Relating Digitization, Digitalization and Digital Transformation: a Maturity Model and Roadmap for Dutch Logistics Companies

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ABSTRACT

The development of digital technologies is a current topic for the logistics sector. In this fast-moving and world covering sector, the use of digital technologies can provide big opportunities. However, a recent study done by Beurtvaartadres, Evofenedex and TLN among Dutch logistics companies showed that most companies lack innovation and do not own the majority of these technologies. For this paper, a literature review has been completed on digitization, digitalization and digital transformation, followed by a statistical quantitative analysis based on available data from a recent survey on digitalization and data use of the Dutch logistics sector. The purpose of the research was to create a conceptual model with classifications of levels of digital maturity for this industry. In the end, a conceptual roadmap to a high level of digital maturity for the logistics sector has been created. The maturity model and logistics roadmap are considered to be valuable tools for the Dutch logistics sector and provide insights into the process, requirements, challenges and/or risks to achieve a high digital maturity level.

Keywords

Digital transformation, digital maturity, digital roadmap, logistics sector.

1. INTRODUCTION

In the last century, there has been a significant rise of digital technologies and their rapid launch into the market. The way organizations are managing their processes is changing because of it. The use of digital technologies has a big influence on business performance, profitability, and competitiveness.

The first big change that can be seen is digitization, the process of converting information from analogue to digital. Nowadays, our society is enormously information-driven, in fact, we have become completely dependent on it. Digitization makes the connection between the physical and the digital world [10, 22].

The next shift in business processes is digitalization, using this digitized information can improve the efficiency and effectiveness of a company by developing new organizational procedures or business models. The use of digitalization can move a business into a digital business [22, 23].

In the last decade, we do see a third shift appearing more often where using technology is creating new ways of doing business to drive growth in new and existing markets. Digital transformation is the integration of digital technologies into all areas of a business and is changing the ways companies conduct their business [10, 15, 22].

The development of digital technologies is a current topic for all industries, for this research paper the focus will be specifically on the logistics sector. In this fast-moving and world covering sector, the use of digital technologies can provide big opportunities [4, 14]. Applications like Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS) and Transportation Management Systems (TMS) can have a big impact on business performance, profitability and competitiveness.

Recently, a study was conducted on digitalization and data use among organisations in the Dutch Logistics sector [26]. Although it was concluded that digitalization "lives" and most companies can not run without digital technologies, it shows that there is a big difference in the use of these technologies. Less than 60% has a TMS, around 30% operates using a WMS and only 20% of the organisations used an ERP.

Another conclusion was that most companies, more than 65%, are considered "followers" because of their lack of innovation [26]. They are shown to have a 'wait and see attitude' in the field of digitalization. It was concluded that a so-called 'first-mover disadvantage' - in this case, the risk of investing too early in the 'wrong' technology - is widely felt.

Although this study shows more insights into digitalization and data use of logistics companies in the Netherlands, there is no overview yet of the state of digitization, digitalization and digital transformation which shows how far the Dutch logistics sector is and where they need to take steps to improve. Therefore the following three goals have been defined for this paper:

- Goal 1: To examine the existing maturity models in terms of digitization, digitalization and digital transformation.
- Goal 2: To discover and map the current maturity level of logistic companies in the Netherlands.
- Goal 3: To create a maturity model and roadmap to a high level of digital maturity for companies in the logistics sector.

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To achieve these goals the following research question has been identified:

What is the digital state of the Dutch logistics industry in terms of digitization, digitalization and digital transformation and what are the required steps and challenges to reach a high maturity level?

To make the research more tangible, this research question has been broken down into the next three research questions that will be used to guide this research:

- RQ1: Which maturity models exist in terms of digitization, digitalization and digital transformation?
- RQ2: What is the current digital maturity level of the Dutch logistics sector?
- RQ3: What are the required steps and challenges for the logistics companies to reach a high maturity level?

By the end of this research, it is expected to have contributed to a better understanding of the importance of digital transformation and to have developed a roadmap with the most important steps to digital transformation. The originality of this work is that it focuses on the Dutch logistics sector and gives a blueprint to digital transformation and this has not been broadly researched yet.

The remainder of this paper is divided into six parts. Chapter 2 will describe the research methodology for each next section of the research. Next, Chapter 3 entails the systematic literature review. Following, Chapter 4 examines the digital state of the Dutch logistics sector by analysing data collected in a survey about digitalization and data use. Chapter 5 discusses the development of the digital maturity model and digital roadmap. To finish, in Chapter 6 a conclusion is written.

2. RESEARCH METHODOLOGY

In the research, multiple methods of doing research will be used. First, an exploratory and descriptive literature review will be performed on digitization, digitalization and digital transformation. Additionally, there will be looked into the existing digital maturity models and digital roadmaps, answering Research Question 1. Lastly, the digital state of the logistics sector is assessed. The literature selection process is based on the grounded theory method of Wolfswinkel et al. (2013) [30].

Secondly, a statistical quantitative analysis will be performed on a data set gathered by Evofenedex from their research on digitalization and data use among organisations in the Dutch logistics sector. This data will be used to identify the current digital state of the Dutch logistics sector and, therefore, answer Research Question 2. Additionally, it will help to create a classification of levels of digital maturity.

Lastly, for the development of the Digital Maturity Model, the literature of the existing maturity models and the findings of the data analysis are combined to determine the dimensions and levels of the new model. Additionally, the guidelines of Bruin et al. (2005) will be used to determine to scope and design of the model [11]. To develop the Digital Roadmap, the literature of the existing roadmaps as well as the findings of the data analysis are combined to determine the steps of the new roadmap. This roadmap will outline the required steps for Dutch logistics companies to reach a higher maturity and, therefore, answer Research Question 3.

3. LITERATURE REVIEW

The literature review is divided into three parts. First, the research methods are described more thoroughly. The second part gives the general definitions of digitization, digitalization and digital transformation and makes a comparison. Next, the existing digital maturity models and digital roadmaps are compared. The last part dives into the digital state of the logistics sector.

3.1 Methods

First, the online literature database Scopus was used to find research papers related to the research questions. The search has been broken down into three search queries, shown in Table 3 in Appendix B.

Next, exclusion criteria for the main search query are established. The exclusion criteria are as follows:

1. The papers not written in English are excluded;
2. Papers that are not available are excluded;
3. Studies before the year 2011 are excluded

The search process procedure that was used is as follows:

1. Enter search query;
2. Apply filters for the section criteria;
3. Read title, abstract and keywords;
4. Read introduction and conclusion;
5. Select relevant studies;
6. Add papers via backward citations

Using the first search query for digitization, digitalization and digital transformation, the initial search has a result of 3.487 papers, as shown in Figure 1. After applying the selection criteria and excluding the double, 1.294 papers remain. Checking both title and abstract for relevance to the research questions resulted in 1.131 excluded. Next, the introduction and conclusion of papers were read, which led to the 54 results. Lastly, 3 extra papers were found through backward citations and were added as relevant. This resulted in a total of 11 relevant research papers.

