

Information Technology and Data Use in 1PL - 4PL Logistic Companies

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ABSTRACT

In the collaborative environment of the logistics sector, Information Technology (IT) plays an impactful role in making logistic processes more efficient. However, different types of logistic companies have different needs regarding IT support. Furthermore, it is difficult for companies to effectively utilize the data flowing from the various IT systems. The purpose of this paper is to provide an insight into the current state- and challenges of digitalization in 1PL – 4PL logistic type companies. Additionally, the paper will review how data is currently used as a resource and the related challenges. Lastly, a conceptual model for the logistics sector will be created to help companies with digitalization, data use, and preventing common problems. Integrative literature research will be conducted into digitalization and data use in 1PL – 4PL companies. Next, a descriptive analysis will be made on a data set from research on data and digitalization in the Dutch logistic sector which will be compared to the findings from the literature review. The result is a framework covering challenges and contributing practices of data use. The contribution of this work is that this work is focused on the different types of logistic companies which provides a new point of view into utilizing IT and data in the logistics sector.

Keywords

Logistics, Data use, Information Technology, 1PL – 4PL

1. INTRODUCTION

In the current age of digitalization, Information Technology (IT) systems are essential in business architecture and vital to enterprise viability in the coming years [4, 12, 41]. Especially in a fast-moving and world-covering sector like the logistics industry, the effective use of IT influences business performance, profitability, and competitiveness [20, 22, 29, 46, 57]. Applications like Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), Transportation Management Systems (TMS), and other logistics IT systems are becoming more apparent within organizations.

Nowadays, more often the data generated by all these IT systems is collected and stored to become a resource that drives management decisions and corporate strategy [5, 10, 35].

Investment decisions, capacity-increasing decisions, customer service improvement decisions, and delivery performance decisions are some of the business strategy decisions that

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nowadays are mainly driven by data [3].

Digitalization among the supply chain provides possibilities for companies to have real-time information on the position of goods, improving warehouse and transportation efficiency resulting in reduced costs of logistic management, fewer warehouse and transport-related problems, and improved sustainability [13, 22, 47].

The improved communication, also resulting from the increased use of IT, between supply chain partners improves the satisfaction of both supplier and customer. As a result of the higher quality of information shared the collaboration improves. It becomes easier for companies to adjust to each other's schedules. As a result, the quicker lines of supply also improve end-customer satisfaction [15, 29]. All these benefits together can increase a firm's profitability in the long term.

However, increased flows of data in combination with the incorporation of more advanced technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) raise new difficulties on the IT topic. One of the problems that arise is that companies do not know how to filter and analyze the data useful for their decision making processes or to measure their performance in different areas [39, 43].

Another problem is that data is typically produced in heterogeneous formats and origins from many different sources [34]. This could negatively influence communication with supply chain partners because there is no standardized way of integrating data along the logistic chain.

This paper includes an integrative literature review on the state of digitalization in 1PL – 4PL logistic companies and gathers insights on how data is currently analyzed and used to support decision making processes and strategy setting.

First party logistics (1PL) firms are firms which apart from manufacturing, own warehouses and are in control of the transportation and retail of their own goods. [1] A second party logistics (2PL) firm is a logistic operator which only takes care of transportation [52]. A third party logistics (3PL) firm offers, next to transportation, also additional services and assets like warehousing packaging and labeling, some supply chain management, quality control, and IT software [11, 52]. Lastly, a fourth party logistics (4PL) firm is in control of the entire supply chain of a company however, different from the other types, a 4PL service provider is a supply chain integrator (organization combines its own assets with assets of other service providers) or orchestrator (non-asset-based 4PL). 4PL firms provide supply chain consultancy [11, 18] to improve process efficiency. The main goal of 4PL service providers is to manage all links in a supply chain by managing resources, planning, communication, and information.

As far as we know there is not a specific logistics model which makes a distinction between the different logistic company types which can help them maximize the value of the currently available IT systems and get the most value out of the present

data flows. The main purpose of this research is to provide a conceptual model for the logistics industry which could help the different types of logistic companies face the challenges of digitalization and data use to be able to realize the benefits. Therefore the goals of this paper can be defined in three parts:

- **Goal 1:** To create an overview of the attitude towards- and the state of digitalization in the different types of logistic companies (1PL – 4PL).
- **Goal 2:** To discover the challenges related to digitalization and data use in the different types of logistic companies (1PL – 4PL).
- **Goal 3:** To create a conceptual model for the logistics industry.

To achieve these goals we will use the following research question:

- ‘How to achieve the benefits of digitalization and data use in 1PL – 4PL companies?’

To guide our research we will divide this question into four sub-questions:

- **RQ1:** What is the current view on- and state of digitalization in the different types of logistic organizations?
- **RQ2:** What are the current challenges regarding IT system adoption in the different types of logistic organizations?
- **RQ3:** What is the current state of data usage and what are the benefits of data usage in 1PL – 4PL organizations?
- **RQ4:** What are the challenges hampering data usage for decision making in 1PL – 4PL organizations?

