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A Dutch CIO Survey and Case Study

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Abstract

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 and validate it by conducting a survey among 33 CIOs. In addition, one of the responses is further investigated through a case study. Based on the survey data, three determinants, namely (i) complexity of chain digitisation solutions, (ii) synchronisation of data and (iii) the size of the organisation, appear to be correlated with chain digitisation maturity. This is confirmed by the case study, which also provides a deeper understanding of alignment of technology and organisation on the one hand, and the supply and demand chain partners on the other. We conclude that the topic of chain digitisation alignment deserves further research, as does its situationality for profit and non-profit organisations.

Keywords: Chain Information Systems (CIS), Maturity, Chief Information Officer (CIO), Survey, Case study

1 Introduction

Chain information systems (CIS) can be considered one of the critical preconditions for successful collaboration in (inter)organisational chains. CIS can be viewed as a specific subset of interorganisational information systems (IOIS) that are probably better known as these have a longer history (e.g. Barrett and Konsynski, 1982). Many different terms belong to the IOIS 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 IOIS 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 paper, we focus on CIS and 'chain digitisation' instead of IOIS, to stress that it encompasses collaboration between multiple organisations, i.e. firms working together along value/supply chains through IT. Chain digitisation 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 interorganisational approach. The alleged advantages of CIS appear to specifically meet these challenges of public organisations, and promise cost reduction, productivity improvements, and innovation (Morrel and 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 little 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 paper:

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

The structure of the remainder of this paper 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. These results will be discussed and lead to the conclusion. We end with some opportunities for future research.

2   Theory & Conceptual model

While in IOIS 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. 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 and Westbrook, 2001). For example the maturity with regard to supply-side functions like (e-)procurement (Plomp and Batenburg, 2009) is not necessarily related to the maturity of demand-side functions like CRM (Batenburg and Versendaal, 2007). When we are interested in maturity from a chain perspective, there is a measurement possible on both the 'upstream' and 'downstream' side of the focal organisation. Hence, chain digitisation maturity is a two-sided concept.

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 et al., 2001; Luftman and Kempaiah, 2007). This is particularly the case for the success of IOIS (Zhu and 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 and Venkatraman, 1993).

For the dimensions and levels of our chain digitisation maturity model, we build upon our recent work on chain digitisation maturity (Plomp and Batenburg, 2010). There,