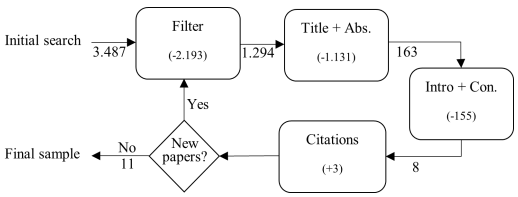

Figure 1. Selection process literature review for Digitization, Digitalization and Digital Transformation

The second primary search came up with 2.941 results for digital maturity models and roadmaps. Applying the same selection process as before, resulting in a total of 9 relevant digital maturity models and roadmaps for this research, as shown in Figure 2.

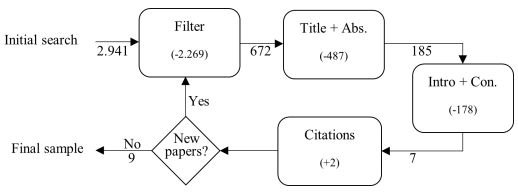

Figure 2. Selection process literature review for Digital Maturity Model and Roadmap

The last initial search, for the digital state of the logistics sector, resulted in 1.322 papers, as shown in Figure 3. Applying the same selection process as before, the result is a total of 5 relevant research papers for this literature review.

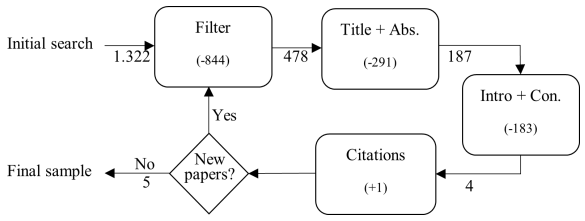

Figure 3. Selection process literature review for Digital state of the logistics sector

3.2 Digital Technologies

The terms "digitization", "digitalization", and "digital transformation" have been explored a lot. They are often used interchangeably, but it is important to note that they each have a different meaning.

3.2.1 Digitization

The term "digitization" can be traced back to the mid-1950s. According to the Oxford English Dictionary, digitization refers to "the action or process of digitizing"; the conversion of non-digital information into digital information [10, 15, 24].

It is important to note when information is digitized, it enables the decoupling of the form and function of and access to information [23]. A straightforward example of this is photography. When images were stored analogue, their form, function and access are constrained. Separating the data from the medium is not easily done, accessing the data can only be done using a specific process. In contrast, since data are digitized, this has become a lot simpler. It is shared in different formats, using different media and can be accessed via different devices. In short, digitalization is a process that produces information that can be expressed in many different ways and accessed and manipulated on many different materials and in many different systems [7].

In addition, Saarikko et al. (2020) stated that digitization also entails the capturing of physical activities and converting them into virtual representations [23]. Products and devices can obtain measurements like location and temperature as digitized data and transfer them. This way, it is possible to create a digital portrayal of a situation, something that is analogue not achievable.

When narrowing down to organisations, digitization has changed the way we are dealing with analogue information as well as analogue processes [6]. However, digitization is the converting of information, whereas digitalization can be described as the converting of processes. The two terms are strongly connected and often used interchangeably in a wide variety of research. The term digitization is often misunderstood and applied to digitalization, and vice versa.

3.2.2 Digitalization

The term "digitalization" first appeared in an essay that discusses the social implications of the "digitalization of society" in 1971 [29]. From there on, this term appeared in many others research papers. However, because many scholars have different interpretations, giving a single definition of "digitalization" is challenging. Nevertheless, there are some areas where these interpretations overlap. Most definitions are based on the process of changing organizational procedures and developing new business models [18, 15, 23]. The use of digital technologies can influence the way of working and fundamentally change an entire business model. It can be seen as the process of changing to a digital business [6, 22]. Furthermore, scholars agree that digitalization cannot be accomplished without digitization [18, 24, 20]. Nonetheless, scholars do focus on different characteristics of the definition. In the next section, three different approaches to define digitalization will be discussed.

Kim et al. (2021) define digitalization as the procedure of digitalizing a company's business activities and distinguishes three types of digitalization; process, product and service digitalization [15]. Process digitalization is the evolution of an analogue process from the real world into one or multiple digital processes in the virtual world. An example is the conversion of a face-to-face transaction between buyers and sellers into a contactless transaction on a website. Next, product digitalization refers to the conversion of physical products into digital products that can be accessed and shared in a virtual setting. Converting vinyl records into music files is a good illustration of product digitalization. Lastly, service digitalization implies the change from offering services in a physical setting to providing them in a virtual setting. Providing education online instead of in a classroom is a good example of service digitalization.

Looking at digitalization in a corporate setting, Corejova and Chinorackỳ (2021) state that it takes place in three phases [10]. The first phase is the selecting of a specific business process and the automation of individual activities within this process. Next, to eliminate unnecessary tasks, related activities are merged and automated. Lastly, the systems of business processes are integrated into one corporate system, for example, enterprise resource planning (ERP) software. To illustrate, a company can digitalize its whole promotion process by exchanging its physical promotion tools for online marketing tools.

Last of all, Brennen and Kreiss (2016) take a whole different approach. These researchers focus on the way people interact with each other. They defined digitalization as "the structuring of many and diverse domains of social life around digital communication and media infrastructures" [7]. Social interactions move away from analogue technologies like letter posts and telephone calls and move to digital ones like email and social media. Digitalization has significant effects as it involves the "convergence" of previously disparate segments of social life. Because of digitalization, single network can convey many forms of information. In addition, devices can merge. A good example is the smartphone, as a telephone, camera and many other devices are now combined into one. Functions can converge as well, a single system is now performing several functions instead of just one. Finally, formerly separated sectors are merged. Examples are the media and entertainment sectors.

3.2.3 Digital Transformation

Both digitization and digitalization refer to processes where companies use digital technologies to work faster and more efficiently. Digital transformation goes a step further. It requires the whole organization to change where the implementation of digital technologies is just a small element. This implementation can only trigger improvement through organizational change [16, 17].

Corejova and Chinorackỳ (2021) state that digital transformation not only takes place across businesses but also across industries and society [10]. Business models and work culture are changing, and in the end, a company uses a large number of digital technologies in different parts of the company and its business activity. As a result, businesses and economies are more interconnected. These interconnections contribute to the concept of a more globalized world economy.

According to Murmura and Bravi (2021), digital transformation is more about people than technology [18]. The adoption and use of digital technologies should enable and empower employees and help change the corporate culture. Internal support is crucial to make real improvements. Additionally, the company is required to make customer-centred changes. Kohnke (2017) adds that digital transformations can create a distance between IT and business functions, causing a significant resistance to change [16]. In order to make real changes, aligning people, processes, organizational structures and culture is crucial.

Similarly, Bloomberg (2018) describes digital transformation as "a customer-driven strategic business transformation that requires cross-cutting organizational change" [6]. Initiatives will usually include multiple digitalization projects but to achieve a real transformation, requires the organisation to deal better with change overall. Digital transformation can not be achieved by executing isolated projects. Change is considered to be the core competency as a business becomes completely customer-driven.

Looking at digital transformation from a product development perceptive, Vrana (2021) highlights the importance of enabling collaboration and connectivity [28]. There is one well-known example of this kind of digital transformation, the smartphone. It is important to note that the smartphone is not a digital transformation, but it enabled one. The connectivity between the internet and all its apps created a completely new ecosystem and it changed the way we live our lives.