By the end of this research we have contributed to a better understanding of the importance of adopting IT systems and the benefits of digitalization, and developed a model with the most important aspects of IT adoption for different types of logistic companies. Additionally, we have contributed to a better understanding concerning the effective use of data and also incorporated this into our conceptual model.

Although some conceptual models have been created for different areas of the logistics sector, no conceptual model was found on data use in the logistics sector.

The structure of this proposal is as follows. In section 2 we provide an outline of related work in the area of frameworks for the logistic sector. In section 3 we discuss the research methodology used to answer the research questions. In section 4 we answer the research questions. In section 5 we explain and discuss the conceptual model. Lastly, in sections 6 and 7 a discussion and conclusion are written.

2. RELATED WORK

To find relevant related work for the research topic Scopus and Google Scholar were used. We used the search term “logistic(s)” in combination with “digitalization” and “data use/usage” or in combination with “IT/ICT” to find information about the state of digitalization in the logistics sector and data use in the logistics sector. To find information on the impact of IT and digitalization on the logistic sector we used “logistic(s)”, “Information technology”, and “impact”. Lastly, to find frameworks for the logistics sector we used the search term “logistics 4.0” or “logistic(s)” in combination with “conceptual model/framework”.

Inclusion criteria we have used is that papers could not be too old. We preferably used articles written maximally 5 years ago. IT gets better and quicker every year and thus the effects it had 10 years ago could differ quite a lot from the effects IT is having now. We have also looked at the relevance of articles based on citations and references used. When a paper is cited by papers that also cover the logistics sector it provided us with other relevant articles as well.

A lot of research has been conducted in the area of IT usage and how the integration of IT into logistic processes has benefits in many ways [36, 37, 40]. These reports give valuable information which was used to compare with the raw data we have obtained from research done in the Netherlands [51]. Also, a survey was found about the use of third party logistics in Mexico [2] and the data from that survey was compared with reports on Europe and the USA. Next to this, also more general research has been done on how the integration of IT influences logistic processes by improving Supply Chain Management (SCM) [15], reducing warehousing costs, improving transportation efficiency resulting in competitive advantages, and increased firm profitability [8, 30, 42].

Likewise, research was found about the use of data in various logistic scenarios. This was split up in specific usage of data, like using AI collaboration for truck drivers [31] or data-driven application modeling in Finnish seaport digitalization [23]. Nonetheless, literature was not limited to these specific scenarios but also contained reviews about how the right use of Big Data enhances the logistic sector even further [7, 55].

Lastly, research on how to cope with the challenges big amounts of data bring and how to translate this into effective use [9, 27, 28] was examined. In addition, reports were found on how to apply new technologies like the Internet of Things [21, 25, 49] or blockchain [32, 50, 56] to improve communication along the supply chain. To conclude, reports on frameworks and models for logistics 4.0 were examined [17, 28, 38, 44, 48, 49, 54].

The interesting insights from all these sources combined provided a good overview of the current use of IT systems and the state of data use. The examined frameworks and models provide a good starting point for the model that is created in this research paper.

3. RESEARCH METHODOLOGY

In this paper, multiple methods of doing research are used. First, an integrative literature review has been performed on digitalization and data use in the logistics sector. The findings from this literature review have afterward been used in a comparative research with the statistical descriptive analysis we have performed.

As mentioned before, a statistical quantitative analysis was performed. This analysis was conducted on a data set gathered by TLN, evofenedex, and Beurtvaartadres from their research on data and digitalization in the Dutch logistic sector [51]. This data set includes a distinction between the different types of logistic companies.

For 1PL companies, the number of respondents who completed the survey was 357. For 2PL-4PL the numbers were 233, 244 and, 67 respectively. This differs for some questions based on exclusion criteria. The sample size provides acceptable accuracy. We cannot generalize the data as this research was performed only on companies in the Dutch logistics sector. The state of digitalization and data use in the Netherlands could be different from the state of digitalization and data use in other countries.

The statistical findings were used in comparison to the literature review to show whether the data from the research in the Dutch logistics sector shows a resemblance with the findings from the integrative review.

After performing the integrative literature review and the statistical analysis the conceptual logistics model was created based on the findings. The conceptual model was based on the 10 step approach by Verschuren and Doorewaard [53]. The conceptual model is focused on the challenges of data use, solutions to these challenges, and the benefits that can be realized.

4. LITERATURE REVIEW AND DESCRIPTIVE ANALYSIS

In this section, we discuss the findings from the literature on digitalization and data use in the introduction and compare this to the data from the research by TLN, evofenedex, and Beurtvaartadres on data and digitalization in the Dutch logistic sector to find an answer to our research questions and to see if the results are similar.