based on 22 existing maturity models a framework is defined, depicted in Figure 1. It consists of two dimensions: technology and organisation, with four maturity levels each. What we add here is the distinction between the supply and demand side, and the operationalisation of the levels by means of items for a questionnaire. Furthermore, we are interested in finding the determinants that influence this maturity.
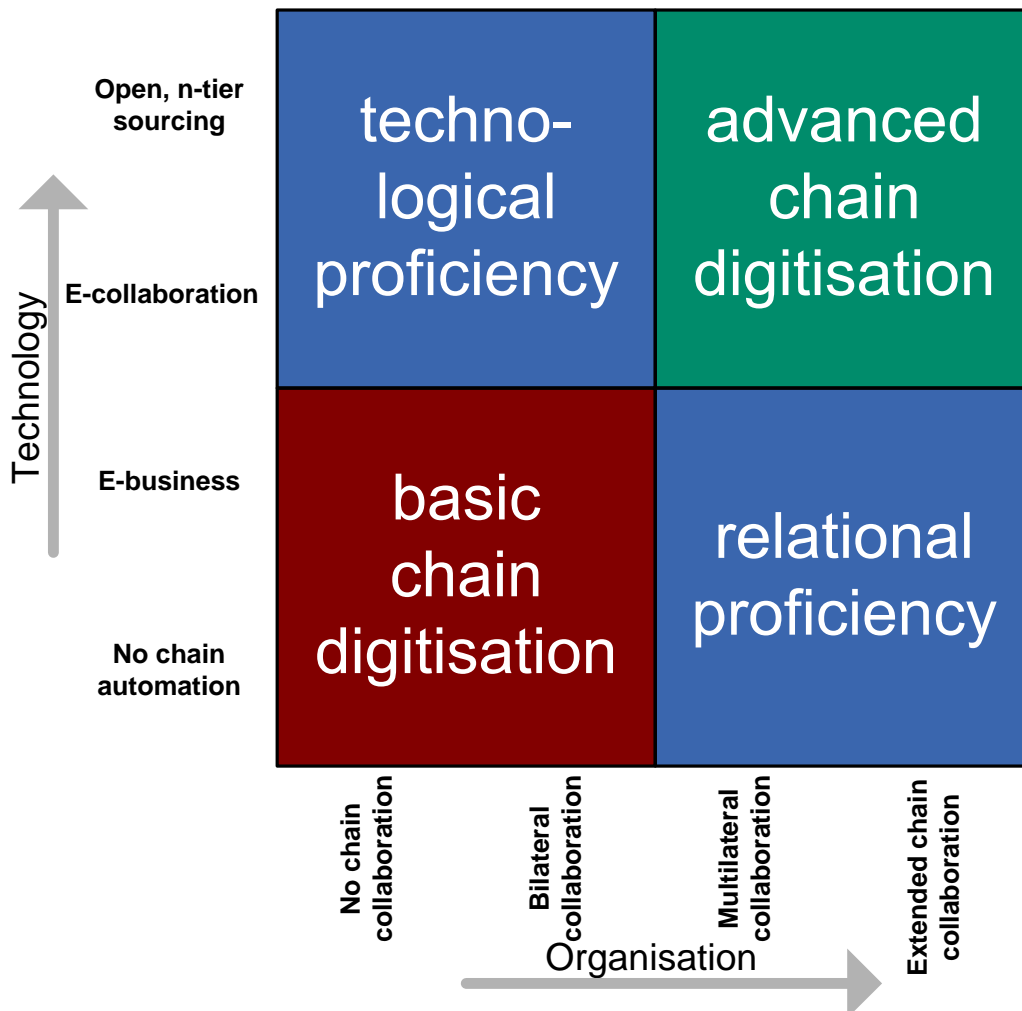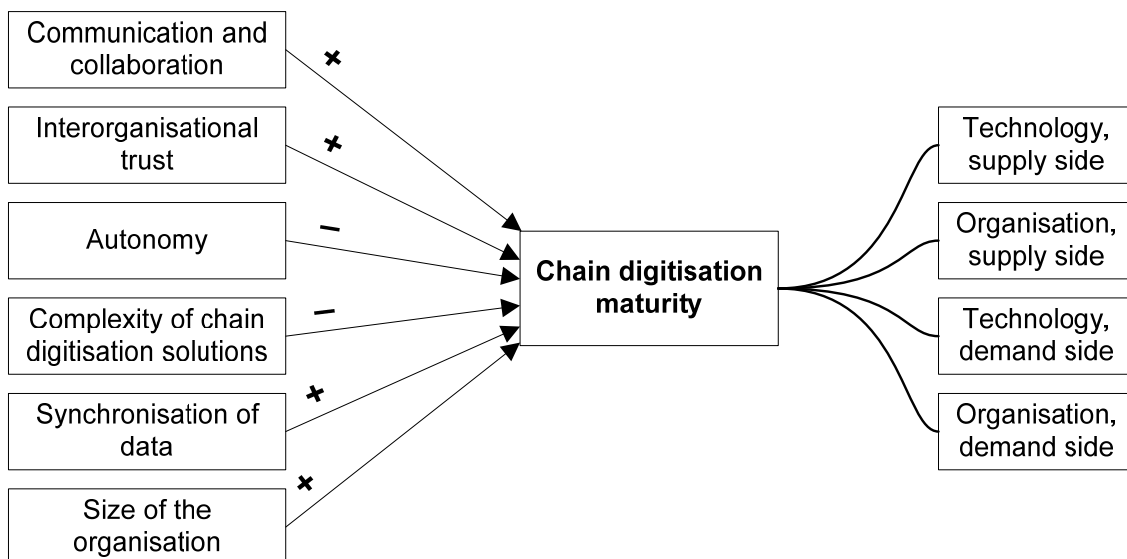

