Design of maturity model for digitalization in retail supply chains: A case study in Ochama

MOT2910 Master Thesis Project

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Summary

With the rise of the internet, mobile technologies, and, most crucially, e-commerce, the retail industry has changed dramatically in recent decades. Emerging digital technologies, such as information and automation, have recently made it feasible for even more types of retail business to exist. One of the key strategic themes for retail businesses in Europe, and indeed the entire world, is the digital transformation of the supply chain. However, many retail representatives have only a vague idea of the exact steps that need to be taken in the digital arena. The retail supply chain does not seem to know how to measure the actual level of its digitalisation, and it is not clear whether the current digital development of the supply chain is on a good track, thus lacking guidelines for further strategy development and investment. Previous studies have shown that Maturity Model (MM) helps enable retail companies assess their level of digitization. On the one hand, MM can help companies assess the gap between themselves and competitive benchmarks. On the other hand, it can help managers to have a more comprehensive and scientific understanding of the current digital performance of their companies. MM is a great tool for both comparison with competitors and internal optimization of companies. All in all, using MM not only helps to position an existing relationship on the maturity scale but also helps to identify areas where improvement is needed to achieve a higher maturity.

Objective

The purpose of this thesis project is to design a MM for the digitalisation of the retail supply chain, which can be used to assess and position the various levels of digital development in critical dimensions to help managers make better digital strategy decisions.

Approach

The approach used in this thesis project is design-science research, which aims to develop technology-based solutions to relevant business problems. This project has gone through five main research phases. The first three phases are considered as conceptual design, or the preparatory phase before model design. In Phase-1 author reviews the characteristics of retail supply chain and proposes two important types of s. In Phase-2 author reviews and presents the definition and scope of discussion of digitalisation in this thesis project and presents the important elements of digitalisation for the retail supply chain as well as the main innovations. In Phase-3 author focuses on the concepts, components and limitations of current research on MMs by means of literature review. Based on these three phases, author summarizes their requirements for the design of a digital MM for the retail supply chain. And the model design is developed in Phase-4. In order to follow the design-science research, the designed model needs to be validated. Therefore, the designed model is demonstrated in Ochama in the fifth phase using a case study approach, which is a grocery retail company based on the Netherlands.

Contributions

A three-dimensional (3D) MM framework is proposed in the design of this thesis project, which includes 4 main components.

1. **A dimensional framework with 15 perspectives:** Focusing on business processes and management, a dimensional framework covering the intersection of two types of key dimensions is proposed.
2. **5 maturity levels:** The five maturity levels are: Ignoring, Defining, Adopting, Managing and Integrated, according to a qualitative answer to the question "To which extent does

our supply chain use best practice stated in digital perspective?".

3. **A 3D MM framework:** Based on the cross-cutting dimensional framework and five maturity levels, a overall 3D MM framework is proposed.
4. **43 maturity items and descriptions of best practice:** Each perspective is made up of one or more assessment factors that make up the maturity items, which are the targets to be measured in the assessment. Best practice is the benchmarking criterion in the measurement.

Ochama plays as the starting point to pilot the model. This demonstration is done via four structured workshops, which invited the leaders and employees from four company departments. In view of the actual business, 41 maturity items were tested in Ochama. The result is that the overall digital maturity level is in Level3- Adopting. Among them, the performance of sales is better, close to Level4- Managing, and the performance of distribution is weaker, well below Level3- Adopting.

Recommendations

The differences in maturity scores between the different subsystems in Ochama's supply chain indicate that the digital performance of companies' supply chains is uneven. Even though in some operations information technology and automation techniques have become sufficiently widespread, there are still some tasks, such as distribution, that have been neglected for digital development. Besides, Ochama as a whole neglects the optimisation of the reliability of digital technology. More attention in this point is recommended. This is reflected in many operational issues, such as the information asymmetry between the Ochama system and the outsourced system. Author considers the addition of third-party inspection as one of the possible approaches, or other similar optimisation solutions. However, author notes that the cost of R&D is one of the factors hindering improvement. This requires Ochama to take further decisions by adopting methods such as cost-benefit analysis.

In addition to this, on the theoretical side, the 3D MM framework proposed by author provides a reference for an innovative theoretical framework for the study of digital maturity in retail supply chains. Ochama proved its usability as the first case of experimenting with this model, which help to increase external validity (i.e., the results are more generalizable to other similar organizational settings). But the maturity of the designed MM is still something that need to be continuously validated in subsequent studies. In other words, Ochama is the pilot and author expects that more retail companies can be evaluated by the model in subsequent studies to help validate the quality and credibility of the model.

Contents

1 Introduction

1.1 Background

Digitalisation is a modern technique for creating a new integrated corporate system that goes beyond isolated and localized technology installations to a supply chain-wide, systematic implementation (Hofmann, Sternberg, Chen, Pflaum, & Prockl, 2019). In this thesis project, "Digitalisation" refers to the enhancement of business processes through information and automation technology (Büyüközkan & Göçer, 2018) and that can bring significant improvements to companies. Numerous analysts have referenced and approved the incredible capability of digitalisation in supply chain. In recent years, emerging digital technologies have been used one after another in the supply chain. Some have combined with the traditional supply chain to replace part of the human work, while others have realized the supply chain conformity, allowing the manners of the flows of information, materials, money, manpower, and capital equipment to be transformed. For example, omnichannel and smart retail environments present new difficulties for retailers in improving their value proposition. Simultaneously, the rising complexity and availability of technical breakthroughs necessitates a continuous assessment of technological and environmental developments in order to keep business competitive and profitable (Pantano, Priporas, Sorace, & Iazzolino, 2017). Since more and more senior executives have realized the relevance of digitalisation on their corporate performance and hence the competitive advantage of the corporation, an increasing number of them have begun to support and participate in organizations' digital efforts (Brown, Sikes, & Willmott, 2013).

Although the concept of "digitization" was introduced in the 21st century, it has only recently been implemented in actual supply chains. Thus the level of digital supply chain (DSC) development in the retail industry today is varied. Some retailers can already use big data to make more informed decisions. For instance, learning based replenishment algorithms (H. Zhang, Chao, & Shi, 2020) utilize observed demand data to help improve inventory decisions over time. Drones and R have been invested in by global merchants Amazon and Alibaba for the handling and delivery of goods (Büyüközkan & Göçer, 2018). However, there are still some traditional supply chains that rely on a mix of paper documents and electronic processes, preventing information from being shared efficiently across the organisation (Raab & Griffin-Cryan, 2011). In any case, digital transformation strategies are still the choice of most European retail companies. A recent study by McKinsey (Mckinsey, 2022) states that the strategic focus and direction in the Netherlands proper remains focused on digital breakthroughs. Also, McKinsey expects that the automation and information integration of grocery retail supply chain are one of the top 15 trends in 2022.

However, Accenture Consulting (Consulting, 2021) pointed out that current DSC cannot meet the needs of most enterprises or users, and the digitisation of the supply chain still lacks effective guidance. This lack of guidance has been accompanied by challenges in the practical application of DSCs. For example, in retail supply chain, Jabber et al. (Jabbar, Lloyd, Hammoudeh, Adebisi, & Raza, 2021) found out that the market acceptability of blockchain is not very high. Even while RFID chips and scanners are now easily available, in reach and access, the availability of technology does not guarantee its uptake. Many warehouses still run using paper at the critical locations. In other words, technical maturity alone does not guarantee the success of digitisation in a company (Berghaus & Back, 2016b), and other factors, such as the training of employees in digital knowledge, is also important. Similarly, many of the benefits of digitization in supply chains remain unexplored because critical organizational transformations and their management are frequently disregarded or postponed (Büyüközkan & Göçer, 2018).

1.2 Problem statement

As a result, how effectively promoting the application of DSC is the key to the success of enterprises. This includes how to continuously optimise costs with digital technology and improve stakeholder and customer satisfaction, etc. Besides, many challenges indicate that the DSC still requires guidance in its practical application, implying that the potential of DSC has yet to be fully realized and appropriately shown with empirical data in real-world circumstances. In the process of developing a digital strategy, the company is always busy with repositioning thinking what is the current level of digital readiness, to help them understand the phenomenon and to act as a boundary object to communicate objectives between the different parties involved (Berghaus & Back, 2016a). Based on the above-mentioned deficiencies, the retail industry needs a tool that can position its DSC level to assess the development of its supply chain to guide managers to make the right decisions on digitization.

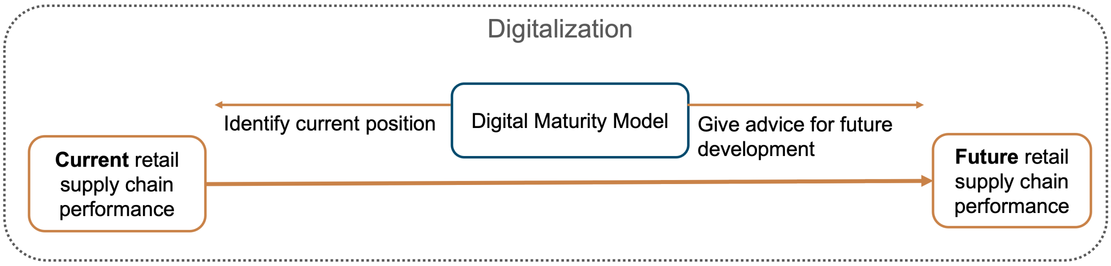


Figure 1: Overview of the research implications of DMM

MM is considered in this thesis project as a tool that can offer organizations a simple but effective possibility to measure the quality of their processes (Wendler, 2012). The MM in digital transformation, also known as the digital maturity model (DMM). DMM acts as a helpful method can assess the current state of digitalisation in supply chains and to guide companies towards development. Also, DMM can serve as a benchmark for the digitalisation process, which enable to provide frameworks to determine the direction as well as priorities for further action (see Fig1).

Although few scholars have proposed a DMM in the retail supply chain, some relevant studies on MM and DMM serve as an important reference for this thesis project. For example, Gill and VanBoskirk (2016); VanBoskirk et al. (2017) have published the fifth iteration DMM, which can measure firms' digital maturity across four perspectives: culture, technology, organization and insights. They conducted questionnaires as the research method to survey thousands of decision makers, making their DMM can be widely used in many multiple use cases. Their research does not limit the scope of the business, which makes their model well generalisable, but lacks an in-depth understanding of the business, making it difficult to be operationally helpful. As a result, scholars have proposed digital MMs in more niche business areas. In the supply chain, scholars such as Oleśków-Szłapka and Stachowiak (2018) and Sternad, Lerher, and Gajšek (2018) have successively proposed assessments of the digital maturity of Logistics 4.0. In their research, they focus on the key dimensions of information flow, material flow and management in logistics management, and eventually also use questionnaires to prove their usability in real companies. Plomp and Batenburg (2010) proposed a DMM for the supply chain that includes both technical and organisational management dimensions, and has done a maturity assessment of selected retail types in the Dutch retail industry by means of telephone interviews.

On the one hand, despite being in different domains, these studies of MMs can all be traced back to the Capability Maturity Model (De Bruin, Rosemann, Freeze, & Kaulkarni, 2005) and the components that make up the entire model are broadly the same. Usually, MMs consist of major components (Ifenthaler & Egloffstein, 2020) such as (a) maturity level, (b) descriptor for each maturity level (e.g., initial, managed, etc.), (c) a generic description of each level, (d) dimensions (and sub-dimensions), (e) evaluation areas linked to corresponding dimensions, and (f) a description of each element for each level of maturity. However, the methodology and the main research phases for developing these components have not been generalised (De Bruin et al., 2005). Furthermore, the field of digital transformation is too broad to enable the use of a MM in its prescriptive functionality, since evolution paths in digitization are not linear, and it is not clear whether a company at the highest maturity level actually performs better than its competitors (Berghaus & Back, 2016b).

On the other hand, in the retail supply chain, the selection of representative maturity assessment dimensions is a key step in the construction of the model. In similar studies, scholars have criticised the fact that some MMs lack a theoretical basis that can be agreed upon by the industry and depend only on the personal views of the researcher (Bibby & Dehe, 2018; Pacchini, Lucato, Facchini, & Mummolo, 2019; Wendler, 2012). Therefore, it makes more sense to select key dimensions of the retail supply chain in order to better assess the performance of digitalisation, which scholars hold various opinions on. For example, Banerjee and Mishra (Banerjee & Mishra, 2017), in a case study of the Indian retail industry, identified the degree of information sharing with suppliers as one of the key dimensions. Xianhai et al. (Meng, Sun, & Jones, 2011) defined eight dimensions, including "trust", "collaboration", "risk allocation" and "communication" from the perspective of supply chain management, and three sub-criteria were defined for each dimension. In addition, logistics, inventory management, labor cost, planning, process control, reverse logistics, etc. are the main dimensions of supply chain maturity discussed in recent years (Cheshmberah & Beheshtikia, 2020). As a result, there is not yet a scientific theoretical framework applicable to the retail supply chain that incorporates these key retail elements.

1.3 Thesis project objective

Based on the knowledge gap mentioned above, this thesis project objective is proposed as follows.

Design and develop the maturity model on the digitisation of supply chain within the retail sector.

With this design aim in mind, author firstly needs to clarify a series of model design requirements for this project by combining an in-depth understanding of the retail supply chain, an assessment of the direction of digitisation and a review of the current state of research on MMs by practitioners and academics. Secondly, author progressively designs and proposes a MM for this project. This includes the basic elements such as the assessment dimensions of the model, the maturity items to be tested, the maturity levels and the model architecture that makes them up. Finally, to pilot that the model proposed in this project can be used by companies in the retail industry in real business, author demonstrates their testing process and evaluation results in the Dutch grocery retailer, namely Ochama.

1.4 Ochama - A case study company

Ochama is an "Automated warehouse" hypermarket, which is a Chinese-owned company with around 120 persons in Dutch retail industry. Ochama's range of products includes fresh produce, food, households, daily necessities, electronics and beauty& care. In addition to fresh produce, Ochama has many exclusive supply chain access from Asia, such as Xiaomi. Combined with the highly automation operation, customers can buy Asian brands here at below market prices.

Ochama is also an omnichannel retailer that links their physical and online presence, which helps them link the various touch-points where customers and brands interact and ensure that information is handed over between touch-points to support a larger commercial and marketing strategy. Currently, Ochama's daily order volume across its four shops is between 800 and 1000 and currently accounts for around 7% of the market share.

Ochama aims to achieve a highly smart supply chain through the integration of information technology and automation, so that the labor cost savings can be fed back into good quality goods at low prices. It opened in January 2022 in four Dutch cities, Amsterdam, Utrecht, Leiden and Rotterdam. Ochama has no offline brick-and-mortar supermarkets, but only offers pick-up stores for customers to pick up pre-ordered items. Within 12 hours of a customer placing an order online, the goods are delivered to the pick-up store from a warehouse in Rotterdam. Customers are free to pick up their goods from the shop within a two-day period. The pick-up process is highly digitally intelligent and integrated, with the goods being picked up by robot arms at each pick-up store and delivered to the customer on a conveyor belt (see Fig2). Although Ochama also offers third-party home delivery services, this thesis project focuses on the self-pickup delivery method in order to fit the context.

Figure 2: The scene of customers picking up goods in the offline shop

It is worth noting that Ochama innovatively integrated a lot of high-tech technologies in retail supply chain. For example, in addition to the automation of the offline pickup shops, in the warehouse, Ochama is equipped with 75 AGVs that obtain the location of the goods through the QR code information on the floor and transport them to the designated work area instead of workers. Further, each container in which the goods are placed have bar code, helping Ochama to locate and trace the order status of that box at any time.

1.5 Thesis project outline

The structure of this article is as follows. In Chapter 2 author narrows down more on the specific scope of the research and presents the thesis project questions as well as the framework. Chapter 3 discusses the two critical types of dimensions of the retail supply chain. Chapter 4 discusses the digitisation and its innovations in retail supply chain. Chapter 5 takes a definitional approach and standardises the definition of MMs and the performance of different maturity levels. This is followed by a review of relevant MM studies and a discussion of the limitations. Based on the research in previous three chapters, author lists the need-to-have and better-to-have requirements in Chapter 6. In Chapter 7, based on an intersecting dimensional frameworks, the digital MM is designed. The framework and use of the model is presented in this chapter. After this chapter, author verifies the requests made earlier. Chapter8 is a demonstration of the model. This demonstration took place in Ochama, a startup retail company in Dutch that fits the research context. Chapter 9 summarizes the contributions of this thesis project, reflects on the shortcomings and presents an outlook for future research.

2 Thesis project methodology

This thesis project aims to create digital maturity models that may be applied to the retail supply chain. To create such models, many types of methodologies might be coupled. Two paradigms characterize much of the research in the Information Systems discipline: behavioral science and design science (Hevner, March, Park, & Ram, 2004). Author believes that MM designed in this thesis project should follow the design-science paradigm, which seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts. MMs are considered artifacts in this process, which aims to develop technology-based solutions to relevant business problems. This design-science research strategy requires that a design artifact's utility, quiality, and efficacy should be rigorously shown through well-executed evaluation methodologies (Hevner et al., 2004). Therefore, this thesis project decided to use case studies to demonstrate the process and results of using the model in Ochama and to try to test the validity of the model. However, author realises that the validity of the model cannot be fully assessed in this project. Compared with lab experiment, field experiments have more external validity (i.e., the results are more generalizable to other similar organizational settings), but less internal validity (i.e., we cannot be certain of the extent to which variable X alone causes variable Y) (Sekaran & Bougie, 2016). Besides, the assessment of just one company does not guarantee the quality of the model, and a larger sample of data is expected.

Author realizes the variety of retail sector and thus narrows down the research areas in Section2.1. In this section, author explains the definition of digital technology in this project, arguing that digital technology should not be limited to a specific few technologies, but rather to information technology and automation technologies that can functionally bring about advances in business performance. In Section2.2, author divides this design process into five phases in order to reach the thesis project objective. In Section8, author uses and extend the systematic step-wise framework proposed by Hevner et al. (2004), which has been developed by Becker, Knackstedt, and Pöppelbuß (2009). Finally, author gives an overview of the methodology and expected outcomes in Table2.