4.1 Current view on digitalization and IT systems

In the introduction of this paper, we discussed articles claiming that IT systems are vital to enterprise viability in the coming years. IT is said to have a big influence on business performance, profitability, and competitiveness. In this section, we looked if these findings were being reflected in the data from the research by TLN, evofenedex, and Beurtvaartadres on data use and digitalization in the Dutch logistic sector.

First, we looked into how the different types of organizations think about the importance of IT for their organization. We expected 4PL companies to value the importance of IT highest as they are non-asset-based logistic network orchestrators who have to communicate with a lot of different supply chain partners, manage resources capabilities and technology. This is a complicated job that seems like it relies heavily on IT support. Next to this, we expected 2PL organizations to value IT importance relatively lowest as they carry out transportation services and thus do not rely as heavily on all different kinds of processes and parties sharing information constantly.

In table A.1.1 we see that the relative lowest importance is among the 2PL logistic type companies with 81.75%.

What is more interesting is that while we expected 4PL companies to value IT most important, the 3PL logistic type organizations seem to value the importance of IT highest. An explanation is that 3PL organizations are logistic service providers which offer a variety of logistic services to their customers. To make sure they can provide effective and efficient services they require a solid IT infrastructure to be able to manage their warehouses, transportation activities, and value-adding services all at once for their customers.

Another interesting fact is that the average percentage of companies among all of the 4 categories that believe IT is unimportant for their organization is just 5.82%. By looking at the number in table A.1.1 we can argue that the claim made in the literature about the importance of IT is well reflected by the numbers for the research.

Although the average importance among the 4 types of logistic companies is 87,10% we also see from the data in table A.1.2 that even though the importance of IT is valued high by all the organizations, over half of the companies believe that the value of humans will remain more important than digitalization. What is interesting is that the 3PL logistic service providers have the

lowest approval rate on the statement from table A.1.2 and in the former discussed table A.1.1 valued IT importance highest.

We argue that organizations mostly still believe that humans will remain more important than digitalization because in some positions humans are not easy to replace. For example, we still do not have completely self-driving vehicles that do not require human presence at all. Another argument will be that companies will still need humans to keep systems operating or perform maintenance on malfunctioning systems.

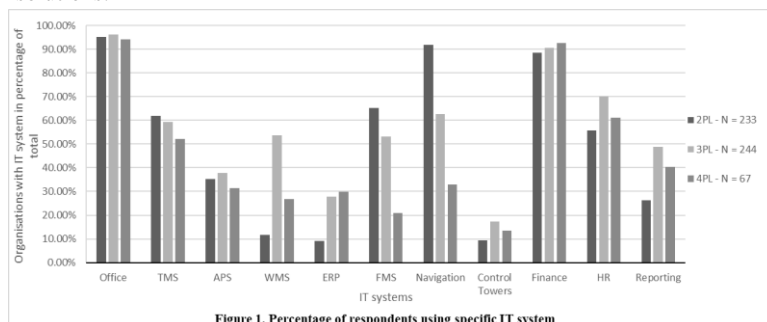
Now we will look at the question ‘does your organization use the following IT system?’ unfortunately this question has not been asked to the 1PL companies so we can only discuss the 2PL – 4PL companies regarding this question.

In table A.1.3 and figure 1 we can see how much of the organizations, in percentage of the total amount of respondents, uses a specific IT system.

First, we looked at Transport Management System (TMS) usage among the different types of companies. The use of TMS is highest among the 2PL companies and lowest among 4PL organizations. This was expected as 2PL organizations are fully focused on transportation and a TMS system can be beneficial for their daily operations.

Secondly, an interesting finding from the table is that over half of the 3PL organizations use a Warehouse Management System (WMS). That this number stands out against the 11.59% usage in 2PL companies and 26.87% usage in 4PL companies is not unexpected considering that 2PL companies do not offer warehousing as an additional service and thus have less interest in WMS. 4PL companies are non-asset-based logistic service providers and thus they also have a lower demand for a WMS. 3PL companies who own warehouses and offer this as an additional service can benefit more from such a system and this is reflected in the usage among this type of organization. If we think about navigation systems we expected the use of these systems to be highest among the 2PL companies as 2PL transportation companies rely on their transportation activities being effective and thus not getting lost or being slowed down by reading maps is a huge advantage. With 91.85% usage among the respondents, this is the second most used system in 2PL companies. We also see that Fleet Management Systems (FMS) are most used in 2PL companies. If we exclude the administrative systems and the office package the top 3 most used systems in 2PL companies are TMS, navigation systems, and FMS. For 3PL companies on the other hand the top 3 most used systems excluding administrative systems are TMS, WMS, and navigation systems. Lastly, for 4PL companies, the top 3 most used systems excluding administrative systems are TSM, Advanced planning & Route planning software, and navigation systems.

An interesting and unexpected discovery is that the 4PL logistic type organizations have the lowest usage percentage for 5 out of the 11 systems in this survey. This is unexpected as we have earlier talked about the need for 4PL companies of IT systems to be able to successfully provide their logistic optimization solutions.