To summarize, information is digitized, processes are digitalized and businesses are digitally transformed. Each one is vital to accomplish the next. Important to keep in mind, digitization and digitalization are in essence about technology, while digital transformation is not. Digital transformation is about change.

3.3 Digital Maturity Models and Roadmaps

3.3.1 Digital Maturity Models

As mentioned before, innovative digital technologies generate opportunities to improve a company's way of working and transform its business model. To constantly keep improving, it is important to identify a company's positioning regarding its digital resources [3]. However, achieving an objective assessment of a company's position proves to be a difficult task. What needs to be measured and how, and what it needs to be compared with, are a few of the questions coming up during this review. Maturity models are valuable tools to help counter these inquiries.

Characteristically, a maturity model contains a series of maturity levels for different attributes. [3, 31]. It represents a path of growth and guides advancement and identifies deficiencies in an organization [21]. The models exist of multiple stages, with the lowest stage standing for an initial state that can be exemplified by an organization having a non-existing or low level of maturity. The highest stage represents the desired state of an organisation with a high level of maturity. Dimensions can be added to a maturity model to indicate the different (business) areas within the assessment [27].

A lot of research has been done on how to classify digital maturity levels as they are seen as valuable tools to assess the current state of a company and identify valuable improvement opportunities. In essence, the idea of a digital maturity model is to show the different levels of development, often with a target. Becker et al. (2009) measure a company's IT performance, identifying six stages of maturity described by three dimensions (contents, organisation and technology) with each having five attributes [3]. Blatz (2018) calculates the digital maturity level of medium-sized companies on a scale of three levels, defined by six dimensions (Strategy & Leadership, Company Culture & Organisation, IT Infrastructure, Data Maturity, Processes & Operations and Product) [5]. Paulk (1993) analyses an organisation's software process capability in a framework of five maturity levels on an ordinal scale of 1 to 5 with two dimensions (projects and software process capability) [21]. Van der Tas (2021) observes the IT architecture focusing on digital transformation by implementing a maturity scale with levels 0 to 5 with five different dimensions (Operations & Processes, Technology, Data, Integration and Shadow IT) [27]. Zentner et al. (2021) compute the digital maturity level of SME's on a scale of 1 to 5, using three different variables (content, experience and platform) [31].

It is interesting to see that although the dimensions of these models are divergent, there is some overlap. One dimension that is obviously part of all models is technology. Organisation is also a dimension that is implemented in a few models. Other dimensions, like data, integration, processes, are observed less.

There are several similarities in the described maturity models. All of the proposed models describe the first stage of digital maturity either as non-existent or as the initial phase and highlight a need for internal support to make real improvements. The highest stage is always characterized by the advanced processing and use of data which is in line with the concept of digital transformation.

A maturity model can be descriptive, prescriptive, or comparative [27]. A descriptive model is good for assessing the as-is situation but has no provision for improving maturity. A prescriptive model gives a better understanding of the current situation and what improvements can be made and therefore enables the development of a roadmap. A comparative model enables benchmarking across industries or regions and would be able to compare similar practices. A wide range of organizations is needed in order to attain sufficient data and, therefore, make it valid.

A maturity level can be measured in two different ways, sequential and continuous. In a model with sequential stages, an organisation moves to a higher level after implementing specific enhancements. For example, Paulk defines five sequential maturity levels (initial, repeatable, defined, managed and optimizing) and specifies the appropriate behaviour of an organisation for each of these levels [21]. When using continuous stages, the company's maturity is calculated and results in a continuous value. Blatz and Zentner et al., both use a formula to compute an organisation's maturity [5, 31].

3.3.2 Digital Roadmap

With the help of the maturity models, organisations can evaluate their positioning regarding their digital resources. However, these models do not guide organisations from

one stage to the next. This is where a digital roadmap comes in. This is a blueprint for actions that will support organisations identify the next steps to take, to get to their desired state. Therefore, this section examines different works explaining how organisations need to achieve a digital transformation.

De Carolis et al. (2017) composed a 4-step methodology to digitalization [12]. During the first step, Maturity assessment, the digital maturity of the company is evaluated and defined. The second step is where a company's strengths and weaknesses are identified, based on their digital maturity. The following step is the Opportunities identification. Here, the company receives a complete overview of the advised actions to take in order to improve its processes. The maturity model has a prescriptive purpose to help create a good outline of which activities are essential to improve their business. In the last step, Digital transformation roadmap definition, the roadmap is created based on the identified opportunities. They are checked for feasibility and achievability and ranked accordingly. Finally, the company is allowed to implement the right measures to take advantage of these opportunities.

Schallmo et al. (2017) created a 5-phase roadmap to digital transformation [25]. In the first phase, Digital Reality, the company's current business model is outlined. This provides an overview of the current digital state of the company in different areas. In the next phase, Digital Ambition, goals for the new business model are defined. These objectives are regarding time, finances, space, and quality in combination with digital transformation. The third phase, Digital Potential, establishes the best practices and enablers. This serves as a starting point for the design of a future digital business model. During the following phase, Digital Fit, the design of the digital business model is examined to ensure that customer requirements are fulfilled and business objectives are achieved. In the last phase, Digital Implementation, the new digital business model is finalized and implemented.

Similarly, Brozzi et al. (2021) developed an Industry 4.0 roadmap service containing five phases, self-assessment, design thinking, scenario planning, project development, implementation [8]. In the first phase, the company's digital level is assessed via a survey identifying existing challenges. The next phase consists of a workshop covering the results of the assessment. During this workshop, the problems within the company are identified and possible solutions are proposed. The third phase considers the different solutions and turns them into scenarios. They are validated and a selection is made of the most promising scenarios. During the following phase, an implementation strategy is proposed that includes the timeframe and internal resources needed, indicated objectives and expected results. In the last phase, the defined I4.0 strategy is implemented.

Lastly, Van der Tas (2021) designed a roadmap to guide organizations during their Digital Transformation. [27]. The roadmap consists of nine phases; Creation of awareness and support, Definition of scope, Identification of business activities, Maturity assessment, Identification of strengths and weaknesses, Opportunities identification, Roadmap definition, Development & Implementation and Evaluation. He states that digital maturity is not a static concept as the digital landscape is continuously changing. Therefore, the roadmap is an iterative approach.

Although the number of steps and their labels in these roadmaps are divergent, there is a lot of overlap. An interesting finding is that all approaches seem to assume that knowledge and expertise are already present. Furthermore, all approaches include an assessment of the digital state of the company, the identification of their strengths and weaknesses and defining and implementation of the roadmap. While the approaches have different outlines, all can be summarized in three fundamental and crucial pillars forming the roadmap to maturity; evaluating, strategizing and implementing.

3.4 Logistics sector

The process of digitalization and the use of digital technologies are essential tools for the desired transformation of companies [2, 19]. This also applies to the logistics sector. They allow companies to strengthen performance, optimize capacity, improve quality and at the same time ensure the flexibility of the whole chain. Additionally, it creates new business possibilities that were not possible in a non-digitalized state. The digital transformation of processes and the implementation of new technologies collectively referred to as Logistics 4.0.