2.1 Thesis project scope

Retail is an extremely varied segment (Righini, 2020). In retail, supply chain systems normally consist of many different components and have different set ups. The relationships between retailers and suppliers in modern retail sectors are complex (Ge et al., 2019). In order for the retail supply chain process to be clearly structured and disassembled for analysis, this thesis project begins by standardizing the types of retail operations and the scope of activities. This scope is defined by the accepted processes of the retail supply chain by scholars in the literature review. The term retail refers to the final sale to the consumer as the customer or end user (Ayers & Odegaard, 2017). The retail supply chain enables the flow of finished goods from the supplier to the end consumer, and it includes both inbound and outbound logistics. This means that there is no manufacturing aspect to the retail supply. Therefore, this paper discusses retail activities with procurement as the starting point of the supply chain and the delivery of goods as the end point. Regardless of the form of sourcing the goods wholesale, the goods are transported directly to the retailer's warehouse, then to the offline store, and finally to the customer. Product after-sales and reverse logistics are scoped out in this thesis project. Thus obtaining the scope of application of the maturity model in this thesis project (see Fig3).

Figure 3: The general scope of retail supply chain in this thesis project

The retail sector is diverse in terms of goods and forms of selling. One can think of differences between food and non-food branches or supply- and demand-driven branches, as the logistics and specificity of the inter organisational chains differ greatly (Ge et al., 2019). In order to improve the applicability of the thesis project and to fit the limitations of the case study, instead of querying retail organizations, the types of goods involved in the MM proposed in this thesis project are mainly lower value groceries such as es fresh non-freezing food, households, daily necessities, electronics and beauty sold in supermarkets.

Technology is considered to be both a driver and a hindrance in advancing the DSC. Although scholars have been active in discussing DSCs, definitions of specific technologies being applied in DCS are lacking, and most of the discussions are on a specific digital technology or technologies. Technologies used in digital supply chains today are listed in Anthony and Matthew's study (Pagano & Liotine, 2019), including Optimization software, Sensors/Telematics, Cloud computing, Data warehouse and integration, Automated storage and retrieval, Growth technologies, Mobility, Wearability. They also categorized these technologies into mature technologies, new technologies and developing technologies by level of technological development. However, since this is a 2019 study, the classification of these technologies is no longer appropriate, so this thesis project only extend the scope of these summarized technologies as digital technologies in this thesis project.

The following summarizes the definition of the scope of this thesis project as mentioned above.

Scope 1:

The retail supply chain discussed in this thesis project is a linear process. The process starts with the supplier supplying to the retail warehouse and ends with the delivery of goods to the customer. Product after-sales and reverse logistics are also included in the activities of the final product delivery.

Scope 2:

The cooperation between enterprises and third-party logistics is not in the scope of this thesis project. The authors are concerned with the delivery process from warehouse transportation to offline stores until delivery.

Scope 3:

In this thesis project, the types of goods available to retailers are mainly daily low-value consumer groceries. Food products that require a cold chain and goods that require reprocessing are not part of the discussion.

Scope 4:

The application of digital technologies in the supply chain is designed to help companies improve business performance, and author believe that specific technologies should not be limited. But in any case all the digital technologies discussed in this thesis project are summarized as information technology and automation technology, which is fully explained in Section 4.1. The digital technologies for the retail industry discussed in this thesis project include, but are not limited to: Optimization software, Sensors/ Telematics, Cloud computing, Data warehouse and integration, Automated storage and retrieval, Growth technologies, Mobility, Wearability.

2.2 Thesis project phases and questions

The thesis project objective has been presented in Chapter1. To achieve this, author divides this design into five phases (see Fig4). The first three steps are the model's conceptual design and try to derive the theoretical needs for model design. These three phases occur concurrently. The fourth phase is model creation by author. The design-science research strategy requires that a design artifact's utility, quiality, and efficacy be rigorously shown through well-executed evaluation methodologies (Hevner et al., 2004). Before introducing it more widely, author employs an observational method to thoroughly investigate an artifact in a business setting in order to add credibility to it. The fifth stage is thus to pilot the usability of the model in a real case and to demonstrate the process.

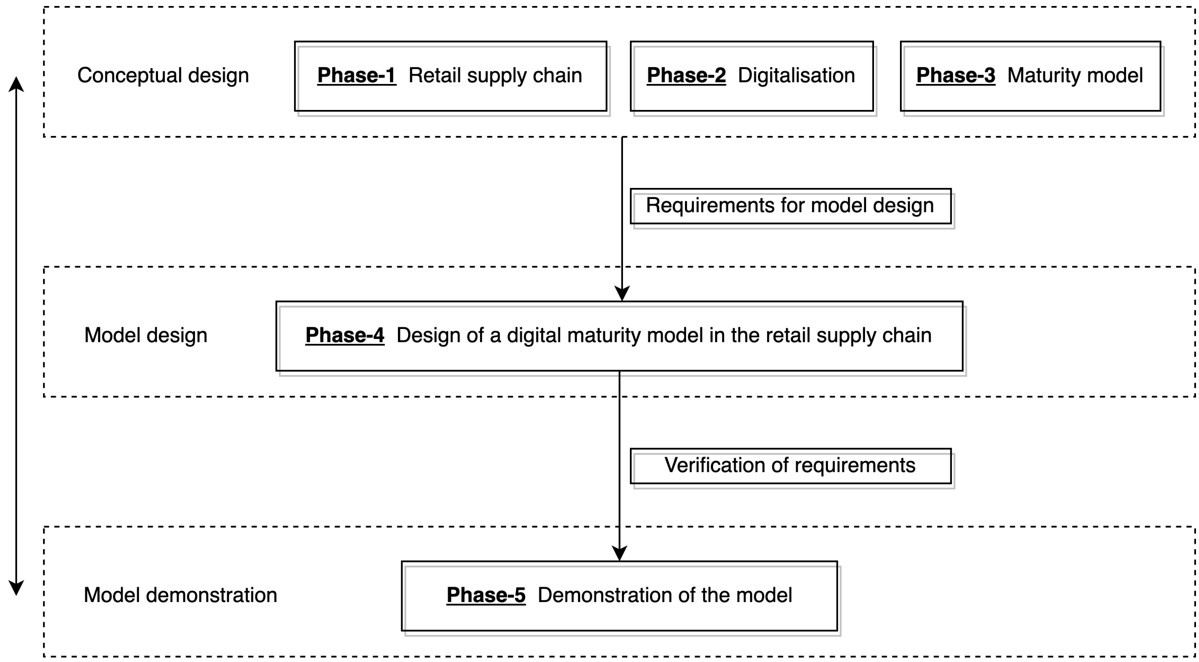


Figure 4: Thesis project phases

Then, the problems corresponding to each phase to be solved constitute the problem overview of this thesis project, which list in Table1.

Table 1: Overview of thesis project guidelines and questions

Phase-1	**Understand the characteristics of the retail supply chain and mainstream structures and activities.**
1.1	What are the characteristics of the retail supply chain compared to other supply chains?
1.2	What are the critical dimensions of the retail supply chain?
Phase-2	**Review digitalisation and innovative performance in the retail supply chain.**
2.1	What are digitalisation and digital technologies in this thesis project?
2.2	What digital innovations have been applied in the retail supply chain and in what dimensions have they improved the retail supply chain?
Phase-3	**Understand the definition, and key components of a maturity model; review current relevant models and assess limitations.**
3.1	What is the definition of 'Maturity'?
3.2	What is the definition of the 'Maturity model'?
3.3	What are the components of a maturity model?
3.4	What are the commonalities and limitations of current relevant maturity models for research on these components above?
Phase-4	**Design of a digital maturity model in the retail supply chain.**
4.1	What dimensions and perspectives are included in the model design?
4.2	What are the maturity levels of the maturity model for this thesis project? How should they be defined? What are the implications of the different maturity levels for the enterprise?
4.3	What is the maturity model framework for this project?
4.4	What maturity items need to be evaluated?
4.5	What is the method of data collection?
4.6	How will the data be calculated and processed?
Phase-5	**Demonstration of piloting the model.**
5.1	Who will be the participant in data collection?
5.2	How will the data results be presented in this project? What are the possible improvements for Ochama

Phase-1 intends to understand the characteristics of the retail supply chain and mainstream structures and activities. Author summarizes from an extensive search what are the main differences between the supply chain in the retail industry compared to other industries, such as manufacturing. The aim is to help the reader understand where the retail supply chain fits into the overall product value chain and its main business components. Then in order to make the MM proposed in this thesis project more useful for practical applications, several dimensions and corresponding perspectives that are most important for the retail supply chain are selected for discussion. In the initial literature review work, it is found that there is currently no single standard or metric for MMs in the retail supply area (Hellweg, Lechtenberg, Hellingrath, & Thomé, 2021). In terms of processes, some discuss the full process while others discuss parts. There are also different discussion perspectives for the dimensions in each process, for example, some discuss the level of digitalisation of the organizational structure and some discuss the level of technology application. This thesis project plans to summarize the prevalent DMM dimensions in retail rector based on a structured literature review. From these, the dimensions which get the board recognized are concludes into the design requirement after

Phase-3 later. Along with the understanding of the dimensions, author also generalize the areas that correspond to the assessment, i.e., which measurement objects can determine the performance on that dimension and whether their impact on that dimension is average.

Phase-2 intends to review digitalisation and innovative performance in the retail supply chain. The authors give the definition and content of digitization in this article by summarizing the definitions of digitization and digitization technology by other scholars in the literature review. The authors need to summarize the key strategic objectives in retail digitization through further literature review. In addition to this, the performance of digital innovations in the retail industry and their their improvement on critical dimensions need to be sorted out in this phase.

Phase-3 is the final step of preparation before designing the maturity model. This phase need to gain a deeper understanding of the concept of maturity models and how they are composed. This includes an advanced exploration of the term "maturity" and the concept of "maturity models", summarizing their meaning in terms of historical research development and literature. These findings lead author to be more certain that the model proposed in this thesis project meets the research directions of the field. Secondly, the conceptual definition of maturity levels and the methods used to design different levels in related studies are also discussed in this chapter. In addition to this, this phase entails reviewing the research directions of related maturity models and analyzing the limitations of them. The preparation of the first three phases helps author to present general design requirements for the next phase of the modeling study.

The fourth phase formally begins the model design phase of this project, which is based on the requirements for model design set forth in the first three phases. During the design phase, the components of the model, including dimensions, perspectives, maturity levels, model framework, and maturity items, need to be presented. Subsequently, methods of applying this model are introduced with the data collection and calculations. In the initial studies, most of them are used by personal questionnaires and interviews. However, it is worth noting that there is some error in the way interviews and questionnaires are conducted, and Meng et al. (2011) acknowledge that interviews with people sometimes receive stage effects. This is because the interviewees' perspectives may change as the work project progresses. They may have a positive view when the work project is going well, but hold a negative view when it is not. Thus Meng et al. (2011) supposed that a continuous manner to collect the findings of interview may contribute to the reliability. Therefore a more suitable method of data collection will be explored in this phase. At the end of this phase, author refers again to the requirements of the previous model design and verifies how well the designed model meets these proposals.

In Phase-5, demonstration of testing the model in a retail company Ochama is presented. The design-science research strategy requires that a design artifact's utility, quiality, and efficacy should be rigorously shown through well-executed evaluation methodologies (Hevner et al., 2004). Ochama plays a pilot in this phase of being tested. The demonstration included the process of collecting the data and the analysis of the findings. In addition to this, author believes that the demonstration of the model in Ochama also demonstrates to some extent that the model can be used in real business cases. But validity, especially external validity (Sekaran & Bougie, 2016), author realises needs to be verified with more suitable cases.

2.3 Thesis project framework

In order to study and answer the questions of the above guidelines in an orderly manner, a systematic step-by-step approach is devised for the construction of maturity models, based on the guidelines proposed by Hevner et al. (2004). The theoretical foundation for these stepwise principles for constructing maturity models comes from design science research. In earlier researchs, similar methods and approaches to building maturity models were used (Schumacher, Erol, & Sihn, 2016). Figure5 depicts the project framework used in this thesis project.

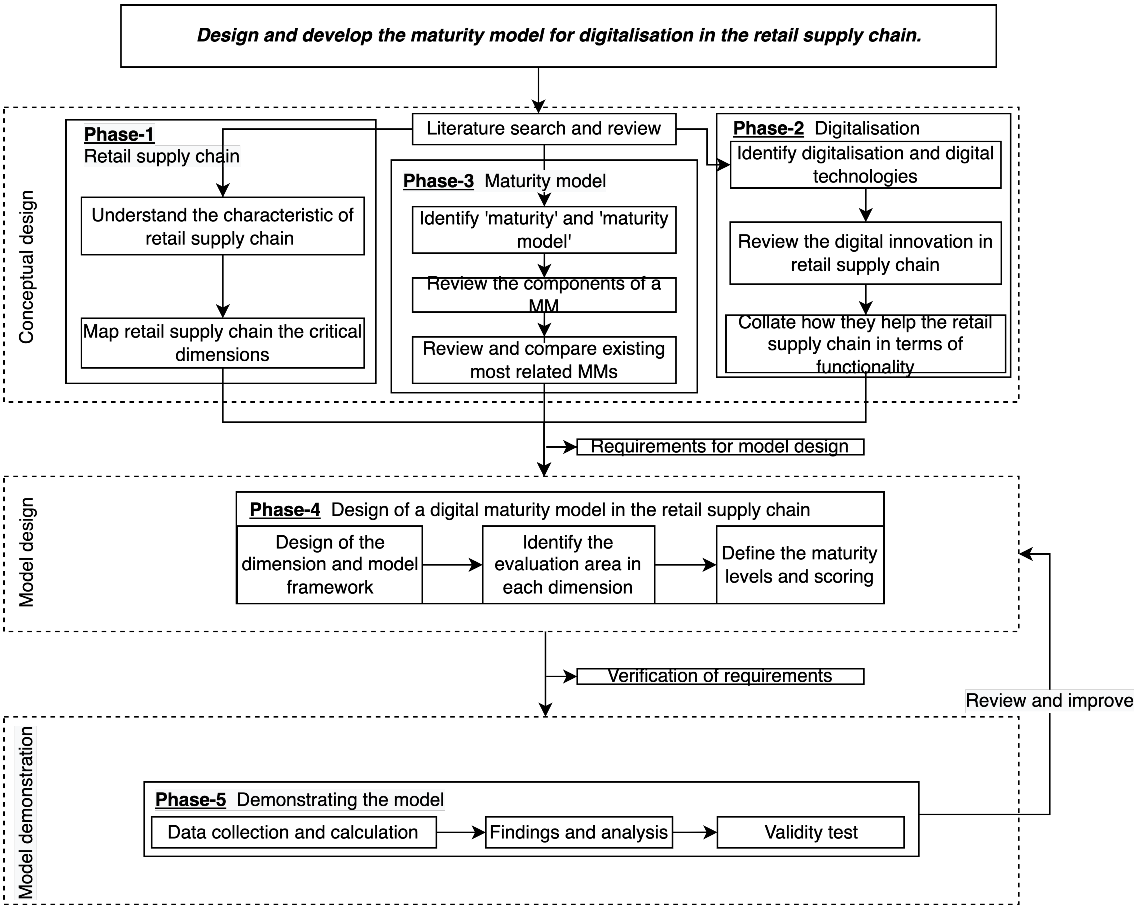


Figure 5: A thesis project methodology for the development of the maturity model.

2.4 Thesis project results

The combination of the thesis project questions in Section 2.2 and the research framework in Section 8 provides an overview of the research methodology of this study. This overview is given in the Table2. Author gives the expected results in the third column.

Table 2: Thesis project results

	Thesis project questions	**Research Instrument**	**Result**	**Presented in**
1.1	What are the characteristics of the retail supply chain compared to other supply chains?	The literature reviews the differences between retail supply chains and others, i.e. manufacturing supply chains.	An overview of the characteristics of the retail supply chain	Section 3.1

Table 2 continued from previous page

	Thesis project questions	**Research Instrument**	**Result**	**Presented in**
1.2	What are the critical dimensions of the retail supply chain?	The literature reviews the main dimensions discussed in retail supply chain management and summarizes the categories in which the discussion is focused.	The dimensions to be discussed in the model design.	Section 3.3& 3.2
2.1	What are the digitalisation and digital technology in this thesis project?	The reviews of the identifications from other researchers.	The definitions of digitalisation and digital technology in this thesis project.	Section 4.1
2.2	What digital innovations have been applied in the retail supply chain and in what dimensions have they improved the retail supply chain?	The literature reviews and summarizes the digital innovations in retail supply chains in recent years and analyzes the dimensions they contribute to.	A list of digital innovations summarized for the retail supply chain.	Section 4.3 & 4.2
3.1	What is the definition of 'Maturity'?	Query the terminology explanation and other scholars' explanation of 'maturity' in maturity model studies.	Definition and understanding of 'maturity' in this project.	Section 5.1
3.2	What is the definition of the 'Maturity model'?	The literature reviews the definition of 'maturity model' from its origin and defines what it means in the context of this project.	Definition and understanding of 'maturity model' in this project.	Section 5.1
3.3	What are the components of a maturity model?	The literature reviews the main components of maturity models.	Components of the maturity model in this project.	Section 5.1
3.4	What are the commonalities and limitations of current relevant maturity models for research on these components above?	Literature review of related supply chain maturity models and comparison of commonalities and shortcomings of the studies therein.	A list of reviews of relevant maturity models.	Section 5.2 & 5.3

Table 2 continued from previous page

	Thesis project questions	**Research Instrument**	**Result**	**Presented in**
4.1	What dimensions are included in the model design?	Design the dimension framework based on the review and requirements proposed in the earlier sections.	A dimension framework.	Figure 8
4.2	What are the maturity levels of the maturity model for this thesis project? How should they be defined? What are the implications of the different maturity levels for the enterprise?	The literature reviews the definitions of the different maturity levels in the relevant supply chain maturity models and what the different levels mean for the company.	A list of definitions of the different maturity levels and what the different levels mean for the organization.	Section 7.2
4.3	What is the maturity model framework for this project?	Combining the definition of maturity models and the industry characteristics of retail supply chain.	The maturity model framework in this project.	Section 8
4.4	What maturity items need to be evaluated?	Explore the mapping of the question 2.2 in 4.1.	A list of maturity items in each dimension and corresponding criteria.	Section 7.4
4.5	What is the method of data collection?	Through literature review and comparison of related studies on data collection methods.	The preparation process includes data collection and caculations.	Section 8.1
4.6	How will the data be calculated and processed?	Through literature review and comparison of related studies on data collection methods; define variables and calculation formulas and compare related forms of data presentation.	The preparation process includes data collection and caculations.	Section 7.5.2
5.1	Who will be the participant in data collection?	Define the participants for data collection according to the needs of the test content.	An overview of the participants.	Table 12

Table 2 continued from previous page

	Thesis project questions	**Research Instrument**	**Result**	**Presented in**
5.2	How will the data results be presented in this project? What are the possible improvements for Ochama	Suggest improvements for companies through maturity levels and their willingness to grow digitally.	An overview of the analysis of Ochama's supply chain digital maturity and suggestions for improvement.	Section 8.2

3 Retail supply chain

This chapter intends to answer the thesis questions 1.1 and 1.2 of the Phase-1.