A potential explanation for this is that 4PL companies use in-house developed software platforms and thus do not require a lot of different systems for different tasks.

What is interesting to mention is that 3PL companies do not have the lowest use of any of the 11 surveyed systems and have the highest usage percentage for 7 out of 11 systems in the survey. This is however not unexpected anymore after having looked at table A.1.1 which shows how much of the 3PL companies believe IT is important for their organization.

Lastly, we looked into how the different types of logistic companies currently think about the influence of digitalization in their organization and what they expect in the future. In table A.1.4 we can see that the average of the organizations of the 4 types combined which think digitalization will help their organization advance in the future is 88.72%. This concurrently means there are still on average over 10% of the companies who think digitalization will have no influence or will have a negative impact. However, when we looked at the organizations which think that digitalization will harm their company, this number is lower than 2% in all 4 of the categories. Referring back to the introduction these numbers support the claim that digitalization will become more apparent in the coming years.

After studying table A.1.1, we found that 2PL organizations which also valued the importance of IT lowest, have the lowest percentage of organizations believing that digitalizing will help their organization in the future. Looking at the type of organization that thinks IT will help their organization most in the future, it was again the 3PL organizations with the highest trust in digitalization.

We even took this a step further by looking at table A.1.5 which shows how the different organizations think about the question ‘how much has digitalization contributed to improving business efficiency?’. In this table, we again see that the percentage of organizations that think IT has contributed much to improving business efficiency is lowest among the 2PL companies and repetitive with the other tables the percentage is highest among the 3PL companies.

We also see that there were quite a lot of companies who are still in the process of digitalization especially among the 1PL type companies.

What also seemed to be a reoccurring pattern is that the 3PL companies who value the importance of IT for their organization highest, A.1.1 also ranked highest in believing that digitalization will help their organization in the future, A.1.4 and also ranked highest in table A.1.5 saying that digitalization has contributed much to improving their business efficiency.

In table A.1.6 we see how the different types of logistic organizations think that digitalization will contribute to improving their business efficiency in the future.

This first interesting thing is that among the 4PL companies there is not a single company that thinks digitalization will have little contribution.

Another interesting shift can be identified among the 1PL companies, where the amount of organizations that believe digitalization will contribute much, has risen quite a lot compared to the former table. This was probably caused by the companies who are still in the processes of digitalization. These think that their process will contribute much to improving their business processes in the future. This is not a weird thought, considering that an organization will not start the process of digitalization if they do not expect it to contribute positively to their organization.

Lastly, we can see that also among the other logistic company types 2PL-4PL the percentage of companies that believe digitalization will contribute much has risen.

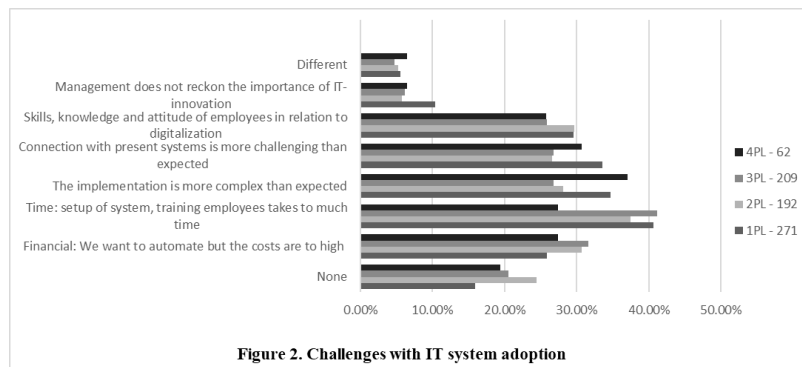
4.2 Current pitfalls with IT systems

In the previous section, we discussed the importance of IT among the 4 types of logistic companies by looking at the data from the research in the Dutch logistics sector and comparing this to the findings from the literature review. In this section, we discuss which challenges the logistic companies currently face regarding IT system adoption.

In figure 2 and table A.2.1 we can see the percentage of companies that have troubles with IT adoption. The first thing to notice is that the least apparent problem is that the management does not recognize the importance of IT innovation. This is in line with what we saw in the data on how the importance of IT was valued. The most common problem for the 1PL-3PL companies is the same. The barrier that troubles IT system adoption most according to the data is related to time. More specifically the setup of the system and the training of employees takes too much time. For 4PL companies, a different challenge troubles IT system adoption most. For them, problems with the implementation of the system being more complex than expected, is the biggest handicap with new IT systems. There is not one specific problem standing out. All challenges, except the lack of recognition by the management, are quite equally present within the four logistic type organizations.

Luckily, not all companies experience problems. Interesting to see is that the 2PL companies have the highest amount of organizations, almost a quarter of the organizations, saying they experience no challenges regarding IT system adoption.

