganisational research. Furthermore, we make a comparison between the retail and health sector and ponder about what lessons these sectors may learn from each other. But first, we discuss some explicit limitations of the dissertation research.

9.2.1 Limitations

One of the limitations of the studies in this dissertation concerns the different levels of analysis (see also §9.2.2 below) to analyse chain digitisation. Although one would ideally conduct extensive research among all parties in a chain, this is often not possible in practice. In this dissertation, we present several solutions for dealing with these difficulties, like our surveying of retail trade organisations in chapter 2, or our querying of focal organisations on their chain digitisation on both the supply and demand side. These solutions may be considered as 'proxies' of what one really would like to analyse, but we still consider them valuable, as the alternative would require a complex linked multi-actor design. However, this does provide an interesting point for further research, to which we will return in the final section of this chapter.

Another limitation lies in the maturity models developed in several chapters (i.e. 2, 3 and 5) of this thesis. They are built on existing scientific literature, but the operationalisation of our maturity models remains highly dependent on the survey design and practical opportunities. For instance, in the operationalisation of our POS system-specific maturity model in chapter 5, the level requirements are stated in the form of functionalities per level, instead of assessing maturity through the calculation of an average item score, as was done in

chapter 3. We believe that each of these models has shown its value, especially due to their (successful) empirical application. However, it should be clear that further research into these models would be beneficial. We return to this point as well.

In terms of the external validity of the research documented in this thesis, another limitation is that all studies have been conducted within the Netherlands. Although it is likely that there exist many similarities with other countries, we can only assume that this is the case. Within the Netherlands, our work may in some instances not be fully generalisable due to sampling issues. In most studies, we aimed to get as complete a picture as possible. For instance, in the retail chain digitisation maturity study described in chapter 2, we contacted all trade organisations that existed. Similarly, for the research on chain digitisation functionalities of POS systems in chapter 5, we approached the complete population of software vendors of POS systems that are used by the Dutch retail sector. After contacting the entire population, the aim was to achieve an as high as possible response rate, by working together with partners recognised at the national level, as the Dutch central board for the retail trades.

In those cases where we could not contact the complete population, ideally all sampling would have been completely random. However, the sampling process was not always easy to perform according to all scientific standards, but we then did try to obtain a high quality sample while limiting potential biases. For instance, in the POS adoption study described in chapter 4, we visited retailers in two different municipalities, and in different shopping districts within those towns. In the chain digitisation survey among CIOs, documented in chapter 3, we used convenience random sampling by having students pick, contact and convince the respondents. A final limitation we mention here is related to this CIO data collection. As we only interviewed one CIO per organisation, it remains an open question whether they all were equally aware of their organisation's need for chain digitisation. A cross-check with e.g. a supply chain manager or procurement officer could have been valuable.

9.2.2 The specific problem of the level of analysis in interorganisational research

Klein, Palmer, and Conn (2000) describe the field of interorganisational relationships as vibrant and active, but at the danger of a "levels-related muddle". According to them, this research field is inherently multilevel, but many researchers do not specify their level(s) of analysis. Fortunately, Klein et al. (2000) also provide an array of the different levels at which these relationships can be conceptualised and studied (see Table 9.1). They argue that each of these levels is valid and appropriate; however, some levels of analysis (e.g. the organisa-

tion as a homogeneous whole) are more often applied in studies than others (e.g. the organisation within the interorganisational dyad).

Table 9.1 Levels of analysis in interorganisational research and their application in this dissertation (levels based on Klein et al., 2000)

Level of analysis	Dissertation chapter(s)
Individuals and groups	4, 6
The organisation as a homogeneous whole	4, 6, 8
The organisation within the interorganisational dyad	3(, 5)
Interorganisational dyad as a homogeneous whole	
Interorganisational dyad within the network	
Interorganisational network as a homogeneous whole	2, 7

We attempted to fit the 7 research chapters of this dissertation into this framework (see Table 9.1). This reveals four things: (i) this thesis covers several levels of analysis, (ii) not all possible levels are covered, (iii) one chapter was hard to position, and (iv) some studies cover more than one level.