The term retail refers to the final sale to the consumer as the customer or end user (Ayers & Odegaard, 2017). The retail supply chain enables the flow of finished goods from the supplier to the end consumer, and it includes both inbound and outbound logistics. Running a sustainable direct-to-consumer (DTC) retail business requires optimizing a good retail supply chain strategy. In order to make the MM proposed in this thesis project effective in real retail supply chain operations, author explores the definition, characteristics and two critical dimension types at the end of this chapter.

3.1 Characteristics of retail supply chain

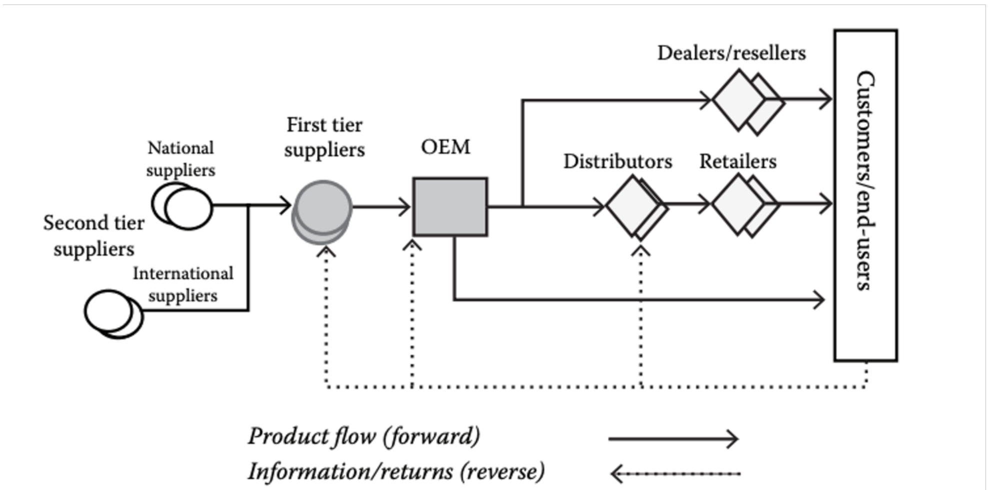


Figure 6: Retail supply chain reference model from actors perspective. (Ayers & Odegaard, 2017)

The supply chain in the retail industry is different than other industries. First, it usually has more suppliers and partners (Ge et al., 2019), which requires the retail supply chain to pay more attention to supply chain coordination. Ayers et al. (Ayers & Odegaard, 2017) proposed a reference model from the actors perspective in retail supply chain (see Fig6), which shows the simplified relationship between seven main roles: Customers or end users, Retailers, Distributors, Original equipment manufacturers (OEMs), First-tier suppliers, Second-tier suppliers and Service providers. Second-tier suppliers refer to some service providers, such as contract manufacturers. For simplicity, Service providers, such as warehouse operators, process and information technology (IT) providers, various consultants, transportation companies, trades companies, and customs brokers are not shown in the figure. Among them, Business to consumer (B2C) and business to business (B2B) transactions are two types of retail transactions . Because consumer supply chains can be extensive, they include both B2B and B2C links, such as those between first- and second-tier suppliers and merchants and customers. Secondly, retail is a B2C market. Compared to manufacturing supply chains, retail sourcing requires more attention to the changing needs of consumers. In addition, consumer demand for service quality and speed of delivery is also growing with the development of emerging technology. Finally, inventory management accounts for a larger portion of retail supply chain costs, so efficient inventory management is important to retailers. Along with these industry characteristics and development needs, the digital transformation of the supply chain is increasingly creating value for enterprises. For example, customers can now trace order delivery in real time thanks to digitized product flows (Ishfaq, Davis-Sramek, & Gibson, 2021), and retailers can more successfully execute fulfillment procedures thanks to real-time inventory information from various fulfillment nodes.

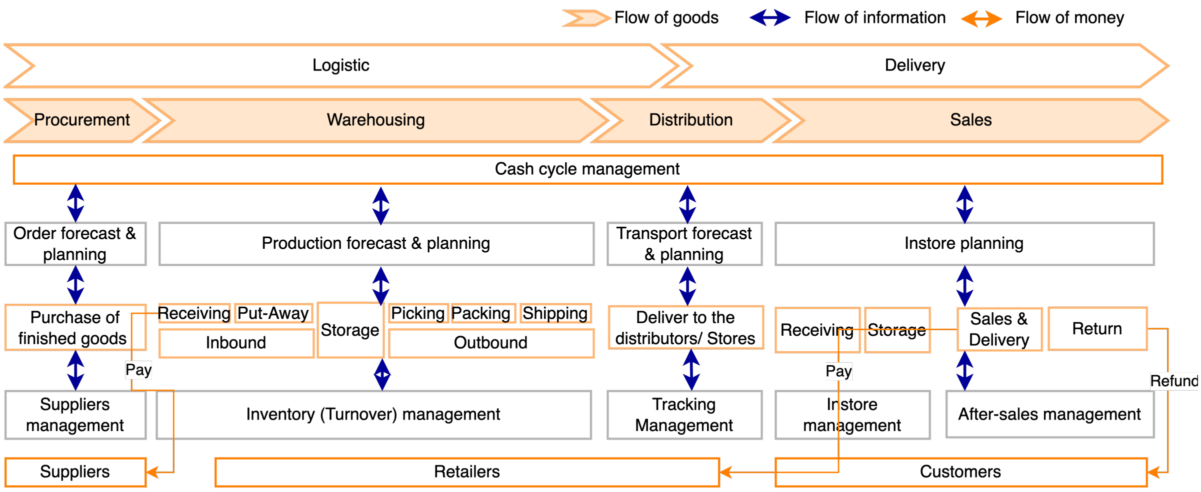


Figure 7: Retail supply chain reference model from activities perspectives.

3.2 Dimension Type I: Four subsystems

There are several moving parts that make up the entire supply chain, including supplier relationships, retail warehousing, inventory management, order picking and packing, transport and carrier partnerships, managing returns and more. As a result, retail supply chain activities frequently necessitate labor (such as warehouse workers and top management roles such as logistics directors) and supply chain technology, which can dramatically increase logistics expenses. To save time and money, many DTC brands may outsource distribution, including shipping, to a third party. Although the supply chain activities of retail receive the impact of the actual business of the company, the authors have simplified and generalised them in Figure7, which is also an extension of the generic SC framework of Hübner, Kuhn, and Sternbeck (2013). This depicts a flow chart of a retail supply chain without cold chain products from an activity perspective, for example in grocery retail. The retail supply chain can be considered as a system that can be further divided into four subsystems as follow that are interdependent but interconnected in some scope. In this thesis project, author regards these four subsystems as sub-dimensions. The delivery process between subsystems is not represented in the Figure7, but is covered within the adjacent subsystems. The interaction process between subsystems usually includes the output of the former subsystem, the transportation, and the revenue of the latter subsystem. For example, between warehousing and distribution includes warehouse outbound, third-party shipping, and distributor acceptance. The author considers the activities of input and output to be the responsibility of the corresponding subsystem, so they are covered in the subsystem. As stated earlier, in between is the fact that transportation is mostly outsourced and is not considered in the scope of this project.

3.2.1 Procurement

Procurement refers to a variety of procedures for acquiring things. Procurement teams strive to purchase competitively priced products that provide the greatest value. However, not all businesses have the same definition of procurement. Many firms view procurement to include all stages of the process, from gathering business requirements and locating suppliers to tracking items and revising payment conditions, while others describe procurement as a smaller set of operations, such as issuing purchase orders and making payments. This thesis project assumes that procurement includes selecting suppliers, negotiating with suppliers, making purchasing decisions, placing purchase orders and receiving payments. Procurement can can help boost company's profitability if managed properly and efficiently. It covers a wide range of tasks related to getting products and services, such as sourcing, negotiating terms, making purchases, tracking supply, and keeping records. It's critical to keep track of and evaluate the procurement process to identify any flaws or inefficiencies. A study by Sverige (2020) stated that lower procurement costs have been a top strategy for companies for many years, particularly in the retail sector, where investment in digital procurement is relatively high. By automating and tracking procurement procedures, technology helps cut procurement costs and administrative overhead.

3.2.2 Warehousing

Receiving, putaway, storage, picking, packing, and shipping are the six basic warehouse procedures. By optimizing these six procedures, retail managers can expedite warehouse operations, minimize costs and errors, and increase the percentage of excellent orders. For example, using power pallet trucks and conveyors in the receiving process and other fixed handling activities allow warehouse to unload cargo and clear dock areas faster and more efficiently. By accurately anticipating incoming shipments, software like labor management systems and dock schedulers allow you to properly allocate the right amount of employees. Besides, using software to guide employees through the processes can help to optimize the packing process. If a packing system has all of the essential information, such as dimensions and weight, it can automatically decide the type and amount of packaging material that will keep the object safe while keeping packing costs low.

3.2.3 Distribution

Distribution in the retail supply chain refers to the process of delivering goods from the warehouse to the customer's pickup location, which can occur before or after the customer places an order. The distribution model of a retail company is highly related to strategy, which in turn is related to product type and cost budget. The decision to distribute is a complex process and in this project the author considers omnichannel distribution in the retail industry, including both online and offline selling. The main activities involved are, among others, store location decisions in distribution and real-time tracking of merchandise status. As omnichannel purchasing becomes the standard, consumers and retailers must be prepared to provide quick, flawless omnichannel service. This will necessitate a new supply chain network strategy.

3.2.4 Sales

Sales emphasizes the final delivery of products and the process of after-sales. With the development of digital technology and the times, sales models have become more and more diverse, such as shop-in-shop, online order pick-up in-store, etc. After-sales is an important service in sales to maintain customer relationships. The definition of after-sales varies depending on the retail product and corporate strategy. The efficiency of reverse logistics is related to the user's after-sales service experience. The scope of retail sales discussed in this project does not include after-sales product repair, but only return and exchange activities. Digital retail sales can enhance the user experience, improve delivery efficiency and order fulfillment, while an efficient order management system helps control labor costs.

In Figure7, the light orange text box represents the flow of materials. The gray text box represents planning and management related activities. The blue arrow represents the information transfer from one activity to another. The orange arrow represents the money transfer from one role to another. It is worth noting that with the development of Industry 4.0 and the integration of supply chains, these activities do not necessarily occur linearly, but potentially in parallel. The order in which money flows can also change with different business models or the application of digital technology. These activities can be broken down into more sub-processes depending on the specific business, which is to be discussed in the Chapter 7.

3.3 Dimension Type II: Four flows

In addition to understanding the retail supply chain from the two perspectives of actors and activities, scholars mainly discuss the supply chain system from the sub-dimensions of information flow, material flow, money flow and management. Products flow from suppliers' suppliers to customers' customers, money flows in the opposite direction, and information flows in both directions. Organization is actually the comprehensive management of product flow, information flow and money flow. These four sub-dimensions are in parallel in most of the cases, which can cover the main activities and demands in the retail supply chain and are used in the maturity model design in later Chapter 7. In this section, the concept and current digitalisation of these four sub-dimensions in the retail supply chain will be introduced.

3.3.1 Material flow

Material flow is also regarded as the flow of goods, which represents the physical activities of products movement from suppliers to the consumers. Conceptually speaking, logistics is indeed an important part of the material flow, but not the whole material flow. Logistics is essentially the movement of a product from A to B. It does not add value to the product itself. A computer, for example, is always a computer whether it is in North America or Australia, it does not add features or perform better just because it is moved from North America to Australia. Neither does increasing inventory time or inventory location. Material flow also includes value-added processes. However, since the scope of the retail industry is the physical flow of finished goods and does not involve manufacturing and reprocessing processes, researchers believe that the material flow in the retail industry can be approximated as logistics (Kain & Verma, 2018). In most of cases, automation technology contribute more to the efficiency and cost of material flow as opposed to IT. Especially in the era of Industry 4.0, more and more automation technologies combined with the support of IT are used in the supply chain process to replace or assist part of the human work. Loebbecke (Loebbecke, 2005) provided a case study from 2002 of Metro's new concept of 'Future Store', which suggested that the use of RFID technology could enable real-time positioning of products in transit. Today, RFID applications are already being seen in the retail environment. Removable tags are used in both warehouse and offline store for track products and theft prevention (Jones, Wyld, & Totten, 2022). Further, the ability of sensing technologies, machines and people to communicate with each other through Internet of Thing (IoT) (Jayaram, 2016). Besides, other hardware supports, such as embedded technology in warehouse security system (G. Li, Zhang, Niu, & Li, 2015), visual auxiliary in inventory counts (Tu & Zha, 2021) and etc., can be integrated to improve the SC cost and efficiency.

3.3.2 Information flow

The design of information flow in supply chains has traditionally followed the physical flow along the chain (Lewis & Talalayevsky, 2004). In many circumstances, weak supply chain performance stems from a lack of information exchange. However, the deployment of advanced information systems that allow for effective information sharing among supply chain members and at all phases of the supply chain could transform this situation (Kaipia, 2009). Critical business processes of an organization are integrated through the supply chain while sharing strategic knowledge and issues for mutual benefit. The integration of organization has recently been discussed in the information management and organization literature. One of the main reasons why many researchers have emphasized the importance of information flow in the supply chain is its increasing complexity. Operating in this new complex environment, collaboration is no longer a theoretical concept, but a key aspect of supply chain organization (Madenas, Tiwari, Turner, & Woodward, 2014). The main activities covered from information flow are as follow (Singh, 1996),

1. Forecasts to reserve capacity or start production from stock;
2. Customer/purchase orders to start production or ship from stock;
3. Inventory management and tracking of goods movement;
4. Monetary settlements;
5. Management reporting;

This can be seen that the interaction between information flow and material flow is closely related, and the reliability and convenience of information system data is one of the very important factors. Traditional supply chains collect and store duplicate information at each layer. Each level has a different level of data organization and focus. However, as information about actual demand moves further up the chain from the source, that information becomes distorted. This distortion usually leads to irregularities, such as the bullwhip effect (Lee, Padmanabhan, & Whang, 1997). With the development of IT, almost every link in a company's supply chain uses IT, such as enterprise resource planning (ERP) systems for material resource management and warehouse management system (WMS) for warehouse management. However, all levels in the supply chain are dependent on the information flow of the previous level and there is a possibility of human intervention. The reliability of data transfer between systems is not fully guaranteed (Lewis & Talalayevsky, 2004). Not only information transfer within the organization, but also information sharing between organizations is important. But the importance of its impact on supply chain performance depends on what information is shared, when and how it is shared, and with whom it is shared (Kain & Verma, 2018). Many firms use Collaborative Planning, Forecasting, and Replenishment (CPFR) to not only share information with their supply chain partners, but also to collectively make decisions to improve supply chain performance. Ge et al. (Ge et al., 2019) provides a successful example of the use of CPMR between Jingdong, a leading supply chain company in China, and multiple its suppliers, demonstrating the value of information sharing in supplier management.

For a long time, people often equate information flow problems with IT problems. In fact, the information flow is not smooth, there are IT problems, but more human factors. For example, other companies are using e-mail, this company is still using handwritten letters, that is a typical technical problem. However, even with the adoption of e-mail, the company still does not share information between departments and personnel, and that is a human barrier problem. In the supply chain, companies are reluctant to share information with each other due to various business considerations. For example, suppliers fear that buyers will use the production information they provide to demand price reductions or leak it to the suppliers' competitors, which is a major cause of supply chain inefficiencies.

IT can reduce the cost and distortion of information processing and delivery, but it cannot overcome the artificial barriers between supply and demand (i.e., business problems). Business problems require business solutions, but not IT solutions. For example, the implementation of ERP systems, it is hoped that many supply chain problems will be solved, in fact, is a major reason for the failure of ERP system implementation. For example, in the 1980s and 1990s, ERP was just introduced to China, some large enterprises into ERP, hoping to solve a variety of company problems. But because of unclear business processes, departmental relationships are not smooth, most of these ERP implementations end in failure.

The biggest challenge of material flow is not production, transportation or warehousing, but the transparency of the supply chain, that is, in the supply chain, the product specifically in which link, how much, to put it bluntly, or a problem of information flow. This problem seems simple, but it is an old problem that has plagued companies for years. Whether it's bar codes or RFID, the goal is to increase the transparency of the supply chain and improve the efficiency of the supply chain by optimizing the flow of information.

3.3.3 Money flow

Money flow is also one of the most important concerns in business operations, which is the monetary feedback from the customer to the manufacturer or service provider for the product or service received. A good example is the "triangle debt" in the 1980s and 1990s (Engelbrecht, 2009): Company A owes money to B, B owes money to C, and C owes money to A, forming a dead-end cycle. This is actually a problem with the flow of funds in the supply chain. During the financial crisis in 2008, the U.S. government injected 700 billion dollars to major financial institutions and lowered interest rates significantly to reduce the financing cost of enterprises and ensure the smooth flow of funds. Money flow is the blood of enterprises and supply chains. The first cause of business failure is not insolvency, not a loss of capital, but the money flow is not working.