One of the papers we found which delves into barriers of digital transformation at logistic service providers reported [14] the four most experienced problems when digitalizing. According to the paper, those are; the complexity of the logistics systems already in place, the absence of required resources including knowledge, resistance to change, and problems with data protection. The first two problems are quite similar to the problems we have identified in our data. The formerly mentioned paper is however not the only paper that discusses challenges with digitalization in logistics. The most common problems we came across when studying literature were; a lack of required knowledge, high investment costs, difficulties with implementation because of legacy systems or because of missing standards, and missing acceptance [24, 33, 45]. Although the problems are spread among a lot of different companies we argue that the time of implementation, financial barriers, complexity of implementation, and lack of required skills and knowledge are the main challenges faced in the process of digitalization.



4.3 Data use in logistic companies

To get an answer to our research question, what is the current state of data usage and what are its benefits, we looked into data use in the different types of logistic companies. In table A.3.1 we see how the different types of logistic companies reacted to the question if they were familiar with IT systems that can support data collection and analysis.

We noticed that 3PL organizations have the biggest percentage of companies currently using systems to support data collection and analysis. This is not a surprise as throughout this research we have seen that 3PL companies are repeatedly the most digitalized of the 4 logistic type companies.

Next to this, we see that a lot of companies still do not know about these systems and there are also companies who even though they are familiar with these systems, are not planning to use them.

This could be a disadvantage for these companies in the long term, as multiple papers discuss the possible advantages effective data use has for a company. The effective collection and analysis of data aids organizations adapt to quickly changing markets [58], benefits strategic and operational decision making [28], it improves customer satisfaction and logistic resources allocation [55]. The effective use of data also leads to reduced costs by improving supply chain design, management and by reducing risks [16, 19].

Although it is clear that not a lot of companies are currently optimizing the data which flows from their IT systems and using this as a tool to their advantage, we can see in table A.3.2 that a majority of the companies in all 4 of the categories believe efficiency will improve by the use of real-time data in the coming years. Concurrently, almost half of the 1PL and 2PL organizations believe that the use of real-time data will improve collaboration with supply chain partners and this is over fifty percent of the companies in the 3PL and 4PL type category. Thus the value of data is acknowledged by the different organizations.

Lastly, we will look at graphs A.3.3 which show how the different types of logistic companies think about certain statements regarding their collected data. We see that especially in the 4PL organizations there are almost no companies that disagree with any of the statements and thus we argue that those organizations are doing quite well regarding data management. However, in the other types of logistic organizations, we notice there is still room for improvement, and even the companies that answered 'neutral' would benefit from improvement. In the next section, we discuss the challenges regarding data collection and analysis.

4.4 Challenges of data use

To make clear what the challenges hampering data use are we mainly found answers in literature as the survey on data use and digitalization we have been using does not contain much information on this topic.

The most stated challenges regarding data use according to literature are the volume of the data, the velocity in which data is generated, the variety of the incoming data, and lastly the veracity of the data [6, 7, 21]. These challenges are related to the amount of data that is generated in a short time, from all kinds of different systems and in different formats, and if the data itself is valuable. The reported challenges regarding the adoption of data management and analytics systems are companies having concerns about the investments [21] required for such systems, if the company has enough expertise to operate such systems, and time constraints [6, 43, 48]. In the

graph below we see what the respondents from the survey in the Dutch logistic sector experienced regarding data management and analytics system implementation. Note, however, that this is based on small sample size because only the companies who had not implemented such a system yet were asked to answer this question.

In figure 3 we can see that the challenges mentioned in the literature are also challenges the Dutch logistic companies are coping with. For the 1PL and 3PL companies lack of time for implementation is the biggest obstruction. For 2PL and 4PL companies the budget is the biggest obstruction. Interestingly, for 2PL companies 'offered systems do not fulfil the organization's wishes' is joint highest while for the other 3 logistic types this is the least apparent obstruction.