Figure 1: Chain digitisation maturity levels for both the technological and organisational dimension (Plomp and Batenburg, 2010)

For the selection of the organisational and technological determinants of chain digitisation maturity, we studied existing literature on the adoption of IOIS. A rigorous IOIS 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: Robey et al. primarily discuss studies describing IOIS 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 IOIS. 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 IOIS, at least with some of their trading partners (Geri and 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, a conceptual model regarding the determinants of chain digitisation maturity can be created (see Figure 2). In line with e.g. Robey et al. (2008), many other determinants can be thought of, but in this study we consider these the main determinants.

Figure 2: The conceptual model

As follows from the conceptual model in Figure 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 is characterised by a technological and an organisational dimension, combined with the supply and the demand side as the organisation's chain position.

3 Data & Methods

To collect data to test our hypotheses, we applied both quantitative and qualitative research methods, i.e. a survey and a case study.

With regard to the quantitative approach, an online questionnaire has been distributed among 38 Chief Information Officers (CIOs) of Dutch organisations from different industries through our extended professional and personal networks (i.e. through

convenience but controlled random sampling). 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 have been motivated to 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 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 however remains a proxy, as other factors (e.g. degree of outsourcing, line of business) likely play a role as well.

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 1: Determinants and the survey questions employed to measure them

Table 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.

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',

- 'Yes, for only one of our suppliers', and

- 'No'.

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

In total, we received 33 complete 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 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'.

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?

Table 2: Maturity dimensions and the survey questions employed to measure them

The scales for the dependent variable were constructed from the questions from Table 2. A reliability analysis was performed for each dimension, which resulted in Cronbach's Alpha scores of 0.84 (technology, supply side), 0.96 (organisation, supply side), 0.86 (technology, demand side) and 0.94 (organisation, demand side). Finally, when we take these four categories together, we obtain an Alpha of .96. These scores imply a good reliability and therefore these five scales can be used to measure the dependent variable chain digitisation maturity (Nunnally and Bernstein, 1994).

For the case study, we focused on the organisation of one of the CIOs that participated in the survey. We made a company description, chain digitisation maturity assessment and considered what we could learn from this specific case.

4   Results of the survey: a quantitative analysis

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 below that the sample is diverse. The manufacturing/producing and professional services sectors are overrepresented, whereas only one governmental organisation has participated.

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%

Table 3: Sector distribution of sample (n=33)

Although all organisations were selected by being active in The Netherlands, it was allowed for them to also be active in other areas. As can be seen at the left side of Table 4, there is a relevant distribution over the different areas of operation, i.e. local, national, continental and global scale.

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%

Table 4: Area of operation and organisational age of sample (n=33)

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 4). On average, organisations are active since 53.4 years, with a relatively high standard deviation of

65.2. This means that the sample does neither only consist of very recent start-ups, nor of age-old organisations, but of a relevant mixture instead.

The main variables to be analysed in this study are summarised in Table 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 chain digitisation maturity level of 4.00, while 18 companies were positioned in the '≥1.00; <2.00' range.

Variable	Mean	SD	Min.	Max.
Chain digitisation maturity dimensions (dependent variables)				
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
Chain digitisation maturity determinants (independent variables)				
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

Table 5: Descriptive statistics of dependent and independent variables (n=33)

Most of the independent variables (the remainder of Table 5) 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 mean and standard deviation of the log-transformed variable are presented in Table 5.

Next, the relationships between the dependent and independent variables have been measured applying Pearson bivariate correlation analysis. The results are in Table 6.