Most levels in the model are covered by at least two chapters from this dissertation. The fact that we did not study two of the levels, can perhaps be explained by the fact that the Klein et al. typology stems from research on interorganisational *relationships*, whereas in this thesis we are more interested in the resulting interorganisational information system. Furthermore, it was difficult to position chapter 5 in the typology, as the main focus of that chapter lies on point-of-sale systems (i.e., software) and not on a specific (inter)organisational constellation. However, as our analysis in that chapter specifically focuses on the backward and forward chain digitisation functionalities, we position it at the "the organisation within the interorganisational dyad" level. Finally, those studies that cover multiple levels, are the studies that focus on the individual and the organisational level. We argue that for SMEs, there is not much difference between the individual and the organisational level, provided that the respondent is the decision maker (e.g. shop owner, general practitioner). Therefore, chapters 4 and 6 cover both levels.

What is of value in the work of Klein et al. (2000), is that they make a plea for multilevel research. Although this thesis contains analyses on many levels, it would be interesting to study a single case on several levels. Reimers, Johnston, and Klein (2010) take this one step further and state that IOIS research should leave its current theoretical paradigm of 'prediction' and 'process' logic (which is also dominant in this dissertation research). Instead, IOIS scholars should 'dimensionalise' the phenomenon of interest, and treat all these dimensions equal. This seems similar to the approach we have taken in our maturity models with the organisational/technological and backward/forward dimensions. Furthermore,

they argue that researchers should take into account the continuous change that is characteristic of interorganisational environments. This seems to fit well with Grijpink's theory of Chain-computerisation. All in all, this type of research sounds like a complex and resource-intensive endeavour, however, we consider it worthwhile to try to develop the IOIS domain in this way.

9.2.3 The specific nature of maturity models for interorganisational information systems

Much has been written about maturity models in this thesis. We refer to the introduction (§1.6), chapters 2, 3, and 5, and our listing of limitations above (§9.2.1). Our one model is generic and deals with the maturity of chain digitisation along two dimensions: technology and organisation (Figure 9.1). The other model is specific, namely aimed at assessing the maturity of POS systems (Figure 9.2). This second model has two dimensions as well: backward and forward chain digitisation.

A logical and intriguing next step for further research is to combine these two designs into one. A maturity model which incorporates technology and organisation, but does so for both the supply and demand side of an organisation. This seems similar to the work described in chapter 3, but actually implies taking it one step further. Analysing organisations (or actually using them as a proxy for two interorganisational dyads) in this way could relate to the concept of 'alignment' (for an overview see Chan & Reich, 2007). By considering the organisational and technological dimension of chain digitisation at both 'boundary spanners' of an organisation (cf. Daft, 2001), a parallel measurement of business/IT-alignment and interorganisational (or *chain*) alignment becomes possible. We are currently developing such a model.

Furthermore, we see that progress can be made in understanding variation in chain digitisation maturity through building a systematic theory on its determinants. We made an attempt at this in chapter 3 (and for POS systems in chapter 4), but it is clear that there is more work to do in this respect. It is a challenge to integrate determinants like characteristics of the individual, and of the organisation, of the environment into one predictive model, while recognising the multilevel nature of interorganisational information systems. Although there are many studies on the determinants of IOS adoption (for an overview see Robey, Im, & Wareham, 2008), we believe that most are limited in their predictive power of chain digitisation maturity.

9.2.4 Does sector matter? A comparison between retail & health

After studying both retail and health in several chapters of this dissertation (retail: chapters 2, 4, and 5, health: chapters 6 and 7, and both sectors as part of non-sector specific studies

in: chapters 3 and 8), it makes sense to reflect on the meaning of sector as field of application. More specifically, we ask what can be learned when we compare the retail SME with the general practitioner (GP), since they seem to have many similarities and can perhaps learn from each other.

We believe the following similarities between a retail SME and a general practitioner can be noted: they are both small organisations, in which usually one individual is in charge (especially when it comes to ICT decisions). Both organisations are positioned near the 'end' of the chain; they are the penultimate link before the end customer. Both have (mainly, some retailers do have institutional customers) individuals as their customers. They are both in the service industry, i.e. they do not create products. It can be argued that retailers are more part of a physical distribution chain than GPs, but their unique selling point is often said to be their (personal) service.