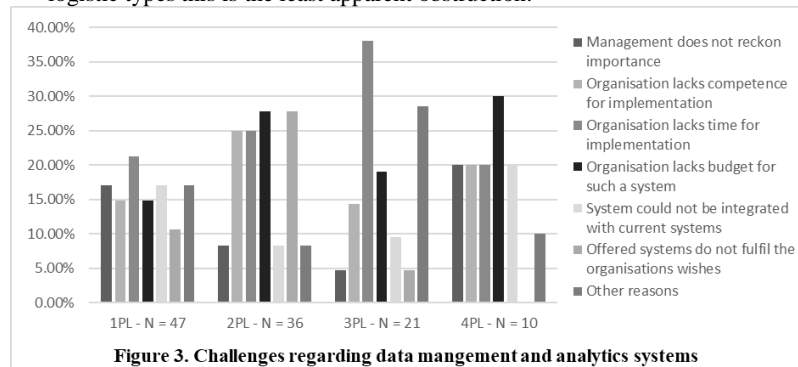


Figure 3. Challenges regarding data management and analytics systems

5. FRAMEWORK

The framework focusses on data use in the logistics sector and is based on the 10 step approach by Verschuren and Doorewaard [53]. In the first step A.4.1, we determined the phenomenon Y we want to change, in our case 'data use'. In the second step, we determined a phenomenon X that has a strong influence on Y. In our case, this is 'company readiness'. In step 3 we determined an additional variable P that has additional influence on Y. We chose 'company awareness of data use benefits'. In step 4 we determined an intervening variable U, in our case 'company cannot handle the data'. In step 5 we determined dimensions of the different phenomena and variables and provided aspects of those dimensions. After completing step 5 we have created the global conceptual framework A.4.2.

Based on the global conceptual framework in step 6 we chose the relevant variables to establish a hypothesis for the definitive conceptual framework. In step 7 we chose intervening variables. In step 8 we determined if there were variables that have a reciprocal effect on each other. In step 9 we made sure the model is closed and therefore valid. The model is closed if there are no variables to be found anymore which influences a variable that is in the model. In step 10, the last step, we add a '+' sign to positive relationships and a '-' sign to negative relationships. The final conceptual framework can be found in appendix A.4.3. We have opted to make the conceptual framework for the improved strategic decision making aspect of data use but this could be any of the benefits mentioned in the global framework.

A limitation the model has is that it could be questioned if data use and effective data use are even measurable. However, with this model we want to create awareness of the benefits data use has, what factors contribute to data use, and also informing about challenges that can be encountered.

Another limitation of the model is that it does not include solutions to the mentioned challenges. This could be an interesting idea for a future framework.

6. DISCUSSION

Literature makes it clear that digitalization has numerous positive influences on companies. In addition, the right IT systems support a company in staying valuable in the future. Most companies are aware of the benefits of digitalization and have a positive attitude towards it in the future. However, in the survey data, we noticed there are still companies that do not see the added value of IT as we can see in table A.1.4. Some companies do even believe that IT will harm their organization. Those organizations may fear that system downtime or security-related issues will harm them more than the benefits IT provides. The survey unfortunately does not provide an answer for this.

The most surprising finding is that 3PL companies seem to have the most positive attitude toward digitalization if we look at the survey data while we had expected this to be the 4PL type companies. This trend can also be seen in the usage of IT systems. As they have the highest use of 7 out of 11 surveyed systems.

In the reviewed literature, we found that the most common challenges regarding IT system adoption are time of implementation, financial barriers, the complexity of implementation, and lack of required skills and knowledge. In the survey, we found that for 1PL, 2PL, and 3PL companies the most common challenge is time constraints. 4PL companies experience complexity of implementation as the biggest challenge. The least apparent problem is that the management of an organization does not recognize the value of IT which is supported by the findings from the section before in which we showed most companies do recognize the added value of IT and digitalization.

Data use is not as incorporated as digitalization yet. Ranging from 29% in 2PL companies to almost 46% in 4PL companies, data use seems not to be as standard as IT. What we noticed however is that the companies who are using data already are quite positive about the data they collect. Data use can improve adaptability, benefit decision-making, increase earnings, and more. In the survey, we also saw improved processes and earnings being reflected. As not all companies are currently satisfied with their result there is still room for improvement regarding data use. Next to this, a lot of companies are not grasping the benefits they could achieve even though they are aware of the benefits.

Lastly, the challenges of data use can be split up into two categories, one relating to problems when using data and one relating to challenges that prevent data use. The volume of the data, the velocity in which it is generated, the variety of formats, and the veracity of the data are the main challenges when data is collected. The challenges preventing data use are related to companies having concerns about the high investment costs, lacking the required knowledge to operate such a system, and time constraints. These problems were also identified in our surveyed data. Most interestingly, 2PL companies experienced that off-the-shelf systems did not fulfil their wishes, while for the other 3 logistic type companies this was the least present challenge.

7. CONCLUSION

This paper used an integrative literature review in combination with a descriptive statistical analysis to review the benefits and challenges of digitalization and data use in 1PL – 4PL logistic type companies. We found that most companies have a positive view of digitalization in the future and believe IT systems are beneficial to their organizations currently. The most common challenges regarding IT adoption are time constraints or

implementation problems, financial challenges and lack of required skills do follow closely. Currently, data use is less present but the attitude towards the collected data is positive. Challenges preventing data use are concerns about the investments required, lack of in-house expertise, and time constraints.

The created framework should help companies that want to start using their data effectively. This framework finds its originality in that it is a framework specifically for data use in logistics companies.

For future research, it would be interesting to research how the different types of logistic companies can tackle the financial, lack of competence, and complexity-related challenges regarding data use, and how to cope with the volume, velocity, variety, and veracity of data.