Author argues that the challenges and difficulties faced by the flow of funds in the supply chain are essentially influenced by the flow of information. In many cases, especially in retail industry, money flow problems go hand in hand with inventory problems. Inventory is closely related to information flow, for example, the "bullwhip effect" in which demand forecast information is distorted and amplified when the supply chain is delayed, leading to overproduction, over-expansion and inventory backlog in the whole supply chain, resulting in a serious capital backlog; buyers deliberately hide market data for commercial reasons, or worry about the lack of capacity of suppliers. and deliberately pull up the forecast, all of which will lead to overproduction and inventory backlog of suppliers (Lee et al., 1997). Therefore, author states that money flow problems often depend on information flow solutions. In other words, money flow is another monetary expression of the essential logistics and information flow. The flow of funds is primarily the conversion of the flow of information and material into something that can be used in a financial sense, either in monetary form or in a financial sense. For example, encouraging supply chain partners to share information timely and accurately is an essential solution to reduce the "bullwhip effect", reduce inventory, reduce the capital backlog, and thus revitalize the whole company. Another area of concern for capital flow is inventory value turnover rate and cash flow cycles, which can also be optimized with more accurate inventory forecasts and sales projections. But the relationship between information flow and money flow is complementary, and some advanced digital payment technologies and money management systems can help retailers not only control the flow of money with suppliers, but also enhance the consumer experience at the point of sale. Amazon Go (Ives, Cossick, & Adams, 2019), Amazon's smart retail store, officially opened to the public in 2018. Consumers can walk right into the store, place the goods on the shelves and leave, without waiting in line to check out. The "Just Walk Out" technology uses computer vision, sensor fusion technology and deep learning algorithms to provide this seamless shopping experience. As an emerging payment field, sensorless payment combines payment and verification into one, which is more convenient and faster than cell phone mobile payment, and users will have a better experience, such as smart parking, smart gas stations and unmanned supermarkets.

In addition, many emerging digital technologies cause a new mode of financial business, and some assistive technologies such as blockchain finance do bring some changes in financial models. But the use of these technologies is determined by business characteristics and the cost of application is also higher because emerging technologies are not yet commonly available. Thus author does not believe that all emerging digital technologies is universal in the flow of funds in retail industry. For example, as stated above, retailers usually have numerous suppliers. In order to ensure the flow of funds, the arrangement between the project cycle and the flow of funds becomes quite important. This has the problem of mistrust of partners between supply chain organizations. In this scenario, credit payment can guarantee the operation of the flow of funds and transparency through the use of a credit currency. Therefore, author in this project will only discuss the maturity of digital technologies that can significantly help the retail supply chain in most cases, such as payment management with suppliers, credit payments with customers and Automatic refunds and other after-sales support.

3.3.4 Organization

The perspective of organization in this master thesis project, is defined as the integrated management of the process of achieving the overall strategic objectives of the supply chain by overseeing activities in the flow of information and materials. It is worth noting that the relationship between information flow and material flow should be complementary and mutually influencing, and coordinating their relationship is one of the main tasks of organization. For example, it has been pointed out that being able to keep the information synchronized with the actual goods in real time is one of the current challenges for complex reasons in practical cases, such as human errors or data transmission issues (Ge et al., 2019). In other words, organization needs to provide support for forecasting, quality control and negotiation of activities in the whole process. The development of digital technologies in the last decade or so has helped a lot in organization.

Among them, the shift from a ”experience-driven” to a ”data-driven” strategy in organization has been one of the most significant changes in recent years (Ge et al., 2019). Human experience is significantly used in ”experience-driven” organization systems to determine crucial decisions such as inventory positioning, fulfillment network design, and so on. While data is still incorporated in this process, the effectiveness of such models is typically determined by assumptions based on experience and human judgment. Traditional inventory replenishment methods, for example, make optimal selections based on assumptions about the shape of demand distribution and supplier lead times (Brahimi, Dauzere-Peres, Najid, & Nordli, 2006); product assortment solutions (Kök, Fisher, & Vaidyanathan, 2008), meanwhile, rely primarily on product similarities, which are mostly appraised by expert category managers. ”Data-driven” models, on the other hand, rely more on the data than on human experience. organization systems may now make decisions solely based on accessible data, thanks to major improvements in data availability and developments in data mining and machine learning techniques. Learning-based replenishment algorithms (VanBoskirk et al., 2017), for example, employ observed demand data to aid inventory decisions. Without making assumptions about demand projections, machine learning-based inventory algorithms (O'Neil, Zhao, Sun, & Wei, 2016) may directly access past sales and purchase order (PO) information to generate optimal recommendations. Without consulting domain knowledge, embedding algorithms (Barkan & Koenigstein, 2016) can efficiently infer product similarities from previous consumer purchase data.

3.4 Chapter conclusion

Retail supply chain in this thesis project focuses on the process of the final sale to the customer or end user, which enables the flow of finished goods from the suppliers to the end consumer. Author finds that two types of dimension becomes the key elements to describe the retail chain system. One regards the retail supply chain as a whole system which can be divided into four subsystems, or namely sub-dimensions based on the main business process. There are procurement, warehousing, distribution and sales. Another one regards the whole process as four flows, which focuses on the flows of goods, information, money and organization. These two dimensions are independent of each other and can be considered as two ways of looking at the retail supply chain. Therefore author combine them as one of the elements in the design of the maturity model later. These two dimensions are independent of each other and can be seen as two ways of looking at the retail supply chain. Author has therefore combined them as one of the elements in the design of the maturity model. Each dimension is subdivided into four sub-dimensions, so that 16 aspects are divided. Specific dimensions lack practical business relevance and will be excluded. The discussion of these 16 dimensions is explained in Chapter 7.

4 Digitization in retail supply chain

This chapter intends to answer the thesis questions 2.1 and 2.2 of the Phase-2.

For the sake of this thesis project, digital technologies and innovations relate to information technology and automation technologies that have been demonstrated to be useful in the supply chain business. In this chapter, author first explains what a supply chain is and why it needs to be digitalized. This is followed by exploring the definition of digitization by scholars and giving the project's perspective on digital technology. Secondly, a summarized description of the main digital innovations in retail supply chain is proposed in Section 4.2. Based on above, author refers to the study from Ishfaq, Davis-Sramek, and Gibson (2022) and discusses the key elements of the digitalisation of the retail supply chain.

4.1 Introduction of DSC

The network among companies and their providers worked for creation and dissemination of a particular item is characterized as a supply chain (Büyüközkan & Göçer, 2018). It addresses the vital advances taken to convey an item or administration to clients. As per the Supply Chain Council (Zhou, Benton Jr, Schilling, & Milligan, 2011), these means can be made do with the assistance of the SCOR model that comprise of the Plan, Source, Make, Deliver, Return processes. The executives of supply chain management is a critical interaction since improved stockpile chains will prompt lower costs and quicker creation cycles. However, some authors proposed that conventional production network, which comprises of a progression of to a great extent discrete, siloed steps, has absence of specific credits that are required in the present and the upcoming business necessities (F. Li, 2020). Changing a conventional production network into DCS can separate these dividers so the chain transforms into a coordinated framework that runs impeccably.

Digitalisation is a modern technique for developing new interconnected business systems that extends beyond isolated and localized technology applications to supply chain-wide system implementations (Hofmann et al., 2019). DSC, according to Kinnet (Kinnett, 2015), is an intelligent, value-driven network that creates new forms of revenue and corporate value by combining new techniques with technology and analytics. Bhargava et al. (Bhargava, Ranchal, & Othmane, 2013) consider that DSC is made up of systems (such as software, hardware, and communication networks) that support interactions across internationally scattered enterprises and orchestrate the activities of supply chain participants. Procurement, producing, storing, distributing, and selling a product are examples of these activities. Although scholars do not have a uniform definition of DSC (Büyüközkan & Göçer, 2018), what is the same is that they all agree that DSC refers to the transformation of business processes, cultures, organizations, etc. by using these technologies to meet market needs. These digital technologies offer many possibilities for companies' SC to rethink how they plan production, transport methods, implementation manners and so on. In other words, it is a rethinking, reimagining and redesigning of business in the digital age (Nasiri, Ukko, Saunila, & Rantala, 2020).

From the above description, it can be seen that most scholars do not define the digitalisation of the supply chain in terms of technology, but more in terms of its function and impact, describing the added value it brings to the supply chain. Digital innovation, according to Yoo et al. (Yoo, Henfridsson, & Lyytinen, 2010), is the recombination of digital technologies and physical components to generate unique digital products. Digitization mainly improve the performance of the business in terms of informatization and automation. *Therefore, digital technologies and innovations, for the purpose of this thesis project, refer to information technology and automation technologies that have been proven to be applicable in the supply chain industry.* Author excludes digital technologies that can be used in the supply chain only in a theoretical sense, because their feasibility cannot be guaranteed. In Section 4.2, author summarizes the technologies that are more mature and have been applied in real business in recent years.

Most scholars and entrepreneurs agree that digitization of the supply chain has a positive impact. Agrawal and Narain (2018) considers that DSC can process large amounts of information and enable SC partners to collaborate and communicate together across digital platforms. Companies from different areas are contributing significantly on digitalizing their business tasks and their SC. For example, DB Schenker, another coordinated operations specialist co-op, is putting resources into an advanced portability lab. Aircrafts with solid freight activities, for example, THY, Lufthansa and Emirates extend their paperless e-cargo contributions with information cleaning for clients.

Further, digital technology has made more business opportunities possible in the retail industry. The omnichannel retail supply chain is one of the major digital breakthroughs in traditional retail over the past decade. The rapid rise of online retailers like Amazon has given shoppers quick access to information, easy ordering from endless aisles of products, and last-mile fast and free shipping that traditional brick-and-mortar retailers cannot match (Ishfaq, Gibson, & Defee, 2016). In recent years, some of the bolder innovations are also continuing to challenge the future of retail. Worldwide retailers Amazon and Alibaba have put resources into robots and R for dealing with and conveyance of products. In other words, digitization is one of the most significant shifts now affecting the retail supply chain (Pantano, Priporas, & Stylos, 2018). This phenomena has changed company opportunities, business structures, purchasing procedures, and forms of trade substantially. Indeed, the spread of digital technologies has had an impact on how retailers deliver new products and services to customers, as well as the new kinds of consumption that are linked with their use (Hagberg, Sundstrom, & Egels-Zandén, 2016).

4.2 Digital innovations in retail supply chain

Therefore, author review the digital innovations proposed by scholars in retail in recent years. It is important to re-emphasize that digital technologies in this thesis project include information technology and automation technologies that can contribute to business performance, but do not limit specific digital technologies. The following summary lists the mainstream digital innovations (see Tab 3).

Table 3: Application of digital technologies in retail supply chain. (Note that IF refers to information flow, MF refers to material flow, M refers to money flow, O refers to organization)

Technology	**Applied in subsystem**	**Applied in flow**	**Benefir for**
Could Computing (Novais, Marín, & Moyano-Fuentes, 2020)	Warehousing	IF & O	Can help information in the process to be visible at a remote location, which help achieve lean manufacturing and improve the integration of supply chain information.
	Shipping	IF & O	Same above.
Internet of things (IoT) & Machine-to Machine communication & RFID & NFC	Warehousing	MF & O	Help to achieve product tracking. (SKU, location, shelf life and status experienced), which can improve transparency and reduce manual operations like inventory counts.

Table 3 continued from previous page

Technology	**Applied in subsystem**	**Applied in flow**	**Benefir for**
	Shipping	MF & O	Improve the real time supervision of logistic processes. (temperature, humidity, light, weight, etc.), which is benefits for management transparency (Gospića & Bakmaza, n.d.).
IT system (KPMG, 2010)	Whole subsystems	IF	IT system can help the whole processed be recorded in the system, which can achieve automatted process. For example, the warehouse fully covered with an advanced IT system can realise real-time inventory management to prevent stock-outs, which can reduce labour costs.
Robotic process automation (RPA)	Procurement	IF & O	Repetitive manual labor can be replaced by RPA, thus reducing labor requirements.
	Distribution	IF & O	Same above.
Robot (R)	Warehousing	MF	Auxiliary inbound and outbound/fully automated inbound and outbound (KPMG, 2010), such as using power pallet trucks and conveyors when receiving cargos. That helps receiving cargo efficiently and correctly and to avoid accumulation at the receiving docks.
Visual Inventory Technology (Tu & Zha, 2021)	Warehousing	MF	Aids and efficiency of inventory counts can enhance management transparency.
Embedded Technology (G. Li et al., 2015)	Warehousing	MF & O	Security systems based on temperature sensors, humidity sensors, monitoring modules, etc. Automatic monitoring to protect warehouse security.
Big data analytics (BDA) & Data-drive services	Procurement	IF & O	BDA enables three major issues: supplier selection , sourcing improvement , and sourcing risk management, which enable automated decision making.
	Warehousing & Distribution	IF & O	Gather the interrelationship among data and optimize the inventory ordering decisions for location problem in retail distribution network design, which help enable automated decision making.
	Warehousing	IF & O	Same above.

Table 3 continued from previous page

Technology	Applied in subsystem	Applied in flow	Benefir for
	Sales	O	Help to do the demand planning and selecting areticles, which helps achieve accurate forecasting.

4.3 Key elements of digitization in retail supply chain

As many inventory, ordering, and scheduling processes are automated through digital integration, efficiency rises and costs fall. Because less manual intervention is required, accuracy is improved. Employees can devote more time to strategic and tactical activities instead of duplicating work, re-entering data, and repeating tedious chores. A supply chain integration plan, in the best-case scenario, can serve as a platform for buyer-supplier collaboration, allowing both parties to optimize processes like as inventory, delivery, and warehousing.

Based on this knowledge, Ishfaq et al. (2022) inductively studied the key elements of retail supply chain digitization and their interactions, which provided an important theoretical basis for the model design of this thesis project. Author proposes the key elements of supply chain digital transformation in the retail industry partly based on his elements, as follows. These elements are one of the important references to design the maturity items in Section 7.4.

Digital awareness

Digital awareness refers to a company's incorporation of a strategic awareness of digitalisation within the company (Davis, Allen, & Dibrell, 2012). This awareness requires that the leaders of the business have some knowledge of how digital the business is at this stage and have a strategic view of digital development. In an interview with supply chain executives, Ishfaq et al. (2022) got this comment from one leader: "The emphasis on digital should not be on how much cutting-edge digital technology the business is using, but rather on the leaders' deep understanding of the business, and then using technology tools to eliminate gaps in the business and optimize the employee experience." In other words, it's a reflection of "digital will," and developing a common strategic will about digital helps retailers align their strategic priorities across constituent organizational entities, which is critical to developing a successful digital strategy. Beyond this, it is equally important to understand the digital value of digital transformation. It identifies the impact of digitization on the way people interact with technology, processes, and each other (Yeow, Soh, & Hansen, 2018). For example, advanced big data analytics can help companies add value to their business. Managers who can recognize the value of digital will also have a greater understanding of technology. In addition to management's digital awareness, the authors believe that employees should also be expected to have this potential to realize digital value. Digitally aware employees are more likely to use efficient ways of working and can also help teams make data-driven, more compelling decisions. Such a group of employees can drive the digital culture of a company.

Process visibility

Process visibility emphasis the transparency and traceability in information flow. The players in the supply chain all have real-time information they care about. As the inbound team in the warehouse, they want to know the arrival time of purchase orders in real time to be ready for receiving. As the person in charge of inventory management, he wants the inventory in the warehouse to be accurate and viewable in real time. As a customer, he wants to be able to check the status of his order and the expected arrival time. This component of the digital transformation process accomplishes a crucial goal of the DSC: information integration and centralization. The integration of data from many sources guarantees that all information is centralized, consistent, and visible across the supply chain. The granular visibility provided by integrated information enables the retail organization to leverage corporate resources and physical assets. Another important goal of process visibility is to be able to adapt promptly to market developments (Wei & Wang, 2010). This component of the DSC is responsible for processing real-time data regarding inventory locations, logistics movements, and resource capacity across the retail enterprise. True visibility enables operational configurations centered on smart warehousing and rapid redeployment, boosting efficiency and responsiveness to market changes (Ishfaq et al., 2022).

Responsiveness

As mentioned above, another goal of digitalisation in the retail sector is to improve the ability to respond quickly to the market. In order to achieve this, on the one hand, companies need to have the ability to anticipate the need, which can be achieved through technologies such as data analysis to predict where trends are heading and thus respond quickly to the changing market. However, demand forecasting is not one of the responsibilities of all companies' supply chains, so it will not be discussed too much here. On the other hand, companies need to have flexible inventories in order to be able to make quick inventory adjustments to changing market demands. Essentially, this is a test of the maturity of inventory information. Managers need to know the actual inventory in a timely and accurate manner and to move stock quickly.

Process automation

Process automation in this project refers to automated equipment that helps the retail industry to improve the efficiency of parcel delivery from the warehouse, order fulfilment and the digitisation of ancillary supervision. In the whole process of the retail supply chain, realising the process of parcels being signed for at the warehouse and delivered to the customer can be achieved by using automated equipment, such as robot arms, to make the process partially unmanned. At the same time, process automation can help the retail industry, especially in the warehousing and delivery process, using equipment such as conveyor systems and electric trolleys to significantly reduce labour costs for the company. In addition, sensors attached to automated equipment can automatically update the status of orders during the warehouse, distribution and delivery process, which enables to reduce the pressure of monitoring by quality control staff.

Automated decision making

Automated decision making refers to the process of building predictive technologies such as intelligence, such as artificial intelligence and machine learning (Watson, 2017), into business processes to enable assisted or even automated decision making. Cognitive automation improves supply chain governance, increases operational scalability, shortens turnaround times and reduces operational errors (Finch, Goehring, & Marshall, 2017).The connection of inventory replenishment decisions in local stores to customer comments on social media and Google search frequency is a nice example of cognitive automation in the retail supply chain (Bertsimas, Kallus, & Hussain, 2016). This proactive assessment of customer demand using demand sensing and integrating it to real-time decision automation assists retailers in improving shelf availability in local stores (Wang, Gunasekaran, Ngai, & Papadopoulos, 2016). This enables merchants to employ cognitive automation efficiently "to place things where they need to be before buyers even think about buying them."

How and by whom supply chain decisions are made within the retail sector is an important part of cognitive automation (McAfee, Brynjolfsson, Davenport, Patil, & Barton, 2012). In this aspect, the digital transformation of traditional decision-making processes begins with a shift in focus (Donate & de Pablo, 2015).This shift in the information focus of leadership has led to an organisational culture that promotes knowledge management rather than management instincts (Ishfaq et al., 2022).

4.4 Chapter conclusion

Previous studies shows that DSC refers to the transformation of business processes, cultures, organizations, etc. by using digital technologies to meet market needs. Digital technologies, in this thesis project, refer to information technology and automation technologies that have been proven to be applicable in the supply chain industry. Author lists the mainstream digital innovation among two dimensions in Section 4.2. Author argues that it is pointless to limit the range of types of digital technologies. It is more important to focus on how positively these digital technologies help companies in terms of important factors. Therefore, for this digital transformation of the retail supply chain, many key elements are presented in this chapter, which becomes an important theoretical basis for the formulation of the maturity object.