3.4.1 Logistics 4.0

At the end of the 19th century, logistics only concerned the physical distribution of goods. The invention of electric power and mass production lead to Logistics 2.0, which focussed on the automation of the supply flow. The third evolution, Logistics 3.0 was triggered by the development of computers and IT technology. Logistics 4.0 entails the rise of "smart" technologies, coming from the acronym "Self-Monitoring, Analysis and Reporting Technology" and encompasses the development and integration of innovative digital technologies into the logistics industry [2]. This fourth revolution entails flexibility of industrial operations and their interoperability, integration with partners and the adoption of new innovative business models [1].

Logistics 4.0 is constructed on two main pillars, digitalization and exponential technologies [13]. The first main pillar, digitalization, is the process that enables the communication and cooperation between people, machines, products and logistics systems. The second pillar on which Industry 4.0 is built is the application of exponential technologies. Exponential technologies are technologies that help to increase the productivity and efficiency of a company. Examples of these technologies are sensors, ICT and mobile technologies, artificial intelligence and advanced robotics. Many of these technologies become a part of daily work in the logistics sector.

Additionally, Logistics 4.0 aims to create a transparent ecosystem, in which all the systems involved can share important data [9, 19]. For companies to operate efficiently, people, machines, sensors, and devices have to be able to share the data. This will create end-to-end visibility and control as well as provide useful insights to support top management decisions.

3.4.2 Digital Transformation in the Logistics Sector

In order to apply the principles of digital transformation to the logistics sector, it is important to understand the digital processes that an efficient and strong logistics organization must rely on.

Barreto et al. (2017) define that at least the five technological applications, Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Intelligent Transportation Systems (ITS) and Information Security (IS) have to be in place to be a Logistics 4.0 or smart logistics organi-

zation [2]. The ERP management processes boost the overall productivity, agility and flexibility to the changes that might occur in the supply chains. A WMS transforms a company's warehouse activities by creating complete alignment and coordination between all the value chain phases. A TMS interacts with an order management system and the distribution centre or warehouse, integrates with other supply chain technologies (like WMS) and can handle electronic communications with partners. An ITS is a system that operates in different fields such as transportation management, infrastructure and control and adopts new technologies like positioning systems, sensor technologies, data processing and planning techniques. Lastly, IS is one of the most crucial requirements as companies need to protect their data because new technological solutions can carry vulnerabilities and security risks.

Nagy et al. (2018) characterize four attributes for Logistics 4.0, the networking of smart production systems, the integration through value chain networks, the through-engineering across the entire value chain and the acceleration through exponential technologies [19]. The networking of smart production systems requires collecting all generated data and complete information integration in order to develop smart technologies that manage the entire supply system. The integration through value chain networks allows to dynamically manage factors such as quality, price and time, and therefore, creates transparency and high levels of flexibility in order to react faster to upcoming problems. Next, through-engineering is exemplified by the fact that data is available at all stages of the supply chain, allowing more flexible data. Lastly, the acceleration through exponential technologies allows customized solutions and flexibility in the supply chain process which can result in cost reduction.

The complexity of the logistics system and its underlying processes can be seen as substantial barriers to a digital transformation [9]. This transformation is different in the logistics sector from e.g. the telecom business because it isn't taking place only in virtual reality as the flow of goods must be organized in the analogue world.
Another barrier is the lack of resources in most logistics companies. Many businesses struggle with shortages of digitally skilled employees. Additionally, digital projects require significant up-front financial investments, but the payback can take a long time.
Irrespective of the logistics sector, resistance to change is one of the most frequently mentioned barriers to digital transformation in general, in particular with successful companies.
The last but crucial barrier regards data protection and security breach [2, 9]. The implementation of digital transformation requires strong integration among various applications and information systems. Sharing of company data imposes a particular focus on protecting this information. Protection against data breaches or unauthorized access has to be managed properly.

Additionally, several success factors and leading practices for digital transformation are identified. The number one success factor is leadership [9]. Leadership provides execution and very strong governance. A clear vision is extremely important especially in a highly distributed sector such as the logistics sector. If the objectives and the understanding of the consequences for the whole organization are not clear from the beginning, the outcome could be disappointing.
Developing a favourable organizational culture is another key success factor. The organizational culture defines how a company operates and how it introduces changes. Engaging employees of all levels in proactive continuous bottom-up initiatives can improve the workplace and its operations and allow the company to perform better for its customers. Employee and partner engagement is a critical factor to the success of the transformation. Early buy-in on all levels of the organization ensures focus on the digital transformation process, stimulating teamwork and developing a "growth mindset".
Process standardization and data integration can contribute to reducing the complexity inherent to the logistics sector. Particularly simplification in a highly distributed service business is not evident. It cannot be dictated, but only encouraged for mutual benefits.
Agility to reallocate resources and get reorganized rapidly, in order to respond to customers' volatile demands and increasing market dynamics, was recognized as a success factor. When introducing a new service based on a technological innovation, being agile benefits.
The final success factor relates to collaboration with technological companies to enhance knowledge for e.g. the introduction of process management systems like ERP, TM or WMS, cooperation on working out industry standards.

4. DATA ANALYSIS

In the previous section, articles were discussed claiming digital processes are crucial in an efficient and strong logistics organization. In this chapter, data collected from a recent survey from Evofenedex on data use and digitalization in the Dutch logistics sector is analysed to identify the current digital state of Dutch logistic companies.

The survey was completed by 206 respondents. Some questions made use of exclusion criteria which changes the number of answers. The data will not be generalized but only used to describe the state of digitalization and data use of the Dutch logistics sector as this research was performed only on companies in this country and sector.

The data analysis is divided into three sections. The first section shows the collection and use of data and is part of the first digital change, known as digitization. The next section identifies the use of software systems and is part of the second digital change, known as digitalization. The last section outlines the mindset, knowledge and decision-making of the people within a company, an important part of the last digital shift, the digital transformation.

4.1 Collection and Use of Data

The use and collection of digital information within the logistic companies are reviewed. The survey shows that 90% of the respondents collect certain data. This is used to i.e. report results, support decision-making and point out deviations as shown in Figure 4. What is interesting to note is that only a fourth of the respondent notes that they have full access to all desired data as displayed in Figure 9 in Appendix A. 18% state that for their business this is not or hardly the case.

Five of the 10 companies gathering data utilize more the one system to obtain it. 52% of these companies also use a tool to combine and analyse this data. Unfortunately, there is no information about what type of tool this is. The majority of the respondents do not register certain data in the used software systems. For 25% of the businesses, this is the case for the transport operations, other responses are depicted in Figure 10 in Appendix A.