The limitations of this research are that the survey data used only contains data from organizations in the Dutch logistics sector and therefore the results could differ when this research is performed in other countries around the world. The scope of this project focused on 1PL - 4PL logistic companies whereas this was not a focus point of the survey and therefore we sometimes missed data from one of the company types.

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APPENDIX

A.1 Literature review and descriptive analysis

A.1.1 importance of IT for organizations per organization type

Importance	1PL	2PL	3PL	4PL
Important	87.12%	81.75%	92.58%	86.96%
Neutral	6.44%	12.70%	1.95%	7.24%
Unimportant	6.44%	5.55%	5.47%	5.80%

A.1.2 Heavy digitalization is an option but also in the future the value of humans will remain more important than digitalization

Opinion	1PL	2PL	3PL	4PL
Agree	66.57%	63.75%	58.37%	71.64%
Neutral	25.74%	26.25%	28.57%	23.88%
Disagree	7.69%	10.00%	13.06%	4.48%

A.1.3 IT systems used in percentage of total respondents

System	2PL N = 233	3PL N = 244	4PL N = 67	Avg total
Office package	95.28%	96.31%	94.03%	95.21%
Transport Management System (TMS)	61.80%	59.43%	52.24%	57.82%
Advanced planning & Routeplanning software	35.19%	37.70%	31.34%	34.75%
Warehouse Management System (WMS)	11.59%	53.69%	26.87%	30.71%
Enterprise Resource Planning (ERP)	9.01%	27.87%	29.85%	22.24%
Fleet Management System (FMS)	65.24%	53.28%	20.90%	46.47%
Navigation systems	91.85%	62.70%	32.84%	62.46%
Control Towers	9.44%	17.21%	13.43%	13.36%
Financial administration software	88.41%	90.57%	92.54%	90.51%
HR administration software	55.79%	70.08%	61.19%	62.36%
Business reporting software	26.18%	48.77%	40.30%	38.42%

A.1.4 Digitalization will help my organization advance in the future

Influence of digitalization	1PL	2PL	3PL	4PL
Digitalization will help my organisation	89.16%	85.42%	92.16%	88.14%
Digitalization will have no influence	9.36%	13.02%	5.88%	10.17%
Digitalization will have a negative impact	1.48%	1.96%	1.96%	1.69%

A.1.5 Contribution of digitalization to improving business efficiency

Contribution of digitalization	1PL	2PL	3PL	4PL
Has contributed much	51.83%	45.76%	61.05%	53.57%
Has somewhat contributed	26.70%	36.72%	23.16%	30.36%
Has had little contribution	5.24%	8.48%	3.16%	5.36%
Still in digitalization process	16.23%	9.04%	12.63%	10.71%

A.1.6 Will digitalization contribute to improving business efficiency in the future

Contribution of digitalization	1PL	2PL	3PL	4PL
Will contribute much	72.96%	57.69%	76.80%	65.52%
Will somewhat contribute	23.98%	32.97%	19.59%	34.48%
Will have little contribution	3.06%	9.34%	3.61%	0%

A.2.1 Challenges with IT adoption

Challenges	1PL	2PL	3PL	4PL
None	15.87%	24.48%	20.57%	19.35%
Financial: We want to automate but the costs are too high	25.83%	30.73%	31.58%	27.42%
Time: setup of system, training employees takes too much time	40.59%	37.50%	41.15%	27.42%
The implementation is more complex than expected	34.69%	28.13%	26.79%	37.10%
Connection with present systems is unexpectedly challenging	33.58%	26.56%	26.79%	30.65%
Skills, knowledge and attitude of employees in relation to digitalization	29.52%	29.69%	25.84%	25.81%
Management does not reckon the importance of IT-innovation	10.33%	5.73%	6.22%	6.45%
Different	5.54%	5.21%	4.78%	6.45%