5 Maturity Modeling

This chapter intends to answer the thesis questions 3.1, 3.2, 3.3 and 3.4 of the Phase-3.

In order to maximize the utility of digital technology in the retail supply chain, a descriptive MM is used to help measure the digital maturity stage of the retail supply chain to better help companies make decisions in developing a DSC. This chapter provides an extensive discussion of the definitions of "maturity" and "maturity model" and aims to systematically summarize and help the reader understand the definition, components, and application value of MMs. In order to better examine related topics, the chapter then reviews MM research related to digitalisation and supply chain topics, and concludes with a list of limitations of MM research and the authors' views on them.

5.1 Concept design

5.1.1 Definition of maturity & maturity model

In an organizational context, the term 'maturity' can be regarded "as the degree to which a process is defined, managed, measured, and continuously improved". The Oxford English Dictionary identifies 'maturity' as "The state of being mature; fullness or perfection of development or growth (Dictionary, 1989)". It goes on to define the immaterial as "the state of being entire, flawless, or ready." Maturity is frequently measured in terms of so-called capability in the field of information systems. A capability is defined as the "general strength or capacity, whether physical or mental, (Dictionary, 1989)" to do certain tasks and achieve specific goals.

This indicates that the objective of employing MMs from a linguistic standpoint is to specify the prerequisites for specific objects of study to achieve an optimal (perfect) state for their intended purpose. Software development capabilities, for example, could be one of these items. There must also be a 'final' state of maturity beyond which no further development is possible (Wendler, 2012). This 'final' state is also referred to as a benchmark, so in other words using a MM is measuring how close the subject is to the benchmark level. One of the standard definitions is as follows: "A maturity model depicts an entity's evolution across time. This entity could be a person, an organizational function, or something else entirely." (Klimko, 2001) or "A maturity model is a set of structured features that describe effective processes at various stages of development. It also includes the cut-off points for each stage as well as the mechanism for moving from one to the next" (Pullen, 2007). All in all, a MM is a tool that is used to measure, compare, describe, or determine a path or roadmap (Proença & Borbinha, 2016).

The question of when this 'final' state is attained has led directly to two views in the creation and usage of MMs: *the life-cycle view and the potential performance view* (McBride, 2010). These two viewpoints were previously evident in the initial MM articles. In 1979, Nolan's data processing model was classified as a life-cycle model. It assesses the state of the four process areas using six distinct 'development stages,' with only the last stage of perfection being referred to as 'maturity.' Because of the impacts of improvement and learning, an organization changes over time and must thus go through all stages (Nolan, 1979).

Crosby's MM for quality management in 1979, is another early model that meets the idea of prospective performance. It identifies five stages of development, the final of which is known as 'certainty' and is also known as the best or ideal stage. Crosby's MM, in contrast to Nolan's, is not articulated in a life-cycle manner. It displays the potential that higher levels of maturity generate, allowing users to select whether or not to go to the next stage. The Table4 shows the main characteristic of the life-cycle perspective and the potential performance perspective

(Crosby, 1980).

Table 4: The overall characteristics of the life-cycle perspective and the potential performance perspective

A life-cycle perspective	A potential performance perspective
MM describes a linear process in which each stage must be experienced.	MM describes a non-linear process in which each stage is not necessarily experienced continuously.
The stages before reaching the final state are discrete.	The stages before reaching the final state are discrete.
The final (perfect) stage is called 'maturity'.	The final stage is called 'certainty'.
The final state changes/improves over time.	Both the stages and the final state change over time.
The development path is shown and can be used as a management tool.	The development path is shown and can be used as a management tool.

Most MMs today take a prospective performance approach rather than a lifespan approach (McBride, 2010). However, it is critical to be aware of this discrepancy because it has ramifications for both the model's application and the stages' interpretation. Models that take a life cycle approach have a clearly defined 'final' state of development that they will reach over time. As a result, they can be utilized as management tools to help the subject under investigation develop. Although the primary goal of the models in the potential performance standpoint is the same, there are some minor variances. These models likewise depict a developmental path, but the emphasis in these stages is on the possible benefits that can be achieved through progressing. Each stage has implicit significance and inherent validity (Kohoutek, 1996). Users must determine whether level of maturity (i.e., completion, perfection) is appropriate for their circumstances.

But regardless of the understanding of the 'final' state, maturity can be captured qualitatively or quantitatively in a discrete or continuous manner. MMs are thus used to analyze the status of a company or a production organization based on one of the stages indicated by the models, in order to acquire meaningful information about the starting point for improving existing organizational processes. In other words, the MM offers an objective assessment of performance (i.e. maturity levels) and indications on how to overcome possible deviations from expected performance (Lahrmann & Marx, 2010). This assessment tool can help organizations identify their strengths and weaknesses and thus help prioritize improvement actions (Lichtblau, 2015). Accordingly, MMs are recognised tools for determining the state of an organisation and for describing activities to achieve a more mature level of the organisation. In addition, comparisons and benchmarking with other organisations can be made (Berghaus & Back, 2016b; J. Zhang, Li, & Wang, 2017).

5.1.2 Components of the maturity model

There is no fixed definition of the components of MM, and the structures of the MMs available all vary (Wendler, 2012). Usually, MMs consist of major components (Ifenthaler & Egloffstein, 2020) such as (a) maturity level or stage, (b) descriptor for each maturity level (e.g., initial, managed, etc.), (c) a generic description of each level, (d) dimension (s) and perspectives, (e) maturity items linked to corresponding dimensions, and (f) a description of each element for each level of maturity. All in all, a MM consists of dimensions and criteria, which describe the areas of action. One-dimensional MMs are those that refer to only one criterion. But most models nowadays are multidimensional, encompassing affected processes, organizational units, problem regions, and so on (Lyytlnen, 1991). Some dimensions can further divided into serveral sub-dimensions and perspectives. And maturity stages that indicate the evolution path towards maturity (Berghaus & Back, 2016b), which are typically categorized into four to five stages, some expressed in numbers and some in terms such as beginner to advanced.

In terms of history, Stewhart began working on process improvement in 1924 with his statistical quality control ideas. Others refined these notions afterwards, including Humphrey, who expanded on them in 1978 and produced software based on them. In 1986, Humphrey introduced this maturity paradigm to the Software Engineering Institute (SEI), where he added the idea of maturity levels and laid the groundwork for its widespread use today. Humphrey then went over the fundamental ideas that underpin many of the so-called Capability Maturity Models (CMMs). The SEI has embraced these principles as a maturity framework for project management and technical foundations for quantitative control of software processes, which is the base for continuous process improvement (Paulk, 2009).

Hundreds of MMs have been developed by researchers and practitioners across many application domains besides software industry, such as risk management, resource management, project management, etc. (Pöppelbuß & Röglinger, 2011) As a result, the Capability Maturity Model Integration (CMMI) model was developed, which is a general model that can be used to a variety of domains. CMMI is a risk-reduction method based on a behavioral model that assists organizations in simplifying process improvement and encouraging efficient behavior in product and service development (Dennis, Aaron, & Richard, 2003). Similar to the previously mentioned life-cycle aspects and potential performance aspects, CMMI distinguishes between two sorts of approaches: 'continuous' and 'layered,' which echoes the idea of the two 'final' states mentioned earlier. Continuous' CMMI permits a company's process area to be identified and one or more components of that process to be improved. Capability levels are used in this technique to indicate the improvements associated with a single process area. The continuous method offers the most flexibility because it leads to incremental performance gains in a single process or numerous areas, all while remaining aligned with the business goals. To create improvement routes, the 'hierarchy' CMMI leverages pre-defined packets of data from multiple process areas. Each improvement path is distinguished by maturity levels, which each specify a distinct collection of process areas. As a result, the strategy offers an organized and systematic road to achieving a given level of maturity. The completion of one level ensures the maturity required to go to the next. The levels of maturity are as follows (Facchini, Oleśków-Szłapka, Ranieri, & Urbinati, 2019):

Level 1-Initial

Processes are characterized by a lack of rules, and they might grow in a 'chaotic' way in some situations. Only a few processes are adequately defined, and the project's success is dependent on human initiative.

Level 2-Managed

The primary processes are usually carefully defined in order to keep costs, time, and function under control. The process' output is reproducible.

Level 3—Defined

Software processes are documented and standardised, covering organizational and production factors. Company processes and standards regulate all software development and maintenance projects.

Level 4—Quantitatively Managed

For each software process, detailed measurements are gathered and analyzed. Processes and goods are under investigation and control.

Level 5—Optimizing

The utilization of novel ideas and procedures, as well as the outcomes of measurements, leads to continual process improvement.

These levels definitions do not apply to the maturity level of the retail supply chain, but provide the normative five stages. Author believes that the retail supply chain, as an integration of complex activities with multiple processes, is not helpful to the actual business by looking only at the overall maturity level, but needs to be split up and assessed in stages for more detailed objects/systems. But in any case, the CMMI five-stage model provides a good reference, and the authors will refer to the degree of these five stages in the corresponding supply chain in the next retail supply chain MM. In the next section the authors review and evaluate the findings of MMs in related areas in recent years.

5.2 Review of existing digital maturity assessment tools in related areas

To collect existing MMs assessment methods connected to digital technologies, a systematic literature review methodology was used. The authors discovered that, while there are numerous previous studies analyzing DSC maturity, there are little study contributions on digital supply chain maturity evaluation in the retail business. Relevant articles were found using various keyword combinations such as "digital maturity models," "stages models," "industry 4.0 maturity models," "digital supply chain maturity," and "smart logistics maturity." Scopus, Web of Science, Taylor Francis, IEEE Xplore, Science Direct, Emerald, Springer, SAGE, and several additional portals such as Google Scholar and Google Search Engine were used to conduct the keyword search. Through a combination of keyword searches, 34 articles appeared in the search results. These works' references were also examined in order to acquire a better understanding of the search for MMs. These efforts resulted in the discovery of 5 new MMs that are relevant to our study goals. The table below lists research that looked at maturity and readiness in linked domains (see Tab 5). Models that are not even featured in the table have less information about development procedures, structure, and assessment methods.

In these related studies, scholars commonly select up to 10 measurement dimensions, which are the domains to be measured, and they are usually independent and general. Some scholars also call them evaluation areas. Among these related maturity studies, there are some dimensions that are commonly recognized, such as the digital awareness of people and the degree of smart warehouse. Based on these macro dimensions, scholars usually split and refine them into more maturity objects. These objects are the ones that are assessed in the final measurement. The number of maturity objects is not regular, depending on the model. Author found that regardless of the domain MM, they all follow 4-5 maturity levels and the maturity is proportional to the level. The vast majority of maturity levels are tested in one or more actual cases. The tests are conducted by interviews, questionnaires and telephone interviews, all of which are personal. Overall, the relevant MMs currently available have maturity dimensions, maturity levels, and maturity objects as basic components, and some MMs consider the weights of maturity objects. Most of the scholars reflect on the limitations of their studies. For example, scholars realize that the models receive limitations in their use due to geographical location and research time constraints in testing the models. These limitations are described in detail in the next section.

Table 5: Review of existing digital maturity assessment tools in related areas

Maturity/readiness assessment model (source)	Research context	No. of dimensions	Maturi levels	No. of maturity items	Practic tested	If yes, what is the measurement?	Contribution and limitations
The Framework of Logistics 4.0 Maturity Model (Oleśków-Szłapka & Stachowiak, 2018)	Logistics 4.0	7	5	16	Yes.	Questionnaire.	The model takes the three micro dimensions of information flow, material flow and management as the starting point and divides them into seven sub-dimensions based on the business process of logistics. And these sub-dimensions are rated separately in the empirical study. The model considers weights, but the definition of weights lacks theoretical basis.
A supply chain assessment test (Netland, Alfnes, & Fauske, 2007)	Supply chain operations	8	5	50	Yes.	Not mentioned.	The model focuses on the overall maturity of the supply chain. It considers the maturity of a company in eight dimensions: strategy, control, process, resources, materials, information and organization. The model provides a clear framework for assessment. Although it has empirical studies, it does not clearly state the scoring details of the measurement objects and cannot be used directly. And it does not consider weights. But his 50 measurement objects provide an important reference for future supply chain maturity dimensions.
Development of maturity model for assessing the implementation of Industry 4.0 (Wagire, Joshi, Rathore, & Jain, 2021)	Industry 4.0	7	4	38	Yes	Interview.	The authors have conducted a systematic review of existing relevant modeling studies in Industry4.0. The design of the model has a sufficient and clear theoretical basis. The model is not concerned with business processes, but the dimensions and measurement objects considered basically cover the existing digital technologies and applications, and have strong reference value. The model considers weights.

The Digital Maturity Model 5.0 (VanBoskirk et al., 2017)	Digital business	4	4	4	Yes	Questionnaire.	The model focuses on the performance of the culture, technology, organization and insights of the company as a whole, without focusing on specific businesses. The generalizability of the model is verified by testing it on a large number of companies. Lack of theoretical explanation of the model's design. Companies can use the model to do benchmarking comparisons, but it is very limited in helping their actual business.
Measuring chain digitisation maturity: an assessment of Dutch retail branches (Plomp & Batenburg, 2010)	Digitisation in retail supply chain	3	4	22	Yes	Telephone interview.	The model focuses on the respective maturity stages of the technology and the organization and the maturity levels of these two levels of integration. The model does not consider weights. The model has been validated in the retail sector, but the model still does not go far enough and does not take into account the characteristics of the retail industry.

5.3 Limitations of MM

The discussion and research on MMs have never ceased over the decades, but scholars continue to criticize and question various aspects of MMs in various industries one after another (Poeppelbuss, Niehaves, Simons, & Becker, 2011). Notably, regardless of the maturity-related assessment tools in any industry, scholars generally agree that the maturity assessment dimensions and assessment criteria lack theoretical justification. In other words. The dimensions and assessment criteria for evaluating maturity mostly depend on the researchers' opinions and only a limited number of dimensions were focused on (Pacchini et al., 2019). This has resulted in a lack of agreement on maturity criteria in most industries, and the proliferation of perspectives makes the unity of MMs ambiguous (Bibby & Dehe, 2018; Wendler, 2012). Wagire et al (Wagire et al., 2021), in their review of studies assessing Industry 4.0 readiness, notes that most relevant studies do not use importance weights for dimensions and assessment criteria. In addition, they point out that most models do not take into account the socioeconomic level and development of the firms being measured, and that there are no MMs specifically designed for emerging countries. However, they believe that this is an important consideration because the industry standards of countries at different levels of development vary widely and the basis and starting point for assessing their maturity will be completely different (Pacchini et al., 2019). Besides, most of the methods applied to test the maturity readiness of companies are questionnaires or interviews with employees. This makes the whole assessment result oriented to the employees' point of view and lacks an objective evaluation of the digital performance of the supply chain. As a result, in many industries, the abstraction of the test objects and the superficiality of the test methods make scholars believe that MMs are not practically helpful for the actual operation and business performance of companies (Maheshwari & Janssen, 2013).

In short, the views on the MM critique in recent years can be summarized as follows.

1. Lack of consideration of maturity items' weights.
2. Lack of theoretical support for the definition of dimensions and evaluation criteria.
3. Lack of consideration of the objective environment in which the company is located, such as the differences in organization, business and culture.
4. The measurement method of the measured object is shallow and subjective.
5. Lack of guidance for the actual operation of the enterprise after the assessment.

In recent years, a number of researchers have noticed the shortcomings in the above MM studies. But there was never an agreement on the idea of MMs design process. There are three main typical design ideas in the design of maturity items' weights. The first one is based on the researchers' personal views, which obviously lacks persuasiveness and will not be discussed here. The second is based on the combined opinions of industry experts. Aniruddha et.al (Wagire et al., 2021) used multi-metric decision making techniques in their MM study of industry 4.0. Ronaghi used Step-wise Weight Assessment Ratio Analysis (SWARA) (Ronaghi, 2021), which allows decision makers to select, weight, and evaluate metrics, in his MM study of blockchain. Essentially both summarize the level of attention experts give to weighted metrics. While this approach can reflect the general opinion of the industry, in the retail industry discussed in this project, corporate strategy and the level of concern of managers for each dimension receive social, cultural, and business influences, and author does not believe there are weights that can be universally agreed upon. A third idea is to use a scoring tool to collect the opinions of the management of the evaluated company, such as the Likert-scale. In contrast author believes that the third approach is the most appropriate in the retail supply chain. This means that author believes that a DMM for the retail industry should not have a fixed weight, but should be discretionary depending on the usage requirements, either by defining weights for each maturity item or by assigning different weights to subsystems. Besides,in order to make the maturity variables can provide reference value to the actual business operation, Francesco et al. (Facchini et al., 2019) disassembled the five maturity levels of Industry 4.0 defined in the North Rhine-Westphalia (NRW) model (Sternad et al., 2018) according to the logistics process and defined the maturity stages in each subsystem. However, the relationship between the explanatory subsystems and the measured variables was neglected in the demonstration of the model. However, it has to be acknowledged that Francesco et al. provides a reference model for process unbundling. Therefore, author follows this approach of disassembling the operation process in this project, which is introduced in the next section.

5.4 Chapter conclusion

Maturity is considered to be the degree of distance to the final state. The MM is a tool to help users measure the distance of the target object from this final state. The MM has been gradually divided into two academic perspectives during these forty years of research, one is the life cycle perspective and the other is the potential performance perspective. The main difference is that the former has a linear maturity scale while the latter has a non-linear one. The current project advocates the use of the potential performance perspective, which is the direction currently advocated by most scholars. The MM mainly consists of maturity levels and corresponding descriptions, maturity dimensions, maturity perspectives, and maturity objects. MMs are widely used in many fields, but their basic components do not change. This view is verified in author' literature review. Although there are subtle differences to some compositions, overall they all have similarities. Of course, these similarities also allow scholars to identify and present the limitations of MMs in these years of research. Author believes that some of these limitations can be improved in this thesis project, including improving the theoretical foundation and increasing the objectivity of the measurement methods.

6 Requirements for model design

This chapter proposes the design requirements for Chapter 7 based on the previous chapters.