Determinant	Technology, supply side		Organisation, supply side		Technology, demand side		Organisation, demand side		Overall digitisation maturity	
	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

Table 6: 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

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 ($p<0.05$), 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 1). As the overall score contains both the technological and the organisational dimension, there is only a trend correlation ($p<0.10$) visible.

The 'complexity of chain digitisation solutions' variable is significantly and negatively related to chain digitisation maturity as well ($p<0.05$), 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, this determinant is also significantly correlated ($p<0.05$) 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 ($p<0.01$).

The variable with the strongest correlation however, appears to be the employee size of the organisation. With all four dimensions as well as on the overall chain digitisation maturity measurement, this determinant shows a strong and significant correlation ($p<0.01$).

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.

5   Results of the case study: a qualitative analysis

In addition to the quantitative survey, we also performed a case study on an organisation of one of the CIOs that participated in the survey. In this section, we take a closer look at the Dutch Railways ('NS'), through a general company description and chain digitisation maturity assessment.

NS is the principal passenger railway operating company in The Netherlands. Its trains operate over the tracks of the Dutch national rail infrastructure company ProRail, which was separated from NS in 2003. On a daily basis, over one million people (out of a population of 16 million) travel by train in The Netherlands. It was founded in 1938, and is now a private company with the Dutch government as sole shareholder. NS was granted (by the national government) the concession to exploit the main lines, whereas other companies received a number of the concessions for the secondary lines. The goal is to give individual concessions for the lines, but (at least) until 2015 NS holds the concessions for the main lines.

The respondent is the CIO from NS' largest business unit: NS Reizigers BV (NS Travellers), responsible for passenger train services and for employing train drivers and conductors. This business unit generates 60% of the total turnover. From here on we refer to the NS Reizigers (NSR) *business unit* when we speak of 'the organisation', as our analysis focuses on this part of the organisation. NSR is a profit organisation and currently has a head-count of 10,820 persons, a large share of the 27,000 employees working for NS. It mainly focuses on a national scale, with 40 offices and a market share of 90% in The Netherlands. NSR operates in a fairly stable market, partly due to the fact that it possesses the main line concessions at least until 2015. Nonetheless, small competitors like Arriva, Syntus (NS owns 50% of their shares), Veolia and Connexxion are present in the passenger train service market as well, occupying niches. The process of tendering the concessions is a competitive process and, if at stake, this makes the environment of the largest national train services company fairly complicated.

According to their self judgement, NSR follows a strategy of product leadership, meaning it focuses on delivering the best product through optimised development, innovation, design, time to market, and high margins in a short time frame (Treacy and Wiersema, 1995).

The CIO of NSR indicated the firm's chain digitisation maturity through completing the same questionnaire as described previously. The company results for all maturity dimensions are (values can range between 1 and 4, where 1 is the lowest maturity level, and 4 is the highest) on the supply side for technology 2.67 (sample mean 1.89) and for organisation 2.14 (sample mean 2.09); on the demand side, the technology score is 3.00 (sample mean 2.04) and the score for organisation is 3.00 as well (sample mean 2.33). Together, this leads to an overall chain digitisation maturity score for NSR of 2.72 (sample mean 2.07).

As can be concluded from these scores, NSR scores above average on both overall chain digitisation maturity and on its four dimensions. It positions around the 80th percentile of the distribution of all 33 cases. Note that NSR has a somewhat higher maturity with regard to both technology and organisation on the demand side compared to the supply side.