Next, the data sharing within the Dutch logistic companies is explored. As mentioned before, nine out of 10 respondents collect and also use data. Three fourth of the

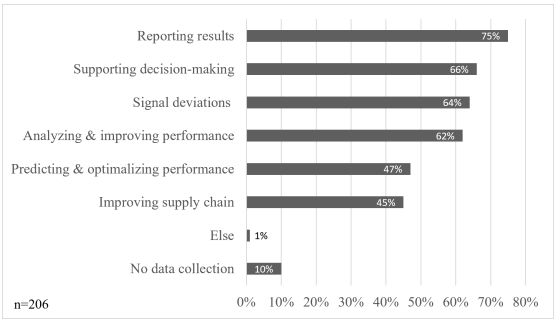

Figure 4. Reasons for collecting data

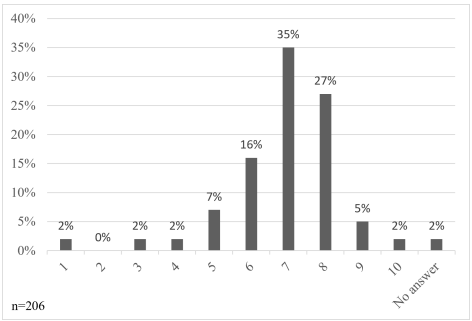

Figure 5. Grading of digital basis

respondents collecting data reveals that they also share their data with partners, mostly logistic partners and customers as shown in Figure 11 in Appendix A. More than 50% states that with at least half of these partners they share via automatic data links as presented in Figure 12 in Appendix A. These data links are mostly custom-made by their own IT departments or a supplier.

4.2 Software Systems

Next, the use of software systems is assessed, depicted in Figure 13 in Appendix A. 93% uses software systems for logistics planning and operation, Microsoft Excel is the most used software with 65%. More than half of the businesses use an ERP system. Management systems for warehouse (WMS), transport (TMS), inventory (IMS) and documents (DMS) are used by 20% – 30% of the respondents.

The majority of the respondents state that their processes are unique and that, therefore, standardized software systems do not fit. More than a quarter declares they use a custom-made software system for logistics planning and operation.

Looking at the connectivity between the used software systems, the survey indicates that six out of 10 respondents are required to rewrite digital information from one application to the next. The most common reasons for retyping stated by respondents are logistic and customer communication, further elaborated in Figure 14 in Appendix A.

Another interesting finding, presented in Figure 15 in Appendix B, is that only one out of 10 companies works (almost) completely paperless. 78% tries to use less paper but can not work without. 12% uses nearly only paper. Two out of five of these businesses intend to work (partially) paperless.

4.3 Digital Mindset, Knowledge and Decision-making

To finish, the digital mindset, knowledge and decision-making within the logistics companies are assessed. When asked what the respondents think of their digital basis, the result of on average a seven out of ten. Around two-thirds give their business a seven or higher, shown in Figure 5.

When questioned about the digital mindset, we see that digitalization has become more important in several aspects over the last five years. Eight out of ten respondents state that the mindset of both management and employees has become more digital. 70% suggest that their company has become significantly more data-driven and two-thirds notices that digitalization is a theme within the annual plans.

In addition to the mindset, the gathering of knowledge has been assessed. Almost eight out of 10 of the respondents indicate that they gained their knowledge of digitization through experience within the company. In comparison, approximately a quarter have followed one or more training courses to gain knowledge about digitization. The software supplier plays relatively the most important role in the way in which knowledge is kept up to date. Other answers are visits to trade fairs or webinars, sparring with other companies and reading professional literature, mentioned by about a third of the respondents, as shown in Figure 16 in Appendix A.

Looking at the investments, the survey shows that more than 60% of the respondents think they invest enough in digitalization. Getting more overview of the ongoing processes and the high return of investment are the most common reasons to invest. Of the 20% that state they do not invest enough, half reason they do not have enough time to make more digitalization changes, other reasons are the lack of knowledge, having no budget/too high costs.

5. DESIGN & DEVELOPMENT

5.1 Scope and Requirements

In this chapter, the digital maturity model and roadmap is designed using some of the guidelines of Bruin et al. (2005) combined with knowledge acquired in the literature review [11].

The focus of both the model and the roadmap, as shown in Table 1, has a domain-specific focus. The maturity model's scope is logistics organisations and evaluates the digital maturity at these organisations. The development stakeholders are practitioners since they are going to use the maturity model but it is good to note that the model is developed scientifically. The maturity model has a descriptive approach as the aim is to establish the current digital state. The roadmap has a prescriptive approach since the goal is to guide organisations to a high level of maturity.

Criterion	**Characteristic**	
Focus of model	*Domain-Specific*	General
Development	Academia	*Practitioners*
	Government	Combination
Approach	Descriptive	Prescriptive
	Comparative	*Combination*

Table 1. Scope of the maturity model and roadmap

Looking further into the design of the model and roadmap, also displayed in Table 4 in Appendix B, the audience is internal, the employees of a logistics organisation. The application method is a self-assessment. The driver of the application is external since this research identifies a gap

between practice and literature, as it is found that organisations are not aware of their digital maturity or how to improve it. Respondents are mainly management because it is most relevant for them. The last consideration is the representation of the maturity stages. The model focuses only on the digital state of a logistics organisation and therefore has a single region. Because the model addresses several areas within this digital state, the model has multiple entities.

5.2 Development of the Digital Maturity Model

In the development of the Digital Maturity Model, the literature of the existing maturity models and the findings of the data analysis are combined to determine the dimensions and levels of the new model. Next, this section proposes a complete description of the model.

5.2.1 Identifying relevant dimensions

The first dimension will be Technology & Applications and assesses the technological resources of a logistics organisation. As discussed in the literature review, digital technologies have a lot of benefits, they help organisations to work faster and more efficiently and can result in cost reduction. Additionally, this section reveals that technology is observed as a dimension in multiple existing maturity models, like the ones of Becker et al. and Van der Tas. Elements of this dimension are also covered in the 'Software Systems' segment of the data analysis. IT security is another critical aspect as new technologies can carry vulnerabilities and security risks.

The second dimension is Data and evaluates how data is collected, stored, processed and shared. As the amount of data increases, the collection, storage, processing and sharing of data become more important. In addition, the quality and protection of data are assessed, as data is valuable and needs to be secure. This dimension relates to the 'Digitization' section of the literature review and corresponds to the 'Collection and Use of Data' section of the data analysis.

The next dimension, Organisation, relates to the implementation of projects within a logistics organisation and is discussed by almost all existing models. As argued in the literature review, for a logistics organisation to achieve a digital transformation, they need more than only the implementation of digital technologies. To make real changes, the aligning of people, processes, organizational structures and culture is necessary. Therefore, the mindset of the people within a logistics organisation, ways of gathering knowledge and the strategy, leadership and decision-making process, also discussed in the last section of the data analysis, will be an important element.

Lastly, the dimension of Integration is about the integration of different systems and connectivity with partners and evaluates the overall design of the IT infrastructure. For businesses to operate as smooth as possible it is crucial that their systems are interconnected. In addition, the link with partners or customers simplifies the sharing of data. As discussed in the literature review, an infrastructure that is capable of storing, processing and sharing data, within the company but also to the outside, is crucial as the amount of data keeps increasing.

A detailed overview of the selected dimensions is shown in the figure below.

5.2.2 Identifying Maturity Levels

In Table 5 to be found in Appendix B, the maturity levels from the three digital maturity models with sequential stages are shown. The other two models are not mapped as their levels are not named. It is interesting to see that although the dimensions of these models are divergent, the levels are almost the same. One difference is that some maturity models start at level 0, the other starts at level 1. This level 0 implies that there are no initiatives to realize a digitalization or digital transformation yet.