However, there also exist some notable differences between these two organisations. Retail SMEs are profit organisations, whereas GPs are non-profit (although this is changing, which makes the question whether there are lessons to be learned even more prominent). In terms of ICT, not every SME retailer has a POS system (cf. chapter 4), whereas every single GP in the Netherlands has a GP information system (cf. chapter 6). Another striking ICT-related difference, is that for GPs, ICT is not the 'double-edged sword' it is for retailers (see §4.1 for an elaboration on this). For GPs, online players do not form a strong force of competition (yet). This makes the general low adoption of (interorganisational) ICT in both sectors even more interesting. However, the theory of Chain-computerisation posits that cutting costs/efficiency considerations are no solid basis for interorganisational information systems (Grijpink, 2010). This may be the explanation for the low diffusion levels: according to Grijpink, a dominant chain problem should be the starting point for digitisation. In that respect, the approach of Diagnosis Related Groups (DRGs; diagnosebehandelcombinatie or DBC in Dutch) in the Dutch health care seems promising. Unfortunately, this has in the end become yet another efficiency measure.

A final point of comparison is the nature of the data that are processed through interorganisational information systems. As already indicated in the first chapter, patient data may be considered more 'sensitive' than retail data. In retail, people tend to be more willing to share personal data, e.g. through their Albert Heijn loyalty card – 'AH Bonuskaart' (Koops, 2011). In health however, people are traditionally very protective of their medical data. This strings a chord with the identity fraud issue which was central to chapter 7. However, as indicated near the end of that chapter, this ID fraud can easily contaminate other chains and is expected to become a larger problem. In that sense, people should also be more worried about their retail data, for instance in case of online shopping.

9.3 Future research possibilities

Many suggestions for additional research have already been given in the previous chapters. Overlooking the whole of this thesis, and the issues raised in the previous section, the following research challenges for the future can be formulated.

Over the course of this dissertation, two types of future research are in high demand: extensive case studies (i.e. truly analysing all parties involved in a chain) and longitudinal work. Both types – and especially their combination – are very rare in IOIS research, and for good reason. Still it could likely provide many valuable insights if it were to be realised, because interorganisational chains are so complex and changes tend to take many years.

In §9.2.3 we already made a case for more research into maturity models for interorganisational information systems, and also for furthering the discovery of determinants that influence this maturity. However, identifying the factors that influence interorganisational collaboration through ICT is one thing, but the next step would be to discover how to make the circumstances favourable. This is especially relevant for managers and policy makers, and could lead to tremendous value in practice.

Related to both maturity models and determinants, is the concept of situationality. For many maturity models, the assumption is that the highest level is the best, and all organisations should strive to achieve this level. However, it is often claimed that the actual determinants, but also the 'optimal' maturity level is contingent on the specific situation. We have already alluded to this before, e.g. in chapter 2 we opted to view our framework as a typology, implying that not all organisations need to achieve the highest level of maturity in order to be successful.

A final valuable thread of research activities would be to take the level of chain digitisation maturity as independent variable (instead of dependent, as is the case throughout most of this dissertation research) and attempt to relate it to organisational (or chain, or societal) performance. It would be most interesting to measure this performance through objective measures (e.g. financial reports, chain performance indicators), instead of the proxy of perceived performance, which was used in chapter 8. If it would then be possible to form a chain of reasoning starting with determinants, through chain digitisation maturity, towards performance, and all of this could be made situational, much would have been gained. We realise however, that this is an ambitious goal. To conclude, we remain that even though the IOIS field already exists since the 1960's, there still is enough academic work to do for the coming decades.

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Summary

Today, more and more information exchange occurs through ICT and across organisational boundaries. Adoption, implementation and use of these interorganisational information systems (IOIS) are inherently complex, as they involve multiple parties, applications, and data sources that need to be aligned and connected. Currently, an interesting variation in IOIS adoption levels exists, both across and within sectors. Many managers, consultants, policy makers, and scholars have been challenged by the key question why some value chains of organisations succeed in achieving full maturity in collaboration and realising extended IOIS, whereas other chains are still struggling and lagging behind in this respect. Still, before answering this question, we claim it is necessary to answer the following main research question of this dissertation:

How can the maturing of interorganisational information systems be furthered through the development of theoretical models, empirical measurements, and practical policies?

In this PhD research, we start from the notion that one should first be able to measure the maturity level of interorganisational information systems. We address this issue through developing a model and typology for chain digitisation maturity. Following a socio-technical approach and based on a structured literature review of 22 existing maturity models, we define a framework for measuring IOIS maturity consisting of two basic dimensions: technology and organisation. We further operationalise this framework through a survey with maturity measurements. The model is applied to gather data from 33 CIOs and measure the IOIS maturity of their organisations, regarding the organisational and technological dimension, for both the supply and the demand side of the organisation. Through a cluster analysis of the results, we show that the model can indeed be applied and can differentiate along those dimensions.