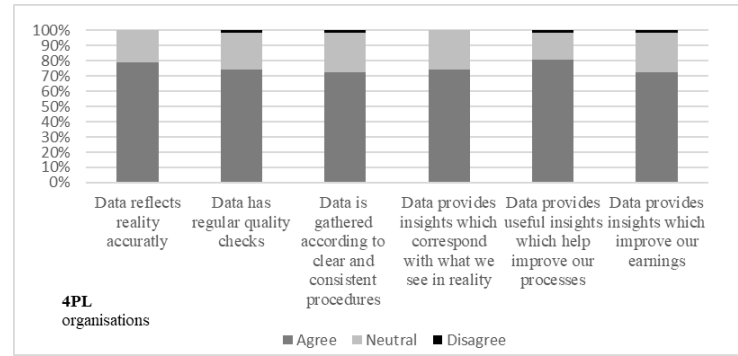
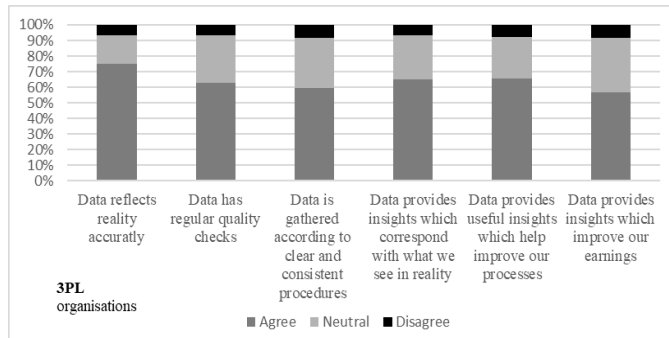
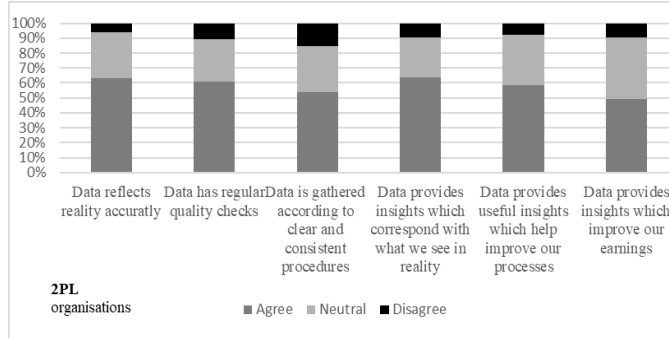
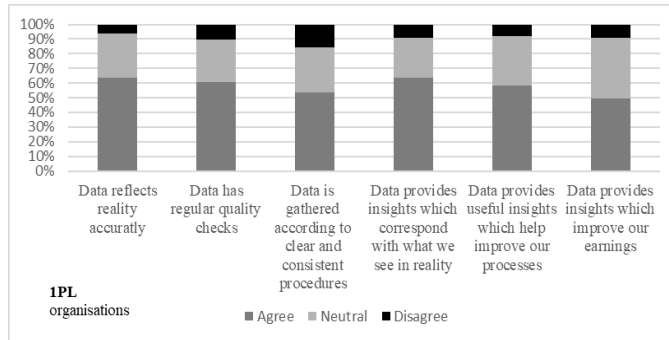
A.3.1 Are companies familiar with IT-systems that can support data collection and analysis

	1PL	2PL	3PL	4PL
Yes + Currently Using	39.08%	29.69%	45.67%	35.48%
Yes + planning to use	21.84%	22.92%	21.15%	16.13%
Yes + not planning to use	18.01%	18.75%	10.10%	17.74%
No not familiar	21.07%	28.65%	23.08%	30.65%

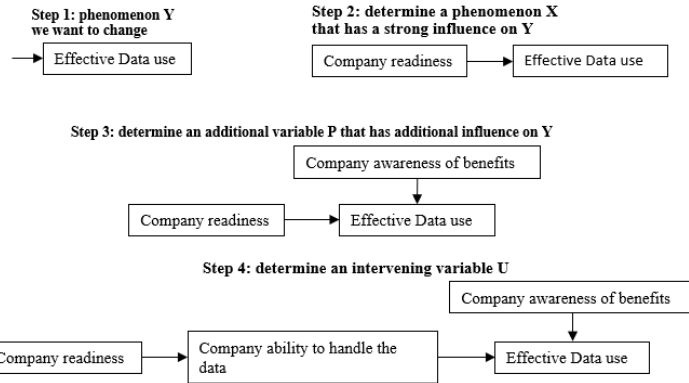
A.3.2 What do companies expect from the use of real-time data in the coming years

	1PL	2PL	3PL	4PL
Efficiency	73.33%	72.55%	81.11%	72.58%
Data driven decision making	35.41%	32.84%	48.39%	35.48%
Safety	19.67%	25.98%	29.49%	22.58%
Better collaboration with chain partners	48.20%	44.12%	60.37%	51.61%

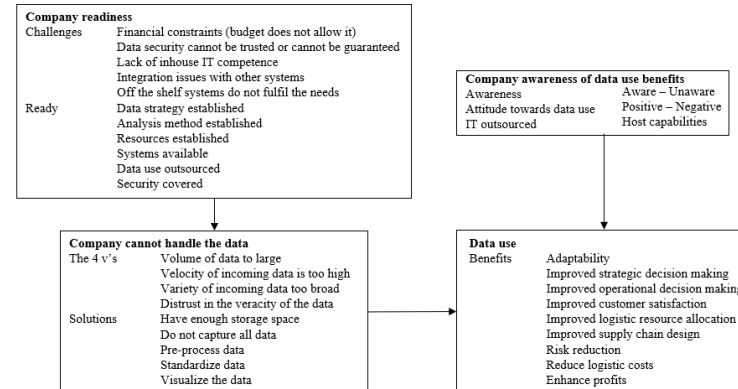
A.3.3 Statements on collected data



A.4.1 10 Step approach step 1 to 4



A.4.2 Global conceptual framework on data use in the logistics sector



A.4.3 Final conceptual framework