For the Digital Maturity Model, a maturity scale from 0 to 5 with sequential stages will be used. Level 0 will be included, as it is important to have a starting point for organisations that have not started with digitalizing. Table 2 shows a complete overview with a description of the levels.

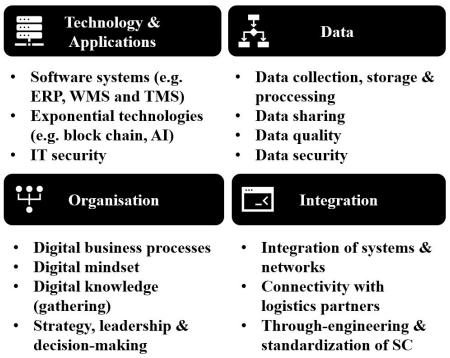

Figure 6. The dimensions of the Digital Maturity Model

Level		Description
0	Non-existent	No digitalization existent.
1	Initiating	A digital mindset established, first digitalization steps taken.
2	Enabling	First digitalization projects in place and future digital transformation plans defined.
3	Integrating	First initiatives for integration within the organisation in place.
4	Managing	The ongoing business processes understood and controlled.
5	Optimising	Business processes getting continuously improved, complete end-to-end connectivity.

Table 2. The maturity levels of the Digital Maturity Model

5.2.3 The Digital Maturity Model 1.0

The previous section identified the dimensions and levels for the logistics digital maturity model. The levels and dimensions are combined in a two-dimensional framework. Each element defines the capabilities required for that specific dimension's maturity level. Each level builds on the previous one. It is possible for organisations to be at different levels among the dimensions. The columns of this model represent the four dimensions selected for the logistics sector as shown in Figure 6, the rows serve as the six maturity levels as described in Table 2.

Figure 7 shows the complete Digital Maturity Model, also attached in full size in Appendix C.

As an illustrative example, the maturity model was applied to the Dutch logistics sector using the results of the data analysis. The determined levels are highlighted in the figure below. The Dutch logistics sector scores in the Technology & Applications and the Data dimension a maturity level of 3. The majority has implemented management systems and shares some data with their partners. Because the mindset of both management and employees is becoming more digital and companies are getting more data-driven, the sector scores a maturity level of 2

in the Organisation dimension. Lastly, it scores a maturity level of 1 in the Integration dimension as the majority has started integrating some of their systems but is still rewriting digital information from one application to the next.

Level		Technology & Applications	Data	Organisation	Integration
0	Non-existent	No use of software systems.	No data collected.	Non-digital mindset, little digital knowledge present. Business processes are not digitally supported.	No integration implemented.
1	Initiating	First use of software applications, like Excel. Only for personal use.	Some data is collected but quality is low and no security in place.	Management open to digitalization and starts gathering information. First initiatives to digitize business processes in place.	First integrations between software systems on a user level.
2	Enabling	First systems in use to access and visualise data. First implementation of IT security.	Some data is collected and used for analysis, first security in place.	Digital mindset, less employee resistance. Knowledge gathering activities.	Integration between multiple management systems within a department.
3	Integrating	Management systems, like ERP, TMS and WMS, in place. Improved level of IT security.	First data is shared with partners. High level of security in place.	Digitally minded business processes. Considering partners during improvement plans.	Integration of multiple systems between divisions.
4	Managing	Systems for data analysis in use. Advanced level of IT security.	Data-driven decision-making, data is of high quality.	Digital strategy in place. Use of real-time data to make decisions.	Systems are organisation-wide fully integrated.
5	Optimising	Use of advanced algorithms and real-time optimisation of processes. A high level of IT security.	Autonomous data-driven decision-making. High level of data sharing.	Continuous improvement of business processes, high cooperation with customers and suppliers. Continuous knowledge gathering.	Full integration throughout supply chain, end-to-end connectivity with partners and customers.

Figure 7. Digital Maturity Model 1.0

5.3 Development of Roadmap to Digital Transformation

With the help of the new Digital Maturity Model, organisations can assess their current digital state. However, the goal of the paper is to determine the required steps and challenges for a logistics organisation to reach a higher digital maturity. Therefore, this section discusses the development of a roadmap that guide organisations to a higher digital state.

5.3.1 Identifying relevant steps

The roadmap is based on the four prescriptive digital roadmaps found during the systematic literature review. Section 3.3.2 discusses the roadmaps in more detail. Table 6 in Appendix B shows an overview of the proposed steps of the existing roadmaps.

The Digital Roadmap will consist of six steps. Additionally, the roadmap has been given an iterative approach as it is important for organisations to continuously improve their processes.

In the first step, the digital maturity of the organisation's is assessed. The organisation uses the developed Digital Maturity Model to get a valuable overview of the "as-is" situation for each of the dimensions.

The second step covers strategizing and defining the target state. The developed Digital Maturity Model can be used to assess and improve a single process or evaluate the digital maturity of a specific department, division or whole organisation. It is important to identify a common goal so there are no diverse expectations. Furthermore, the company should make a clear strategy to achieve this goal, which includes annual planning and investment policies.

Digital transformation is about change. To make real changes, people, processes, organizational structures and culture should be aligned. Therefore, the third step is about creating digital awareness and support throughout the organisation. Management and employee engagement is a critical factor to the success of a transformation. In addition to having a digitally open mindset, it is crucial that all parties are digitally educated and have the right process and project management skills.

Next is the selection and implementation of technologies based on the previously chosen strategy. Depending on the target state, this step could include the roll-out or acceleration of exponential technologies such as advanced automation, AI and blockchain.

The fourth step includes the integration of data and the interconnectivity with business partners within the supply chain. As mentioned before, standardization and data integration can reduce the complexity inherent to the logistics sector. Data integration creates transparency and high levels of flexibility in order to react faster to upcoming problems. Furthermore, enabling collaboration and connectivity with partners and customers is crucial as it simplifies the sharing of data.

Lastly, the approach and implemented solution are evaluated. The organisation identifies all challenges and limitations experienced during any of the steps. In addition, they examine if the solution improved the digital maturity.

5.3.2 Digital Roadmap 1.0

The previous section identified the steps for the logistics digital roadmap. Each element defines the tasks required for that specific step.

Figure 8 shows the developed Digital Roadmap. Appendix C displays the roadmap in more detail.

Figure 8. Digital Roadmap 1.0

6. CONCLUSION

In this paper, a systematic literature review resulted in a comprehensive overview of the maturity models focussing on digitization, digitalization and digital transformation.

In a descriptive statistical analysis the digital state of the Dutch logistics sector was determined. It was found that the majority of the Dutch logistics companies have implemented management systems and share the first data with partners. In addition, companies are getting more data-driven and the mindset of both management and employees is becoming more digital. In terms of integration, it has been found that most companies lack innovation and a real digital transformation has not happened yet.

The developed maturity model can support companies that want to assess that digital state. The created roadmap should provide them with valuable insights into the process, requirements, challenges and/or risks to achieve a higher digital maturity level. Both the model and the roadmap find their originality in that it is specifically developed for the Dutch logistics companies.

For future research, there should be a more detailed survey in regards to the determined dimensions of the maturity model. Furthermore, a validation of both the model and the roadmap can be performed by practitioners of the logistics sector.