By combining an in-depth understanding of the retail supply chain with an assessment of the direction of digitisation and a review of the current state of research on maturity models by practitioners and academics, the author intends to clarify a series of model design requirements for this project in this chapter. In the next two sections, author presents the mandatory (Need-to-have) and recommended (Better-to-have) requirements for model design, respectively, and indicate the respective reference paths for these requirements, partly as a result of the analysis and discussion in the earlier chapters and partly as a requirement for model design in literature review.

6.1 Need-to-have

In the previous review, first, a maturity model requires a total maturity score, and some scholars also provide scores for various dimensions of multiple dimensions. Second, a maturity model for the retail industry needs to include the four major subsystems of the retail supply chain and focus on the actual business processes. The assessment of the model needs to focus on what digital technology brings to the performance of the business, rather than being limited to the use of technology.

Besides,scholars have raised many different expectations about the design of future MMs. Fagerhaug (Fagerhaug, 1999) argues in 1999 that MMs as a tool for corporate self-assessment need to enhance employee involvement and focus on business processes and different performance dimensions (Netland & Alfnes, 2008). Foggin et al. (Foggin, Signori, & Monroe, 2007) believe that MMs need to be simple in order to facilitate their replication. They suggest that the model should not require large and detailed data and should not take too long. In other words, the model should be mainly qualitative. Based on this, Netland et al. (Netland et al., 2007) proposed the Supply Chain Maturity Assessment Test (SCMAT), which has a similar purpose and content as the MM, but it is more concerned with the performance of the supply chain. The content of this test focuses on the best practices of supply chain operations in terms of strategy, control, processes, resources, materials, information, and organization. These scholars' perspectives on model design are taken into account, and combined with the analysis in Chapter 3 & 4 & 5, author proposes the need-to-have requirements for model design in this graduate program (see Tab 6).

Table 6: 16 need-to-have requirements for model design

	Requirements for model design (Need-to-have)	Reference
1)	Ability to have a maturity score for the supply chain as a whole	Section 5.1
2)	Ability to have separate maturity scores for different business modules/departments	Section 5.1
3)	Include an assessment of material flow	Section 3.3.1
4)	Includes an assessment of information flow	Section 3.3.2
5)	Includes an assessment of money flow	Section 3.3.3
6)	Includes an assessment of organizational management	Section 3.3.4
7)	Focus on business processes	Lockamy and McCormack (2004)
8)	No restrictions on specific digital technologies	Section 2.1
9)	Uses different dimensions of performance (i.e. is balanced)	Netland and Alfnes (2008)
10)	Be generic	Fagerhaug (1999)

Table 6 continued from previous page

	Requirement for model design (Need-to-have)	Reference
11)	The testing process should enhance employee involvement	Fagerhaug (1999)
12)	The process of data collection ensures the security of the company's data	-
13)	Do not involve overly complex data processing	Foggin et al. (2007)
14)	Existing methods and models are taken into account	Section 5.2; Fagerhaug (1999)
15)	The findings are visual	Fagerhaug (1999)
16)	Can give strategies and improvement advice corresponding to companies with different maturity levels	Section 5.3

6.2 Better-to-have

The five limitations of the current maturity model are listed in section 5.3. Three of these points are considered to be better-to-have design requirements. The first is that scholars often ignore or use flawed methods to define the weights of dimensions. Dimension weights are considered to be important to consider, but industry-specific maturity dimensions are also not uniform and need to be determined based on the needs of the user, such as the digital strategy of the company under test. Therefore author put the weights in the design requirements of better-to-have. That is, if the evaluated company does not use the dimensions, it probably means that there is currently no very clear strategic focus direction and each dimension has an average impact on the company's performance and overall impact. The results of such an assessment are considered to provide the company with direction for its next strategic development, such as reprioritizing digital investments. If the assessed company has a clear digitisation goal, it can modify the weight of the dimensions or the weight of the maturity items, aiming to detect the implementation of the strategy. The second point is that author requires the model to take into account objective conditions such as geographical and cultural factors of the company where it is located. For example, two different sets of criteria for maturity levels can be used for developed or developing countries. The third point is that the authors would like the companies' assessment process of the companies to be more objective. In the review, author believes that most of the data collection methods are personal interviews or personal questionnaires, which are considered subjective and potentially affected by fluctuating changes in the company's operations (Meng et al., 2011; Netland et al., 2007). These three points are summarized in the table 7.

Table 7: 3 bettter-to-have requirements for model design

	Requirements for model design (Better-to-have)	Reference
1)	Maturity items have weights that are in line with corporate strategy in the retail industry	Section 5.3
2)	Consider objective factors such as geographic and cultural factors where the company is located	Section 5.3
3)	Use a more appropriate way to eliminate the subjectivity of views	Section 5.3

7 Design of a digital maturity model in the retail supply chain

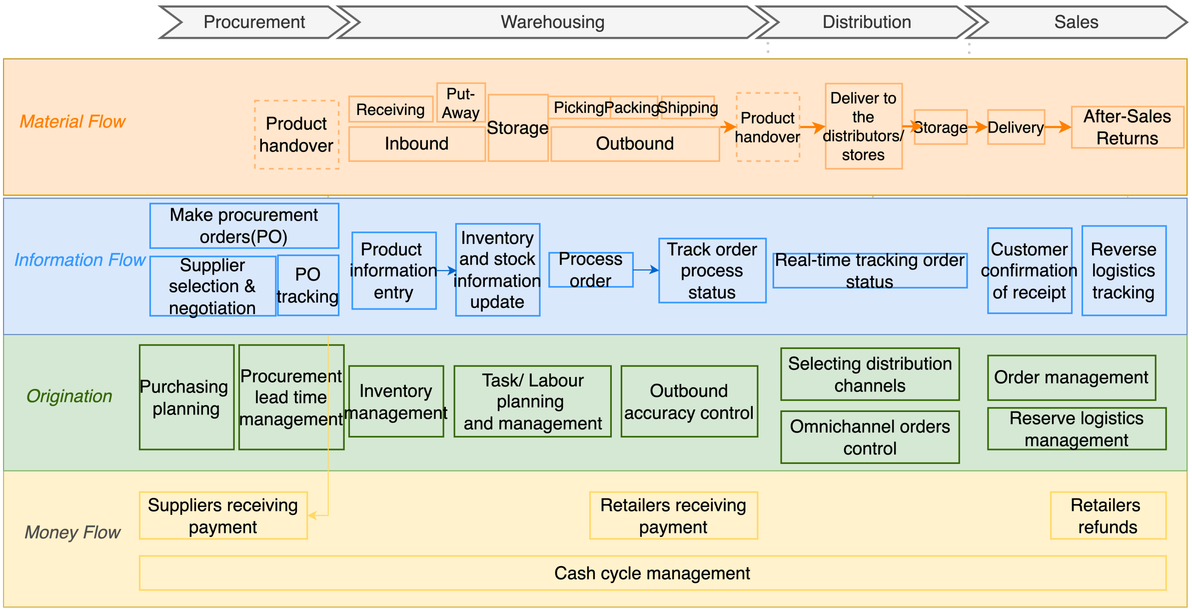
This chapter intends to answer the thesis questions 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 of the Phase-4.

The MM proposed in this thesis project follows the main components of the existing MM, but uses an intersecting dimension framework to reconstruct the MM framework. In this chapter, author first proposes this dimension framework and corresponding evaluation areas. Author states that the differentiation of maturity levels should follow the definition of Netland and Alfnes (2008), determined by the answer "To which extent does our supply chain use best practice stated in digital perspective?", which is also consistent with the description of the role of the maturity model in Section 5.1. Then author proposes the maturity model framework in this thesis project based on earlier findings and design requirements. After that, author defines and describes the maturity items in the empirical evidence and their best practices. Finally, author

7.1 Maturity model dimension and evaluation area

Council of Supply Chain Management Professional(CSCMP) gives the definition of SCM, which is "...... includes planning and managing all activities involving procurement, conversion and all logistics management activities. It also encompasses coordination and collaboration with channel partners, which might include suppliers, intermediaries, third-party service providers, and customers. SCM, in essence, blends supply and demand management within and across businesses.(of Supply Chain Management Professionals' (CSCMP), n.d.)" Although logistics is a part of supply chain activities and, in the retail industry, logistics occupies the main activities of the retail industry. Here, author further refers to the CSCMP definition of logistics management, which defines logistics as "...that part of SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements". This definition emphasizes the need to manage the entire collection of material and information flows in the logistics process (Facchini et al., 2019). Besides, as has been motioned in Section 3.3.3, money flow is also taken into consideration. Therefore, these four sub-dimensions serve as one of the bases for the establishment of the maturity model dimensionsl framework for this master project.

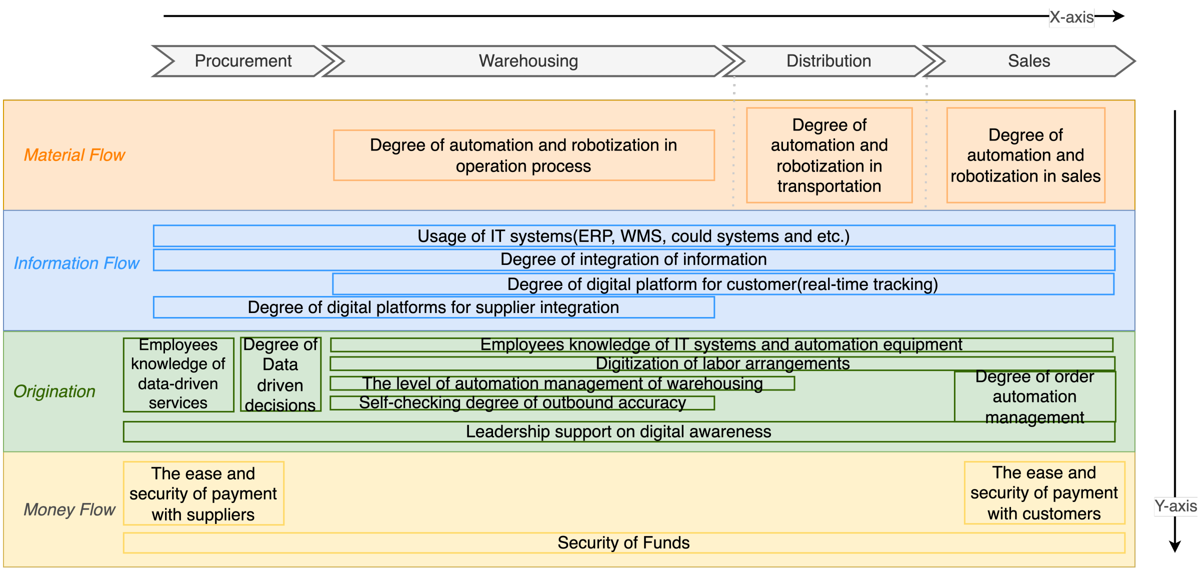
Subsequently, author proposes an approach to defining maturity dimensions for disassembling processes through interviews within the retail industry, combined with other researchers' comments on current relevant maturity models and research expectations. Author breaks down retail supply chain system by process into four subsystems/ sub-dimensions: purchasing, warehousing, distribution and sales, based on the four most critical key steps in the retail supply chain system. Therefore, author argues that the dismantling of dimensions should not be done using a single viewpoint dimension. Author combines the above findings to propose a cross-dimensional dismantling approach to combine these two types of dimension. In other words, the maturity model proposed in this project takes the basic framework consisting of these 16 perspectives as the starting point of this design maturity model, called dimensions (see Fig 8). Although the framework is presented in the form of a table, it does not indicate the existence of clear boundaries between sub-systems. For example, information flow is a continuous process of transferring the information involved in supply chain activities. The transfer of information between each subsystem is tightly linked. For each perspectives under test, the assessment of this proposed model focuses on the usefulness and sensitivity of emerging digital technologies in the organization's operational processes. Thus in Figure 8 author summarizes the main activities of retail companies included in this basic framework. As can be seen from the Figure 8, the authors assume that there is no material flow activity in the procurement system. Although some scholars believe that signing for and inspecting goods sent by suppliers is also within the scope of purchasing's responsibilities, in the retail supply chain, author subsumes this action in warehouse receiving.



WMS: Warehouse Management System; ERP: Enterprise Resource Planning;

Figure 8: The activities in dimension framework

Thus the use and effectiveness of digital technologies for these 15 perspectives under test needs to be assessed. Based on the key elements discussion of retail digitisation in Section 4.3, author summarizes the corresponding areas to be tested based on the activities in these 15 perspectives (see Fig 9), which are refined to maturity items in the next section.



WMS: Warehouse Management System; ERP: Enterprise Resource Planning;

Figure 9: Dimension framework and areas of evaluation

To facilitate the subsequent sorting out of the dimensional framework in the Figure 9, author introduce a two-dimensional right-angle coordinate system to represent each perspective. Let the four subsystems be S_1, S_2, $S_3$and S_4 on the X-axis, with S_1 denoting Procurement, S_1 denoting Warehousing, and so on. Similarly, let the four flows be F_1, F_2, F_3 and F_4 on the Y-axis. Thus the following definition is obtained.

1. $(S_1, F_2) \triangleq (Procurement, Informationflow)$
2. $(S_1, F_3) \triangleq (Procurement, Organization)$
3. $(S_1, F_4) \triangleq (Procurement, Moneyflow)$
4. $(S_2, F_1) \triangleq (Warehousing, Materialflow)$
5. $(S_2, F_2) \triangleq (Warehousing, Informationflow)$
6. $(S_2, F_3) \triangleq (Warehousing, Organizationflow)$
7. $(S_2, F_4) \triangleq (Warehousing, Moneyflow)$
8. $(S_3, F_1) \triangleq (Distribution, Materialflow)$
9. $(S_3, F_2) \triangleq (Distribution, Informationflow)$
10. $(S_3, F_3) \triangleq (Distribution, Organization)$
11. $(S_3, F_4) \triangleq (Distribution, Moneyflow)$
12. $(S_4, F_1) \triangleq (Sales, Materialflow)$
13. $(S_4, F_2) \triangleq (Sales, Informationflow)$
14. $(S_4, F_3) \triangleq (Sales, Organization)$
15. $(S_4, F_4) \triangleq (Sales, Moneyflow)$

7.2 Maturity levels

According to the basic definition provided by CMMI, the model proposed in this thesis project states five maturity levels. The different maturity levels follow the viewpoint of the supply chain maturity assessment test (SCMAT) proposed by Netland et al. (Netland & Alfnes, 2008), according to a qualitative answer to the question "To which extent does our supply chain use best practice stated in digital perspective?". As defined in the Section 5.1, maturity models are studied in order to help companies reach the optimal state for their intended purpose. The maturity levels accordingly represent the different stages of development before reaching the optimal state.

- **L1 Ignoring** - The majority of labor/information and data transfer/money transactions and management are done in the traditional human and paper-based way. Companies at this stage are either not digitally aware or have some reasons for not being able to implement any digital development. Author recommends that companies at this level adopt more mature and low-cost digital technologies in a key business as a whole or in a dimension from a strategic point of view, such as cost control, as a trial. First raise the awareness of the enterprise management and employees of digital innovation, and then gradually introduce more costly information technology or automation technology to assist some of the work.
- **L2 Defining** - Companies use some information technology and automation technology, but the use of these technologies is fragmented in business processes and lacks integration. For example, digital payments (Korpela, Hallikas, & Dahlberg, 2017) can be used with some suppliers, data sharing of shared documents used in parts of the organization, etc. Companies overall at this stage have some digital awareness and have started digital technologies, but the operations between departments, including material delivery and information sharing, are limited to some people, and there is no integration of the entire supply chain or information sharing with the outside. Most of the digital initiatives in

companies are for business needs rather than having an active strategic plan for digital development. Author recommends that companies at this stage sort out their current digital applications and business needs. On the one hand, pull together information sharing between departments to avoid duplication of effort. Try to establish information integration between multiple departments through digital means. On the other hand, invest in automation equipment in warehouse and distribution to reduce human workload according to business needs.

- **L3 Adopting** - Companies are using information technology and automation technologies more frequently throughout the supply chain and have achieved local integration within the organization. For example, the warehouse is able to use WMS to efficiently manage the order production and outbound storage, and synchronize the information to other related internal systems. Some basic automation can be achieved in the merchandise flow, such as conveyor belts, etc. However, most of the operations, especially the product flow, cannot be unmanned. The employees at this stage are digitally aware and have already started to use it in their business spontaneously. The company has some awareness of digital strategy and it fits into the actual business. Author suggests that companies at this stage try to improve the reliability and security of information technology and automation technology, and try to integrate information with external third parties, such as sharing part of the commodity inventory between suppliers.
- **L4 Managing** - Companies use information technology and automation in business and strategic planning throughout the supply chain and are integrated within the organization. For example, employees across departments are able to access shared information at any time, and the transportation and delivery of goods has been partially unmanned. However, the business is not balanced in every dimension and lacks insight-driven development. In other words, companies are not yet using the data in IT to help make decisions such as management decisions and purchasing. In addition to this, the lack of mutual matching between business processes and digital technologies sometimes affects the effectiveness of the use of technology. Companies overall at this stage are well digitally aware and on the leading edge of digitalisation. Author recommends that companies do some expansions and upgrades to their current digital applications. For example, try to establish an information sharing network with external suppliers and add automatic replenishment reminders, or preventive and predictive technology features such as status abnormality alerts. In addition, companies should continue to strengthen and upgrade the reliability and security of their internal information networks and automation equipment.
- **L5 Integrated** - Companies use information technology and automation in business and strategic planning throughout the supply chain, and the organization is integrated internally and has real-time information exchange with the outside world. Companies at this stage overall have a good sense of digital innovation and are at the forefront of digitalisation, meeting the best performance of most researchers and being the benchmark for the retail supply chain. Author suggests that companies can invest in more new digital technologies as business needs dictate and better integrate business processes with digital innovation.

Voss et al. (Voss, Chiesa, & Coughlan, 1994) adopt research-based best practice statements as signs of superior performance. Thus, in line with this defination, author summarize the performance of the most discussed and agreed upon aspects of digitalisation in the above dimensions by using a literature review and interviews with industry experts. 43 best practices have been identified and will be assessed for maturity in the current test version. It is worth emphasizing that author is not attempting to define a set of best practices that would guarantee world-class performance. It is, however, designed to showcase real-world digitization best practices that most researchers would agree on. As a result, while author will cover some of the most frequent digital technologies and performance indicators used in the retail supply chain in next section, the model does not attempt to limit the usage of digital technologies.