More specifically, we applied the theoretical concepts/framework in the practice of the Dutch retail. Through querying trade organisations, we measured the (technological and organisational) IOIS maturity of 24 different retail branches. The results show that, as of 2007, the branches and their interorganisational chains were generally quite immature in their (organisational and technological) level of chain digitisation. Within the retail sector, we further focused on a specific instantiation of IOIS maturity: the adoption of point-of-sale (POS) systems by small retail firms. Derived from literature study, we formulated seven hypotheses, related to different personal and organisational determinants of POS adoption. Based on data from 37 respondents, we found that the retailer's innovativeness and computer literacy prove to be significantly related to POS adoption. In a second study on POS systems, we studied the maturity of IOIS in retail from a different angle. Instead of focusing

on retail firms, we developed a specific maturity model for assessing the extent to which POS systems, as product software applications, can potentially support chain digitisation within retail chains. This maturity model for POS systems consists of two basic dimensions: backward and forward chain digitisation. Both have similar maturity ladders consisting of four levels. We used this model to assess 86 different POS systems, examining IOIS functionalities through a vendor questionnaire and subsequent company visit of these POS vendors. We found a large diversity in IOIS functionalities among the 86 POS systems, and showed that not all systems fully support advanced levels of chain digitisation.

We also applied our IOIS concepts to health care. We studied the adoption and use of interorganisational ICT in Dutch primary care. For this purpose, we used data from a small-scale panel survey, conducted among a group of 49 Dutch family doctors (GPs) in 2009 and 2010. The results show that the 49 GPs have become more advanced regarding their adoption of interorganisational ICT between 2009 and 2010. As hypotheses, technological, organisational, and environmental determinants were predefined to explain the GPs' interorganisational ICT adoption. It appeared that only the type of electronic medical record (EMR) system in use by the GP practice is related to their IOIS adoption.

Finally, we studied IOIS in value chains from a policy perspective in two ways. First, we applied the theory of Chain-computerisation on two domains, criminal justice and health. In this policy study, we focused on the development of a future-proof (chain) information strategy that takes identity fraud into account. As identity fraud influences the entire chain, and exists in many domains, we argue it poses a major threat to our information society. Because of fallacies of the wrong level, this threat is far from being averted. We show how the chain analysis method can be used to understand the peculiarities of large-scale chain co-operation and the corresponding chain information infrastructures. Second, we evaluated a large-scale Dutch ICT policy programme, aimed at increasing adoption and use of (interorganisational) ICT by Dutch small and medium-sized enterprises (SMEs). Through a survey among SMEs that participated in the policy programme (n=516), and a matched control group of non-participating SMEs (n=124), we found that the programme indeed contributed to a significantly higher uptake of IOIS. The participating SMEs also stated considerably more frequently that ICT enhanced their company's performance. These results were consistent and robust for firm size and most sectors. This study can be interpreted as a plea for basic, awareness-focused policy programmes.

In conclusion of this dissertation, we discuss the limitations of the different studies, reflect on some key concepts, and provide suggestions for future research. One key point that demands further research is the issue of the unit/level of analysis in interorganisational research, i.e. we plea for initiating more innovative and multilevel studies. Furthermore, we argue that the 'optimal' maturity level may be contingent on the specific situation.

Samenvatting (Dutch summary)

Vandaag de dag heeft meer en meer informatie-uitwisseling plaats middels ICT en over de grenzen van organisaties heen. Adoptie, implementatie en gebruik van deze interorganisationele informatiesystemen (IOIS) zijn per definitie complex, aangezien ze gemoeid gaan met meerdere partijen, applicaties en gegevensbronnen die op elkaar moeten worden afgestemd en aangesloten. Op dit moment bestaat er een interessante variatie in IOIS-adoptieniveaus, zowel tussen als binnen sectoren. Veel managers, adviseurs, beleidsmakers en wetenschappers zijn uitgedaagd door de centrale vraag waarom sommige waardeketens van organisaties er in slagen volledige volwassenheid te bereiken in hun samenwerking en uitgebreide IOIS te realiseren, waar andere ketens op dit vlak nog steeds worstelen en achterlopen. Voordat deze vraag beantwoord kan worden, zo claimen wij, is het echter noodzakelijk de volgende centrale onderzoeksvraag van dit proefschrift te beantwoorden:

Hoe kan het tot volle wasdom komen van interorganisationele informatiesystemen bevorderd worden door de ontwikkeling van theoretische modellen, empirische metingen en praktisch beleid?