To further our understanding of NSR's situation, Figure 3 shows how the organisation scores on the six maturity determinants as measured by the questionnaire.
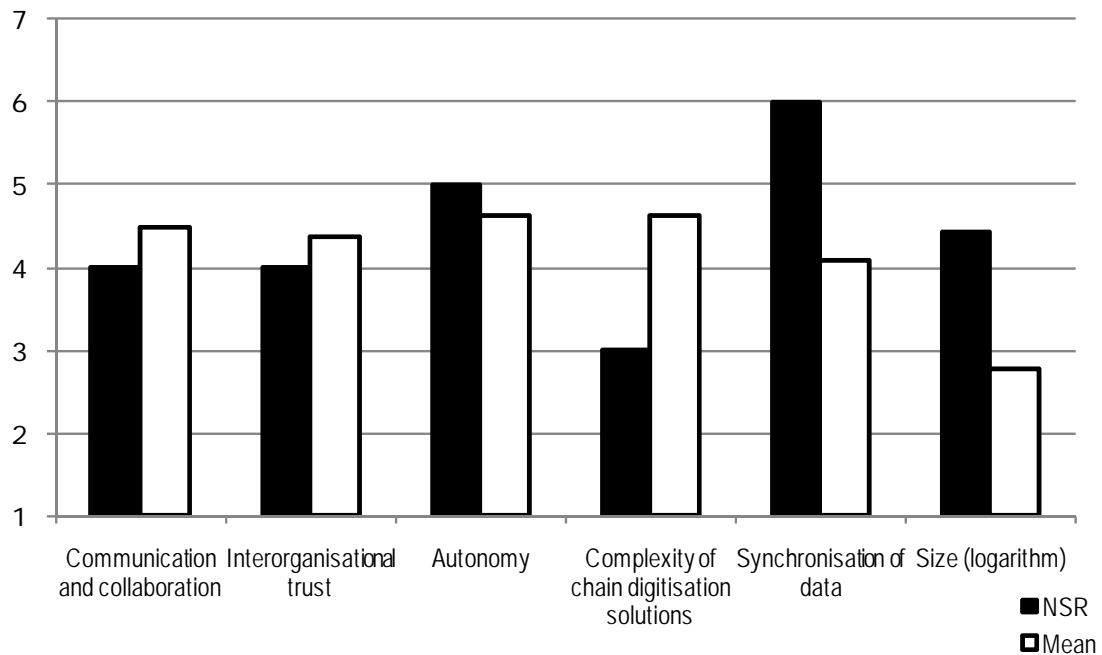
Figure 3: Scores of NSR on the independent variables vis-à-vis the sample mean

From the figure we see that for the first three variables, NSR scores lower or about equal compared to the sample mean. For the other three variables on the right hand of the figure, NSR clearly outperforms the sample mean (assuming that lower complexity of chain digitisation solutions is better). Interesting enough, these determinants overlap with the three independent variables that were most significantly correlated with the overall chain digitisation maturity as described in the previous section. This confirms at least a substantial part of our conceptual model.

To turn these results into policy recommendations remains difficult, however. Obviously, variables like size and the importance of data synchronisation are factors that are hard to change to further chain digitisation maturity. This leads to the tentative conclusion that the need for chain digitisation maturity is situational. We will return to this point in the following section.

Also of interest is the phenomenon that NSR's chain digitisation is more mature on the demand side than on the supply side maturity dimensions, consistent for both the technological and the organisational dimension. This could be related to the main focus of the NSR business unit (next to its product leadership): the passenger. NSR is indeed known for its profound public relations campaigns and employs more and more customer e-business applications like real-time departure information and e-ticketing.

6 Conclusion

In this paper, a framework for chain digitisation maturity has been developed and turned into a survey that is applied on 33 CIOs of Dutch organisations. Combined with literature study on this topic, our goal was to find and test the main dimensions and determinants of chain digitisation maturity.

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.

When viewed from a strategic outside-in standpoint, these 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 factors that influence chain digitisation too. Finding these remains one of our future research objectives.

7 Discussion

A major limitation of many studies on IOIS, 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. 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 and Batenburg, 2010). One could also approach this topic in a more qualitative way, through case studies of an entire value chain (e.g. Grijpink et al., 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 and 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. A deeper analysis of our current 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.

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