7.3 Maturity model framework

The dimensional framework in Figure 8 helps sort out the 15 most critical perspectives of the retail supply chain and the corresponding measurement areas. For example, in the material flow of warehousing, author believes that digital maturity is reflected in the degree of automation and machinization of the warehouse during the entire flow of operations from inbound to outbound goods. In other words, the extent to which digitalisation and automation technologies help the process in this perspective is the focus of the author's attention in this project.

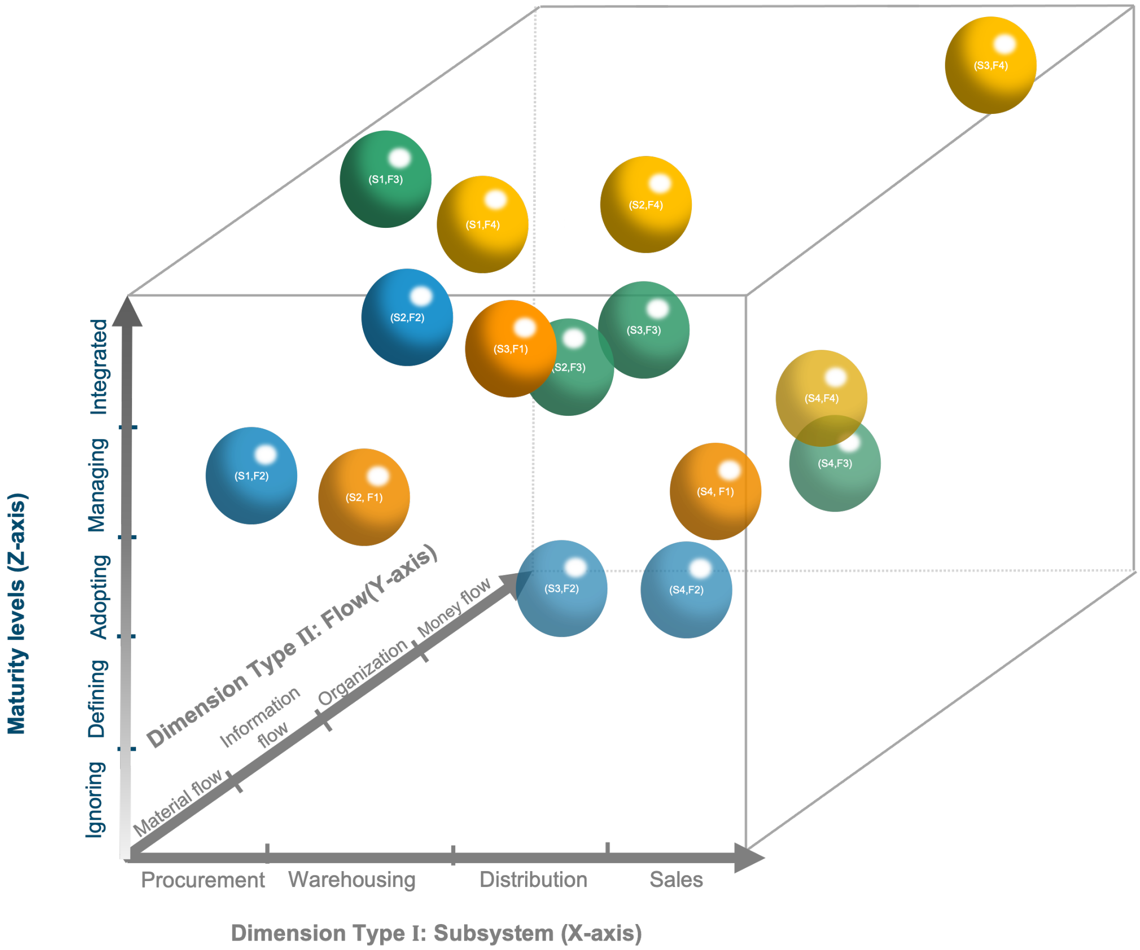


Figure 10: Maturity model framework

As a result, author refers to the MM study from Facchini et al. (2019) and advances five maturity levels for measuring the maturity of organizations in each of the 15 perspectives, based on the literature review in Section 7.2 about the idea of 'maturity levels.' There are five maturity levels: the first identifies the lack of any digtialization performance in retail supply chain, and the fifth defines the complete implementation and integration of digital supply chain solutions. The five maturity levels are: Ignoring, Defining, Adopting, Managing and Integrated, which are combined with the dimensional framework in Figure 9, resulting in the maturity framework for this thesis project. It should be noted that since the levels are mostly described in words and not "hard measurements", it is impossible to explain the differences between the levels. Still, the maturity model in this project is more to provide a framework of thought and indicative results for companies to analyze the digital performance of their supply chains, and also, the current researchers do not put too much emphasis on a uniform rubric for maturity (Plomp & Batenburg, 2010). Figure 10 shows as an example of 15 perspectives in 3D MM framework. Following the color labeling in Figure 8, the orange ball indicates material flow, the blue ball indicates information flow, the green ball indicates origination, and the yellow ball indicates money flow. The smaller the transparency of the ball, the higher its maturity level is indicated.

That is, each perspective has five independent stages of maturity, which are represented here by introducing a third variable coordinate L. L_1 indicates Ignoring, L_1 indicates Defining, L_1 indicates Adopting, L_1 indicates Managing, and L_1 indicates Integrating.(S_2, F_2, L_2) then indicates that the level of digitization of information flow in warehousing is at Defining level, and so on for the others. The definition of the five levels that apply to the description of the whole as well as to the description of each perspective, will be mentioned in the next section.

7.4 Maturity items

Author presents the maturity items to be measured and the corresponding best performance according to different perspectives in the following table 8. Also the tables in this section will be used as test forms in the next section.

Table 8: Maturity items

Perspective	Maturity items	Functional Description/ Best Practice
(S_1, F_2)	Usage of IT systems (ERP, could systems and etc.)	All information is collected automatically and accurately throughout the process.
	Degree of internal data transfer	Data interface within this subsystem is in real time and few error.
	Degree of information integration between subsystems	The data between procurement and other subsystems can be transferred automatically and correctly.
	Degree of digital platforms integration for supplier	The company provides digital platforms enable to automatically get PO tracking updates.
(S_1, F_3)	Leadership support on digital awareness	The manager's aligment towards employees' digital skills and qualifications to adopt digitalisation.
	Employees knowledge of data-driven services	Buyers have the awareness of using big data to assist in their work and applied them.
	Degree of Data driven decisions on souring management	Buyers use digital technology to assist with purchasing and marketing decisions.
	Digitalisation of supplier management	Use data-driven solutions to do vendor selections
	Degree of automation process from procure to invoice management	Digital procurement enables core purchasing by performing repetitive tasks in bulk, automatically triggering requisition and approval processes to invoice management activities with automation and standardization.

Table 8 continued from previous page

Perspective	Maturity items	Functional Description/ Best Practice
(S_1, F_4)	Digitalisation of payment	Use of digital technology to secure financial transactions with suppliers. i.e Applying smart contract technology to automatically enforce contract terms and accurately trigger the appropriate payment process, thereby eliminating manual verification; Use of convenient forms of payment such as electronic payments.
	Security of Funds	Use digital technology to guarantee the correctness and security of money flow data.
(S_2, F_1)	Degree of automation and robotization in operation process	Reliable automation of the entire process from inbound to outbound of commodities helps significantly in the assessment index of each link.
(S_2, F_2)	Usage of IT systems (ERP, WMS, could systems and etc.)	All information is collected automatically and accurately throughout the process.
	Degree of internal data transfer	Data interface within this subsystem is in real time and few error.
	Degree of information integration between subsystens	The data between warehousing and other subsystems can be transferred automatically and correctly.
	Degree of automatic replenishment process	When the inventory in the picking area is less than a set value, the system can automatically push a replenishment notification to the manager.
	Degree of digital platform for customer (real-time tracking)	The digital platforms provide to the customers to know the order status of their products, tracking product delivery and attending specific customer demands.
(S_2, F_3)	Leadership support on digital awareness	The manager's aligment towards employees' digital skills and qualifications to adopt digitalisation.
	Employees knowledge of IT systems and automation equipment	Warehouse employees use automated equipment and IT systems to improve the efficiency of their operations and are digitally aware.
	Digitization of labor arrangements	The warehouse uses digital technology to help optimize labor arrangements, such as data analysis of human efficiency.
	Degree of automatic production of orders	Automatic supervision of the production process; Abnormalities in warehouse operations can be automatically fed back to superiors, including low stock alerts, product expiration alerts, etc.
	Self-checking degree of outbound accuracy	The use of automated checks, etc., helps to review the accuracy of the outgoing inventory and improve the quality of operations.
(S_2, F_4)	Security of Funds	Use digital technology to guarantee the correctness and security of money flow data.
(S_3, F_1)	Degree of automation and robotization in transportation	Dispatchers use automation technology to improve delivery speed efficiency.

Table 8 continued from previous page

Perspective	Maturity items	Functional Description/ Best Practice
(S_3, F_2)	Usage of IT systems (ITS, ERP and etc.)	All information in transit is collected automatically and accurately.
	Degree of internal data transfer	Data interface within this subsystem is in real time and few error.
	Degree of information integration between subsystens	The data between warehousing and other subsystems can be transferred automatically and correctly.
	Degree of digital platform for customer (real-time tracking)	The digital platforms provide to the customers to know the order status of their products, tracking product delivery and attending specific customer demands.
(S_3, F_3)	Employees knowledge of IT systems and automation equipment	Employees use automated equipment and IT systems to improve their delivery efficiency and delivery security, and are digitally aware.
	Digitization of labor/ cargo arrangements	The distribution team uses digital technology to help optimize labo/ cargor scheduling, such as data analysis of manning efficiency.
	Leadership support on digital awareness	The manager's aligment towards employees' digital skills and qualifications to adopt digitalisation.
(S_3, F_4)	Security of Funds	Use digital technology to guarantee the correctness and security of money flow data.
(S_4, F_1)	Degree of automation and robotization in sales	The whole process of inbound to delivery in stores and after-sales realize the whole process of reliable automated operation, which can help significantly in the assessment index.
(S_4, F_2)	Usage of IT systems (ERP, WMS, could systems and etc.)	All information is collected automatically and accurately throughout the process.
	Degree of internal data transfer	Data interface within this subsystem is in real time and few error.
	Degree of information integration between subsystens	The data between warehousing and other subsystems can be transferred automatically and correctly.
	Degree of digital platform for customer (real-time tracking)	The digital platforms provide to the customers to know the order status of their products, tracking product delivery and attending specific customer demands.
(S_4, F_3)	Leadership support on digital awareness	The manager's aligment towards employees' digital skills and qualifications to adopt digitalisation.
	Employees knowledge of IT systems and automation equipment	Store staff will use automated equipment and IT systems to operate the store and be digitally aware.
	Digitization of labor arrangements	Store managers use digital technology to help optimize labor scheduling, such as data analysis for people efficiency.

Table 8 continued from previous page

Perspective	Maturity items	Functional Description/ Best Practice
	Degree of order automation management	Orders do not require manual intervention from creation to completion and can update their status automatically.
(S_4, F_4)	The ease of payment with customers	Use convenient payment methods, such as mobile payment, to enhance the user experience.
	Security of Funds	Use digital technology to guarantee the correctness and security of money flow data.

As stated in the Section 3.3.1, the direction of digital transformation of material flow is mainly to reduce labor cost, improve operational efficiency with more automated devices and make the process smoother. Considering that the material flow is more concerned with the flow and operation of goods in the actual business, author splits the material flow further according to the business process (see Tab 9). Due to the diversity of automation techniques, author here only give examples of techniques that are helpful for the assessment metrics to help the reader understand. As long as the assessor believes that the company under test has achieved the level of automation or digitization described from functional prospective, it can meet the best practice, and there is no single standard for the technology used.

Table 9: Sub-maturity items in material flow

Diemension	Sub-maturity items	Functional Description/ Best Practice
(S_2, F_1)	Process Automation/ Optimization- Receiving	The warehouse implements equipment such as power pallet trucks and conveyors, which significantly improves receiving accuracy and timeliness.
	Process Automation/ Optimization- Put-away	Solutionss such as slotting and space management systems automatically assign optimal spaces for each cargo to allow for a streamlined putaway process and maximized space utilization, and significantly improve inventory accuracy.
	Process Automation/ Optimization- Storage	The use of digital technology to quickly get the location and quantity of products and assisted in improving the timely replenishment rate.
	Process Automation/ Optimization- Picking	The warehouse implements technologies such as mobile and wearables, and significantly improves picking accuracy and timeliness
	Process Automation/ Optimization- Packing	Software is used to guide people through the task. For example, by entering information such as product dimensions and weight into the system, the system automatically confirms the type and quantity of packaging materials to ensure the safety of the goods and improve packaging efficiency. As well as using digital means to improve compounding accuracy.
	Process Automation/ Optimization- Shipping	The warehouse uses solutions such as loading systems to have guides that clearly instruct how to load cargo safely and efficiently.

Table 9 continued from previous page

Diemension	Sub-maturity items	Functional Description/ Best Practice
(S_3, F_1)	Process Automation/ Optimization- Pick-up & Loading	The shipping team implements equipment such as power pallet trucks and conveyors to improve the safety and efficiency of picking and loading.
	Process Automation/ Optimization- Shipping & Arrival	The shipping team implements solutions such as SmartSensor to protect cargo from temperature, moderation, shock, light and even air pressure changes.
	Process Automation/ Optimization- Unloading & Sign-off	The shipping team implements solution such as unloading robots, etc. to ensure the safety and efficiency of unloading, and automatic receipt of goods using bar codes to actively obtain product information, etc.
(S_4, F_1)	Process Automation/ Optimization- Storage	The store implements solutions such as robot arms and robot cars to automatically storage goods.
	Process Automation/ Optimization-Customer pickup and delivery	The store implements solutions such as robot, conveyor belts and etc. to realize unmanned pickup and delivery.

7.5 Preparation Process

In the preparation before using the designed model, the method of data collection and the calculation of the data are clarified in this subsection.

7.5.1 Workshop

As mentioned previously in Section 5.2, most of the data collection for the previous MMs is held in the form of personal interviews or questionnaires. However, author believes that interviews with individuals do not guarantee fairness of the data and can be influenced by the current work status or project progress, making the collected data less objective. There are two methods author believes can eliminate this limitation. One is to use a continuous interview format, collecting data for the same interviewees over a period of time and taking the average thus eliminating subjectivity (Meng et al., 2011). However, this method requires a longer period of data collection, which is not possible for author. Another approach is to use a structured group interview (Sekaran & Bougie, 2016), or namely a workshop, to provide open discussions in which employees can eliminate potential information asymmetries about the business and thus make the discussed results more generally agreeable.

The workshop plans to have three main tasks. (a) Introduce the topic and objectives of the workshop to the participants. (b) Use multimedia to show the best performance of the maturity items and lead their own discussion. (c) Collect the results of their discussion and gather their scores on the performance of that maturity item as well as the target scores. The target score is intended to collect the ideal performance for that maturity item in the current business situation.

7.5.2 Calculating the maturity score of dimension and overall maturity score

While author acknowledges that different dimensions of digital maturity performance contribute to the overall measurement results to different degrees, there is no universally agreed weighting perception of maturity items for the retail industry. Therefore, instead of proposing a fixed set of weights for maturity items in the previous section, author defines a weight variable W here, and if the tested companies have their own clear digital strategy goals, they can define their own distribution of weights. By default, maturity items have the same weights. In order to calculate the maturity of individual items and the overall maturity score (M_o) of the organization, the following steps are established appropriately:

The maturity model has 'k' maturity items in each 'm' maturity perspectives. The 'm' equals to 15 in this thesis project. (S_i, F_j), where $i = 1, 2, 3, 4; j = 1, 2, 3, 4$, represents these 15 maturity perspectives and has been identified in Section 7.1. W_k refers to the weight of maturity item 'k' and $W_{(S_i,F_j)}$ refers to the weight of maturity perspective (S_i, F_j). Following that, the maturity score for a particular maturity perspective is derived using the weighted average of the 'k'th maturity item as stated in Equation (1), based on replies R_k from correspondingly participants (see Table 10).

Table 10: Scoring mechanism of maturity model

To which extent does our firm use best practice in digital perspective?	**Score (R_k)**
L1 Ignoring- Never or does not exist	1
L2 Defining - Sometimes or to some extent	2
L3 Adopting - Frequently or partly exist	3
L4 Managing - Mostly or often exist	4
L5 Integrated - Always or definitely exist	5

$$Maturityscoreforperspective = M_{(S_i,F_j)} = \sum_{k=1}^{k} W_k \times R_k \tag{1}$$

where $M_{(S_i,F_j)}$ is the weighted average for maturity perspective (S_i, F_j). Equation (2) is used to determine the variable W_k when the measured company does not have an explicit preference for weighting.

$$W_k = \frac{1}{k} \tag{2}$$

$W_{(S_i,F_j)}$ refers to the weight of maturity perspective (S_i, F_j). $W_{(S_i,F_j)} = 0.25$ when the measured company does not have an explicit preference for weighting. Equation (3), as shown below, is used to obtain the overall maturity score (Mo) for the case organization.

$$Overallmaturityscore = M_o = \sum_{m=1}^{m} W_{(S_i,F_j)} \times M_{(S_i,F_j)} \tag{3}$$

The results of the data processing are intended to be presented in a kind of graph, and author believes that the spider diagram is the best method to present the data for the designed model. The data needs to be presented for each of the 15 maturity perspectives, i.e. the results need to be processed separately for each of the four sub-dimensions: purchasing, warehousing, distribution and sales. For each maturity item in the diagram, its actual score and the interviewee's target score for it are displayed in the spider graph. The difference between these two is of great interest. If the target score is much larger than the actual score, this indicates that the performance of this maturity item in the company is not recognised and that there is a greater need for improvement. In addition to this, the overall average score for this sub-dimension is also to be displayed in the graph. An example of a graph for data presentation is given in Figure 11.