In dit promotieonderzoek vertrekken we vanuit de notie dat men eerst in staat zou moeten zijn het volwassenheidsniveau van interorganisationele informatiesystemen te meten. We adresseren dit punt door ontwikkeling van een model en typologie voor ketendigitaliseringsvolwassenheid. Volgens een sociotechnische benadering en gebaseerd op een gestructureerd literatuuronderzoek van 22 bestaande volwassenheidsmodellen, definiëren wij voor het meten van IOIS-volwassenheid een raamwerk bestaande uit twee elementaire dimensies: technologie en organisatie. We operationaliseren dit raamwerk nader middels een vragenlijst met volwassenheidsstellingen. Het model is toegepast om data te verzamelen van 33 CIOs en de IOIS-volwassenheid van hun organisaties te meten ten aanzien van de organisationele en technologische dimensie, aan zowel de vraag- als aanbodzijde van de organisatie. Door een clusteranalyse van de resultaten tonen we aan dat het model inderdaad kan worden toegepast en kan differentiëren langs deze dimensies.

In het bijzonder hebben we de theoretische concepten/het raamwerk toegepast in de praktijk van de Nederlandse detailhandel. Door het bevragen van brancheorganisaties, hebben we de (technologische en organisationele) IOIS-volwassenheid gemeten van 24 verschillende detailhandelsbranches. De resultaten laten zien dat, in 2007, de branches en hun interorganisationele ketens over het algemeen vrij onvolwassen waren in hun (organisationele en technologische) niveau van ketendigitalisering. In de detailhandelssector hebben we ons verder gericht op een specifieke verschijningsvorm van IOIS-volwassenheid: de adoptie van point-of-sale (POS-)systemen bij kleine detaillisten. Afgeleid uit literatuurstudie formuleerden we zeven hypothesen met betrekking tot diverse persoonlijke en organi-

sationele determinanten van POS-adoptie. Op basis van data van 37 respondenten, vonden we dat de detaillist zijn innovativiteit en computervaardigheid significant blijken samen te hangen met POS-adoptie. In een tweede studie naar POS-systemen hebben we de volwassenheid van IOIS in de detailhandel vanuit een ander perspectief bestudeerd. In plaats van te concentreren op detailhandelszaken, ontwikkelden we een specifiek volwassenheidsmodel voor het bepalen van de mate waarin POS-systemen – als productsoftwareapplicaties – potentieel ketendigitalisering binnen detailhandelsketens kunnen ondersteunen. Dit volwassenheidsmodel voor POS-systemen bestaat uit twee elementaire dimensies: achterwaartse en voorwaartse ketendigitalisering. Beide kennen een vergelijkbaar volwassenheidsverloop, bestaande uit vier niveaus. We hebben dit model gebruikt om 86 verschillende POS-systemen te beoordelen, lettend op IOIS-functionaliteiten aan de hand van een leveranciersvragenlijst en navolgend bedrijfsbezoek van deze POS-leveranciers. We vonden een grote verscheidenheid in IOIS-functionaliteiten onder deze 86 POS-systemen, en hebben aangetoond dat niet alle systemen de gevorderde niveaus van ketendigitalisering volledig ondersteunen.

We hebben onze IOIS-concepten ook toegepast op de gezondheidszorg. We bestudeerden de adoptie en het gebruik van interorganisationele ICT in de Nederlandse eerstelijnszorg. Voor dit doel hebben we data gebruikt van een kleinschalig panelonderzoek, uitgevoerd onder een groep van 49 Nederlandse huisartsenpraktijken in 2009 en 2010. De resultaten geven aan dat de 49 praktijken tussen 2009 en 2010 geavanceerder zijn geworden met betrekking tot hun adoptie van interorganisationele ICT. Technologische-, organisationele- en omgevingsfactoren waren als hypothesen geformuleerd om de huisartsenpraktijken hun interorganisationele ICT-adoptie te verklaren. Het bleek dat alleen het type huisartsinformatiesysteem (HIS) dat in gebruik is bij de praktijk gerelateerd is aan hun IOIS-adoptie.