The limitations of this research are that the sample size of the used survey was relatively small. Evofenedex has 15000 members that could have completed the survey but unfortunately, only 206 companies responded. Therefore, the results could differ from the actual digital state of the Dutch logistics sector.

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APPENDIX

A. FIGURES

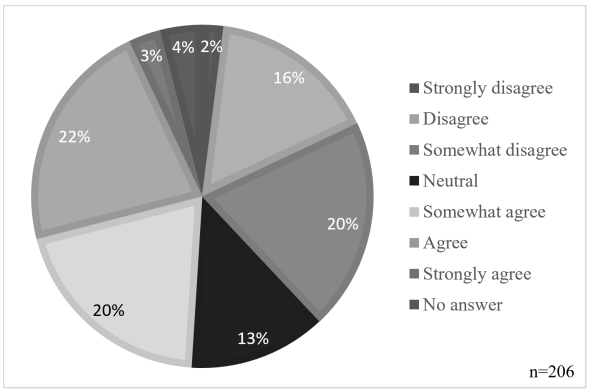

Figure 9. 4.1.1 Data analysis: Full access to all desired data

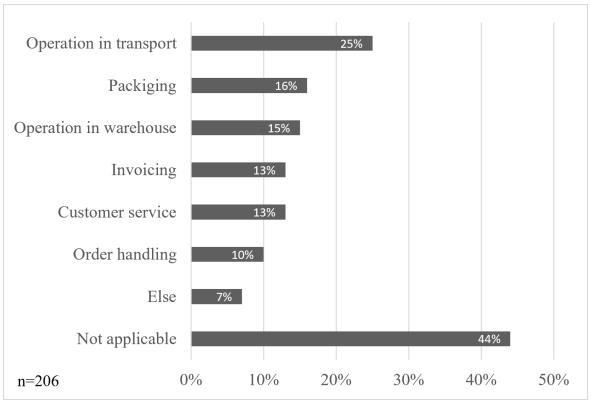

Figure 10. 4.1.1 Data analysis: Not registering data in the used software systems

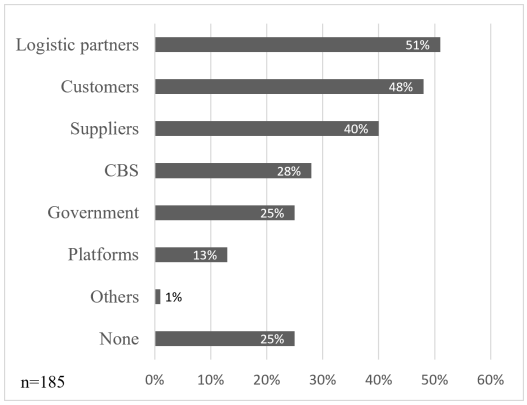

Figure 11. 4.1.1 Data analysis: Sharing data with partners

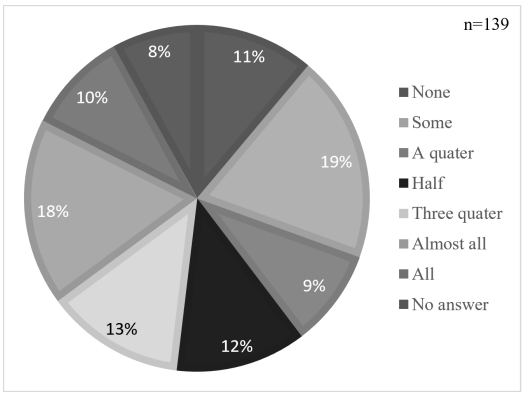

Figure 12. 4.1.1 Data analysis: Sharing via automatic data links

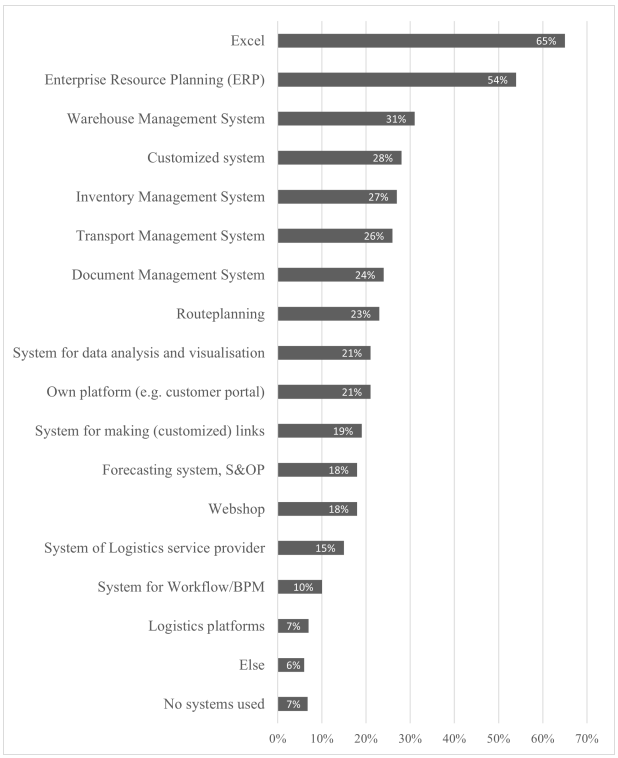

Figure 13. 4.1.2 Data analysis: Used software systems

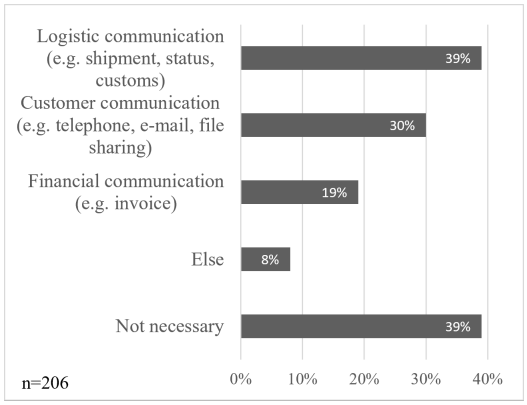

Figure 14. 4.1.2 Data analysis: Retyping information

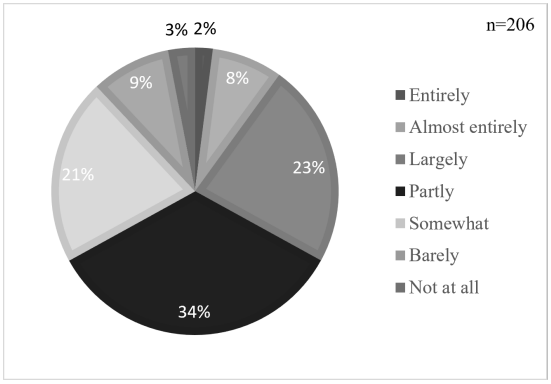

Figure 15. 4.1.2 Data analysis: Working paperless

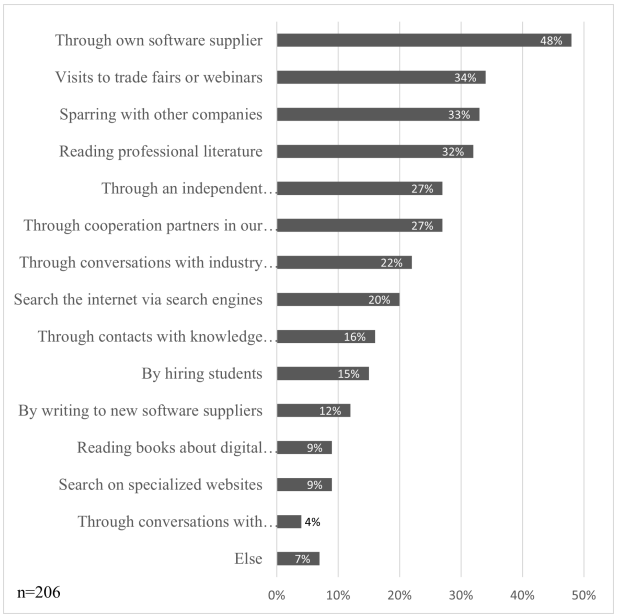

Figure 16. 4.1.3 Data analysis: Ways of gathering knowledge

B. TABLES

Literature review	Search term
Digitization, Digitalization and Digital Transformation	TITLE-ABS-KEY(digitization AND digitalization) OR TITLE-ABS-KEY(digitization AND “digital transformation”) OR TITLE-ABS-KEY(digitalization AND “digital transformation”)
Digital technologies of the logistics sector	TITLE-ABS-KEY ((logistic* OR ”transport sector”) AND (”digital technologies” OR digitization OR digitalization OR ”digital transformation”))
Digital Maturity Model and Roadmap	TITLE-ABS-KEY(digital AND (maturity AND (model OR framework)) OR roadmap)

Table 3. 3.1 Literature review: Queries used in the literature review

Criterion	**Characteristic**		
Audience	*Internal*	External	
Method of Applications	*Self-Assessment*	Third party Assisted	Certified Practitioner
Driver of Application	Internal Requirement	*External Requirement*	Both
Respondents	*Management*	Staff	Business Partners
Application	1 entity / 1 region	*Multiple entities / single region*	Multiple entities / multiple regions

Table 4. 5.1 Design of the maturity model and roadmap

Maturity model	Nr. of levels	0	1	2	3	4	5
Becker et al. (2009)	6	Non-existent	Initial	Repeatable	Defined	Managed	Optimized
Paulk (2002)	5		Initial	Repeatable	Defined	Managed	Optimizing
Van der Tas (2021)	6	Non-existent	Initialing	Enabling	Integrating	Optiming	Continuous improvement

Table 5. 5.2.2 Comparison of maturity levels from existing digital maturity models

Brozzi et al. (2021)	De Carolis et al. (2017)	Schallmo et al. (2019)	Van der Tas (2021)
			Creation of awareness and support
		Digital Reality	Definition of scope
			Identification of business activities
Self-Assessment	Maturity assessment		Maturity assessment
Design Thinking Workshop	Strengths and weakness identification	Digital Ambition	Identification of strengths and weaknesses
Scenario Development	Opportunities identification	Digital Potential	Opportunities identification
Project Development	Digital roadmap definition	Digital Fit	Roadmap definition
Implementation		Digital Implementation	Development & Implementation
			Evaluation

Table 6. 5.3.1 Comparison of proposed steps from existing digital roadmaps

C. DIGITAL MATURITY MODEL AND ROADMAP

Level		Technology & Applications	Data	Organisation	Integration
0	Non-existent	No use of software systems.	No data collected.	Non-digital mindset, little digital knowledge present. Business processes are not digitally supported.	No integration implemented.
1	Initiating	First use of software applications, like Excel. Only for personal use.	Some data is collected but quality is low and no security in place.	Management open to digitalization and starts gathering information. First initiatives to digitize business processes in place.	First integrations between software systems on a user level.
2	Enabling	First systems in use to access and visualise data. First implementation of IT security.	Some data is collected and used for analysis, first security in place.	Digital mindset, less employee resistance. Knowledge gathering activities.	Integration between multiple management systems within a department.
3	Integrating	Management systems, like ERP, TMS and WMS, in place. Improved level of IT security.	First data is shared with partners. High level of security in place.	Digitally minded business processes. Considering partners during improvement plans.	Integration of multiple systems between divisions.
4	Managing	Systems for data analysis in use. Advanced level of IT security.	Data-driven decision-making, data is of high quality.	Digital strategy in place. Use of real-time data to make decisions.	Systems are organisation-wide fully integrated.
5	Optimising	Use of advanced algorithms and real-time optimisation of processes. A high level of IT security.	Autonomous data-driven decision-making. High level of data sharing.	Continuous improvement of business processes, high cooperation with customers and suppliers. Continuous knowledge gathering.	Full integration throughout supply chain, end-to-end connectivity with partners and customers.

Table 7. 5.2.3 Digital Maturity Model 1.0

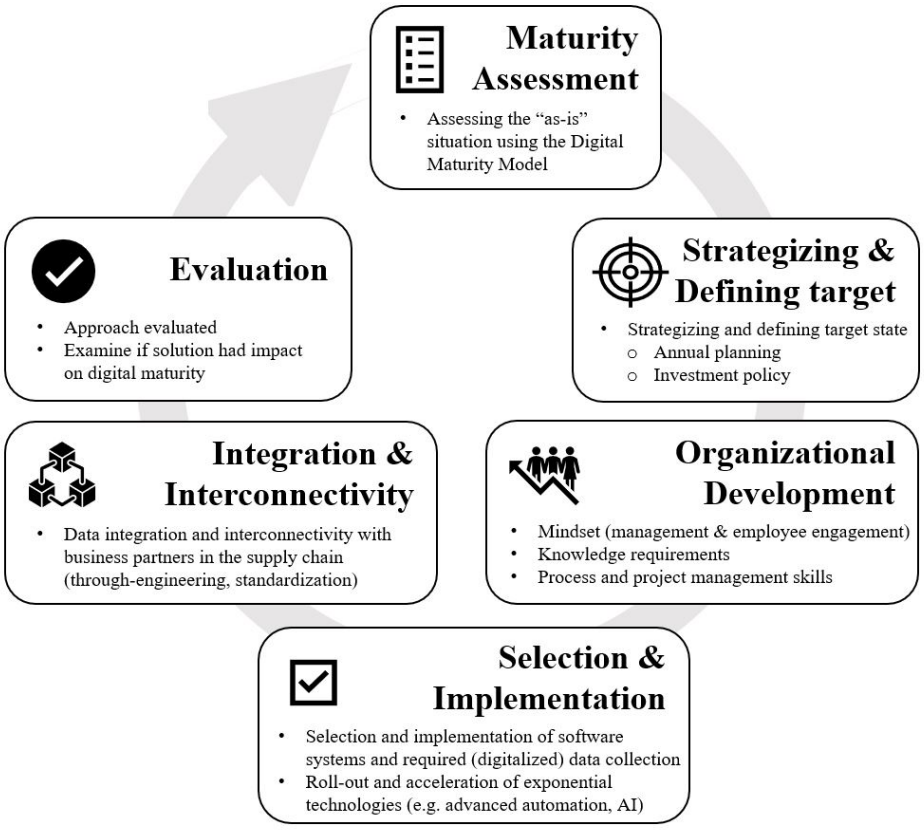

Figure 17. 5.3.2 Digital Roadmap 1.0