Ten slotte hebben we IOIS in waardeketens op twee manieren bestudeerd vanuit beleidsperspectief. Ten eerste hebben we de theorie van Keteninformatisering toegepast op twee domeinen, strafrecht en zorg. In deze beleidsstudie hebben we ons gericht op de ontwikkeling van een toekomstvaste (keten)informatiestrategie die rekening houdt met identiteitsfraude. Daar identiteitsfraude de hele keten treft en voorkomt in veel domeinen, betogen we dat het een ernstige bedreiging van onze informatiemaatschappij is. Door toedoen van niveauvergissingen is deze dreiging verre van afgewend. We laten zien hoe de ketenanalysemethode gebruikt kan worden om de eigenaardigheden van grootschalige ketensamenwerking en de bijbehorende informatie-infrastructuren te begrijpen. Ten tweede evalueerden we een grootschalig Nederlands ICT-beleidsprogramma, gericht op het vergroten van adoptie en gebruik van (interorganisationele) ICT door Nederlandse midden- en kleinbedrijven (mkb'ers). Middels een vragenlijst onder mkb'ers die hebben deelgenomen in het beleidsprogramma (n=516) en een gelijksoortige controlegroep van niet-deelnemende

mkb'ers (n=124), vonden we dat het programma inderdaad heeft bijgedragen aan een significant hogere invoering van IOIS. De deelnemende mkb'ers verklaarden ook aanzienlijk vaker dat ICT hun bedrijfsprestatie heeft verbeterd. Deze resultaten waren consistent en robuust voor bedrijfsomvang en de meeste sectoren. Deze studie kan geïnterpreteerd worden als pleidooi voor basale, op bewustzijn gerichte beleidsprogramma's.

Ter afsluiting van dit proefschrift bespreken we de beperkingen van de verschillende onderzoeken, reflecteren op enkele centrale concepten en doen suggesties voor toekomstig onderzoek. Een belangrijk punt dat verder onderzoek vraagt is de kwestie van eenheid/niveau van analyse in interorganisationeel onderzoek, dat wil zeggen we pleiten voor het initiëren van meer innovatieve en multi-niveau studies. Verder stellen we dat het 'optimale' volwassenheidsniveau af zou kunnen hangen van de specifieke situatie.

Curriculum vitae

Marijn Plomp was born on the 25th of May 1984 in Hilversum, the Netherlands. He obtained his bachelor Information Science and master Business Informatics in the period 2002-2007 at Utrecht University, both *cum laude*. In 2008, he started as a PhD Researcher at the Department of Information and Computing Sciences of Utrecht University. Within the group Organisation & Information, Marijn performs research on interorganisational information systems, lectures for bachelor and master students, and supervises master theses. His research is published in several academic journals (e.g. *Supply Chain Management: An International Journal*, *Electronic Journal of e-Government*, and the *International Journal of Information Technology and Management*) and conferences (e.g. *Americas Conference on Information Systems*, *Bled eConference*). In the final quarter of 2011, he was a Visiting Scholar at the Sauder School of Business, the University of British Columbia in Vancouver, Canada. During that visit, he successfully completed his dissertation and will defend it back in Utrecht within the appointed four years.

Marijn functions as reviewer for several international journals and conferences, among which the *European Conference on Information Systems*, *Bled eConference*, *Supply Chain Management: An International Journal*, and the *Journal of Theoretical and Applied Electronic Commerce Research*. Since its conception in 2005, Marijn has been involved with a research project on the 'Chain landscape of The Netherlands', in close collaboration with Professor Jan Grijpink. This has led to a jointly edited (Dutch) book in 2009. From 2010 onwards, Marijn is managing editor of the scientific section of the *Journal of Chain-computerisation*.

Next to his academic work, Marijn is employed part-time as researcher/consultant at Dialogic *innovation & interaction* since 2008. He performs research, advises, and hosts workshops on themes like chain digitisation, e-strategy, and innovation. He has worked on numerous projects and the resulting reports for various clients, among which Dutch ministries and provinces, and the European Commission. Marijn has ample experience in hosting and facilitating computer supported group meetings using group decision support systems.

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