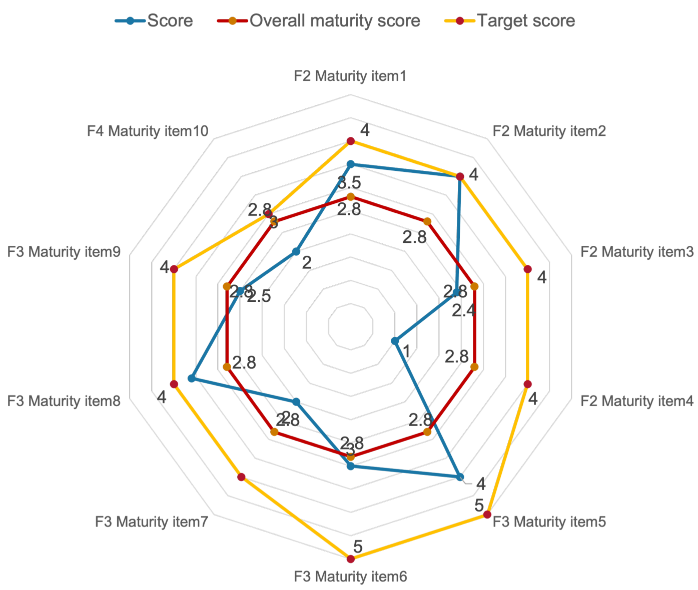


Figure 11: An example of data presentation in the spider diagram

7.6 Verification of requirements for model design

The chapter concludes with author reviewing the requirements for model design proposed in Chapter 6 and evaluating whether these requirements are fulfilled by the models designed in this chapter, see table 11.The chapter concludes with the authors reviewing the requirements for model design and evaluating whether these requirements are fulfilled by the models designed in this chapter. Due to the scheduling of the chapters, some of the content of later chapters will be mentioned early.

Author tries to make the model as close to the actual operation of the business as possible, but they realize that the further dismantling of the process and the universality of the model are to some extent contradictory. However, in any case, the MM provides a theoretical framework and corresponding maturity items from the definition, and users can adjust or delete the test objects according to their business characteristics without any significant impact on the results.

Table 11: Conformity with the 16 need-to have and 3 better-to have requirements

	Requirement for model design (Need-to-have)	**Conformity with requirements**
1)	Ability to have a maturity score for the supply chain as a whole	Yes. See Section 7.5.2.
2)	Ability to have separate maturity scores for different business modules/departments	Yes. See Section 7.4.
3)	Include an assessment of material flow	Yes. See Tab 8 & 9.
4)	Includes an assessment of information flow	Yes. See Tab 8.
5)	Includes an assessment of capital flow	Yes. See Tab 8.
6)	Includes an assessment of organizational management	Yes. See Tab 8.
7)	Focus on business processes	Yes. See Section 7.1.
8)	No restrictions on specific digital technologies	Yes. See Section & Tab 8.
9)	Uses different dimensions of performance (i.e. is balanced)	Yes. See Tab 8.
10)	Be generic	Yes.

Table 11 continued from previous page

11)	The testing process should enhance employee involvement	Yes. See Section 8.1.
12)	The process of data collection ensures the security of the company's data	Yes. See Section 8.1.
13)	Do not involve overly complex data processing	Yes. See Section 7.5.2.
14)	Ensure that models and testing methods are mutually	Yes.
15)	Existing methods and models are taken into account	Yes. See Tab 5
16)	The findings are visual	Yes. See Fig 13 & 14 & 15 & 17 & 18
17)	Can give strategies and improvement advice corresponding to companies with different maturity levels	Yes.
	Requirement for model design (Better-to-have)	**Conformity with requirements**
1)	Maturity items have weights that are in line with corporate strategy	No, but the formulas in Section 7.5.2 allows the user to adjust the values of the weights flexibly.
2)	Consider objective factors such as geographic and cultural factors where the company is located	No.
3)	Use a more appropriate way to eliminate the subjectivity of views	Yes, the workshop provides relatively fair results to have a group interview.

8 Demonstration of the model

This chapter intends to answer the thesis questions 5.1 and 5.2 of the Phase-5.

To demonstrate that the designed model can be used in a realistic case, field research within the Dutch retail sector is performed. Rather than querying retail organizations, author gathered information at the trade association level, which represents a specific retail branch. Due to the nature of traded products, retail is quite diversified, which provides an intriguing chance to investigate variances in retail branch kinds. Because the logistics and uniqueness of the chains vary widely between businesses, we can evaluate distinctions between food and non-food branches, or supply and demand-driven branches. Ochama, a grocery retailer, was chosen because it offers everything from food to everyday fast-moving goods, appliances, and household items, represents many small businesses, and their organizational structures and business features are generally comparable.

8.1 Data collection: Workshop

In order to use this model in Ochama and other enterprises, it is necessary to specify a way to access the data. This was partly done through workshops with employees from the four departments of responsibility. These workshops were held on June 20, June 21, June 22 and June 23, 2022 through a combination of offline structured group interviews and open discussions. The workshops were divided into three parts. The first part was designed to familiarize all participants with the topic and the purpose of the workshop and was presented in a slide show format. The second part is designed to show groups of employees in the same department of responsibility how their current work is performing in the industry benchmark, and will be presented through visuals. The third part aims to obtain data in the form of an open discussion in which the same group of employees will give a score for the maturity items to be measured that have been developed. At the same time, the interviewees are asked to explain the ratings given and give their expected digital performance.

5 for best performance and 1 for no informational or automated performance. Participants are asked to score within this range of scores. As mentioned in Section 7.2, the participants' scoring criteria is based on the distance from the best practice in Table 8 of the company's current performance on a maturity item.

Participants

Participants from four functions were invited to participate in the workshop (see Table 12). These participants were selected based on their work, their familiarity with the company's business. They were all full-time employees. In each functional area of responsibility, author invited at least three types of employees, at least one of each type. These types can be translated into the general manager of the department, the manager of a function, and the full-time employee.

Table 12: An overview of the participants

Workshop	Department	Position	No. of participants
Workshop1	Purchasing Department	Purchasing supervisor, purchasing staff, finance supervisor.	5

Table 12 continued from previous page

Workshop	Department	Position	No. of participants
Workshop2	Logistics - Warehouse Department	Warehouse supervisor, inbound supervisor, outbound supervisor, inventory supervisor, warehouse staff.	12
Workshop3	Logistics - Transportation Department	Transportation manager, driver.	4
Workshop4	Offline Operations Department	Offline operation director, store manager, store employees.	12

Workshop procedure

The four workshops collect data on maturity items in each of the four subsystems of the model, procurement, warehousing, distribution, and sales. Therefore, in each of the four workshops, author invites people from the respective departments of responsibility. The content of each workshop is divided into three parts and an overview is shown in the Figure 12. The workshop is about 30-40 minutes and author will show the best practice in Table 8 in that maturity item now through visual aids such as pictures and videos. The open discussion lasts no more than 15 minutes, and the workshop becomes fast when the employees agree on the company's performance in that maturity program.

The model is used to access the maturity level of Ochama. To demonstrate the model, the current situation of these delivery chains had to be assessed.

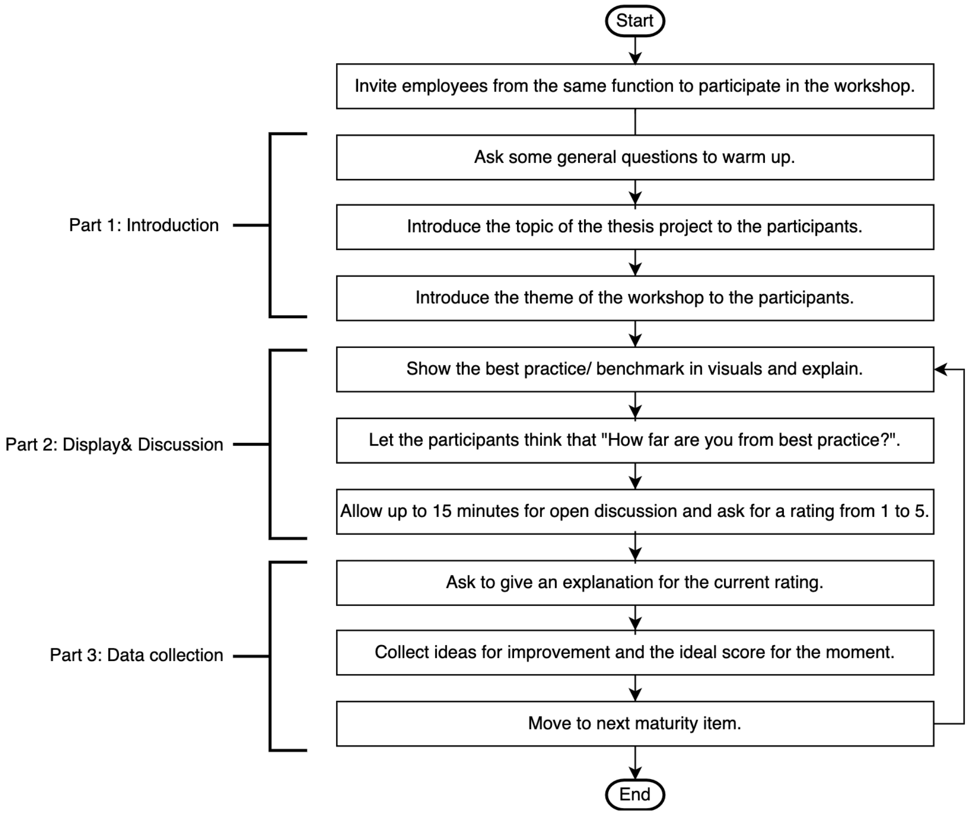


Figure 12: Workshop procedure

8.2 Findings

The assessment results of the case organisation are completed for 41 maturity items. The overall maturity score on digital supply chain of Ochama is 3.1, which locates at the **Level3-Adopting**. The maturity score of 14 maturity perspectives presents in Figure 13. The blue line refer to the maturity score as estimated. The yellow line refers to target score collected. The red line refers to the average score of the variables in this graph. Due to the lack of funding activities for Ochama's distribution, the (S_3, F_4) is not taken into consideration. In this section, author presents the digital performance of each of the four retail supply chain subsystems, explaining the scores for material flow, information flow, money flow, and organization and how employees rated that measurement when they scored it.

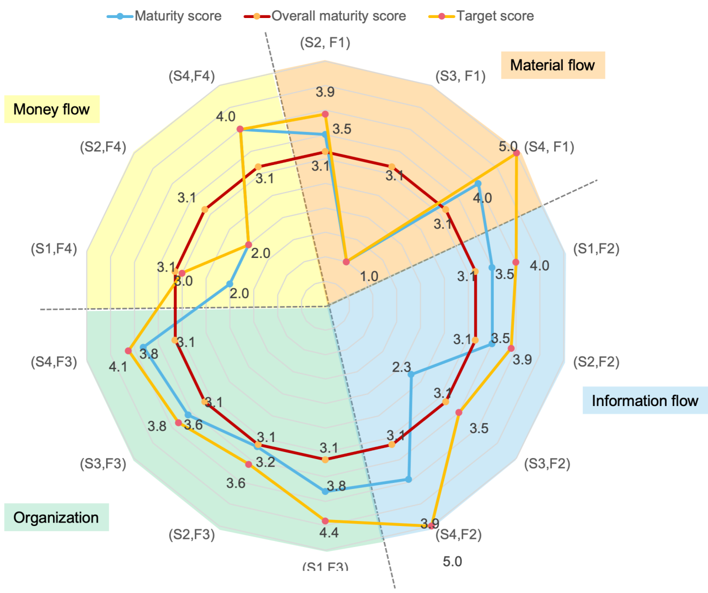


Figure 13: Overview of maturity score

Procurement

The process for system development for procurement and the establishment of a shared information platform for suppliers is hampered by the fact that the order size and procurement needs of companies are not large enough.

The overall digital maturity performance of the procurement perspective is 3.3, and the interviewer's target score for overall digital performance is 4.1. Procurement in this project does not include material-relative activities, and the scores and corporate expectations for the other maturity items are shown in Figure 14. In terms of information flow, Ochama's ERP system can cover all necessary business needs of the purchasing department and the stability of data transfer within purchasing. Moreover, ERP supports the establishment of data interfaces with suppliers' product information and the sharing of information on goods that are in stock. However, at present, suppliers are reluctant to establish ERP system interfacing due to the limitation of order volume and purchasing demand, and suppliers' consideration of data privacy. In other words, the current scale of business is not yet able to advance this digital development requirement. In terms of the degree of information integration with other subsystems, there is data transfer between systems that manage inventory with the warehouse. Although the interviewee acknowledges that there is a discrepancy between online inventory and physical inventory, he believes that this is a common problem for all supply chain and is not related to the level of digitization. It is necessary to schedule regular inventory checks between picking and selling and the warehouse.

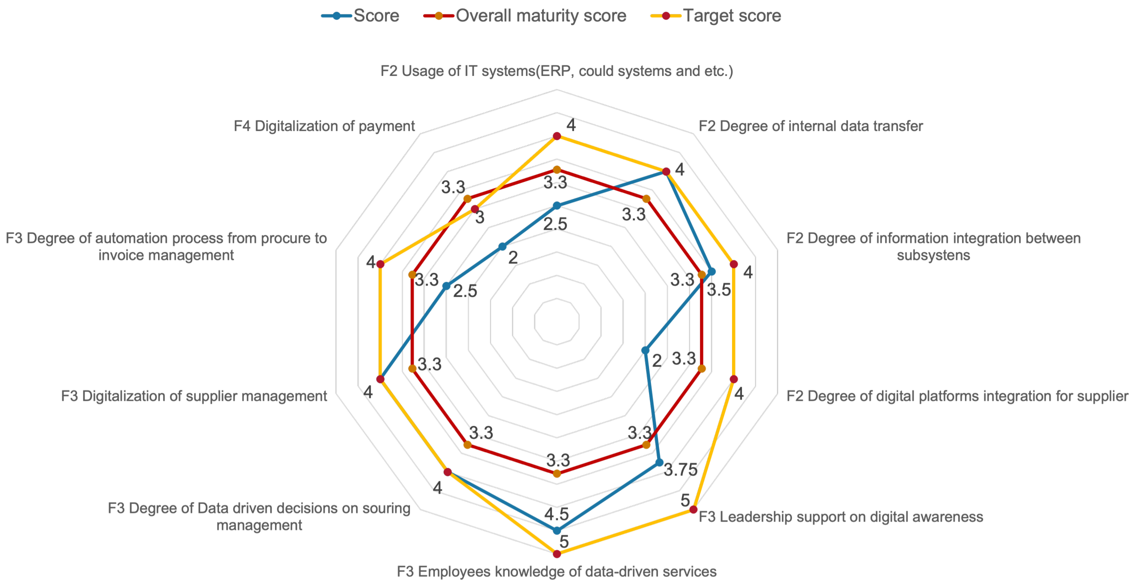


Figure 14: Maturity score in procurement

The maturity score for the management perspective is 3.6. In terms of digital awareness of personnel, the leader is clear about the digital development of the purchasing department and is aware of the benchmark performance in the industry. For example, he hopes that the integration of commodity information with suppliers and the improvement of the interface of the ERP system can be the next step. However, he is also aware that digital progress is limited by business volume and cost, and the R&D cost of system development does not yet support him to reach the current benchmark level. Overall, the procurement team has a high level of digital awareness and a clear digital presence in their work. The selection of products is judged on the basis of available sales data or customer reviews. Historical sales data is also used as an important criteria when selecting marketing programs. However, since Ochama's product range includes Asian products and some Chinese brands that are being sold in the Netherlands for the first time, the selection of new products in this area is based on human experience, so the maturity score is relatively lower. In addition to this, respondents believe that the selection of suppliers and the digital maturity of merchandise management are strongly correlated. Ochama's purchasing department sometimes selects suppliers and then selects merchandise. Sometimes it's the other way around. But in either order, they evaluate and screen the supplier's background, compliance and other data. The purchasing managers believe that when Ochama's sales volume as well as demand expands, having their own supplier management system will be the next step in R&D. However, the maturity in terms of automation of the purchasing order placement process is weak. Placing orders is done in the ERP system, a process that is highly dependent on human involvement for approval. For the time being, there is no database of suppliers or commodities that can help them place orders quickly and select products efficiently.

As Ochama is based in China, purchase payments are subject to cross-border transactions, etc. The payment process is not outstandingly digital for the time being. Payments to suppliers require manual verification by employees and proactive fund tracking. However, this process is paperless, so the maturity score for funding is 2.

Warehousing

Ochama is in the early stage of its business, and the current level of warehouse automation and information technology can cover the current business needs. The manager is clear about the current shortcomings and digital development direction of Ochama warehousing, but he is still satisfied with the current state.

The overall digital maturity performance of the warehousing perspective is 3.2, and the target score for overall performance is 3.6, which has been shown in Figure 15. In the material flow, author further splits the functions of warehousing by the activities in the good flow, and the scores for each of them are shown in Figure 16. The overall score for the material flow is 3.5 and the employees' expectations are nearly 4.0, indicating that the warehousing department is almost satisfied with the overall level of automation in the warehouse. The maturity degree of automation of warehouse receiving, inspection and put-away is relatively low. Further, the warehouse receiving goods have electric trolleys to help receive and carry the goods. After receiving the goods, quality inspection and input of product information into the IT system are done by hand. Even though the manager is aware of the improvement space in this part, he still said that the current daily average number of received goods is not up to the development demand, he thought it is necessary when the daily average of received goods is above 100 thousands, however, now it is about 10 thousands. Ochama's goods are mainly divided into small goods and large goods. The shelving process of small goods is assisted by Automated Guided Vehicle (AGV), which helps to transport the shelves to the front of the employee, and then the employee uses a bar code scanner to scan the goods and places them on the shelves. The shelf code is then scanned and the shelf number is tied to the product number on the system for inventory management and picking. However, Ochama currently lacks a digital solution for shelving large items, and employees are transported to designated stacking points via electric carts. Optimizing the shelving of large goods could be the next step in Ochama's digitalisation. In terms of put-away and picking, Ochama uses "Goods-To-Person", which makes efficient and accurate process possible. However, this feature has requirements on the size of the goods, and currently only supports small and medium-sized goods. Solutions are still missing for large shipments. However, since large shipments make up a small portion of the overall SKU, respondents noted that it is not very necessary for their current business. In terms of packing, the composite packing system helps employees to double confirm the correctness of picking up goods. This assessment focuses on the scope of business of self-pickup in Ochama offline stores, so in this regard, the packers only need to put the goods into the container with bar code, and do not need to pack and paste the courier slip. However, for the rest of Ochama's delivery business, all packing operations are done manually, without digital performance.

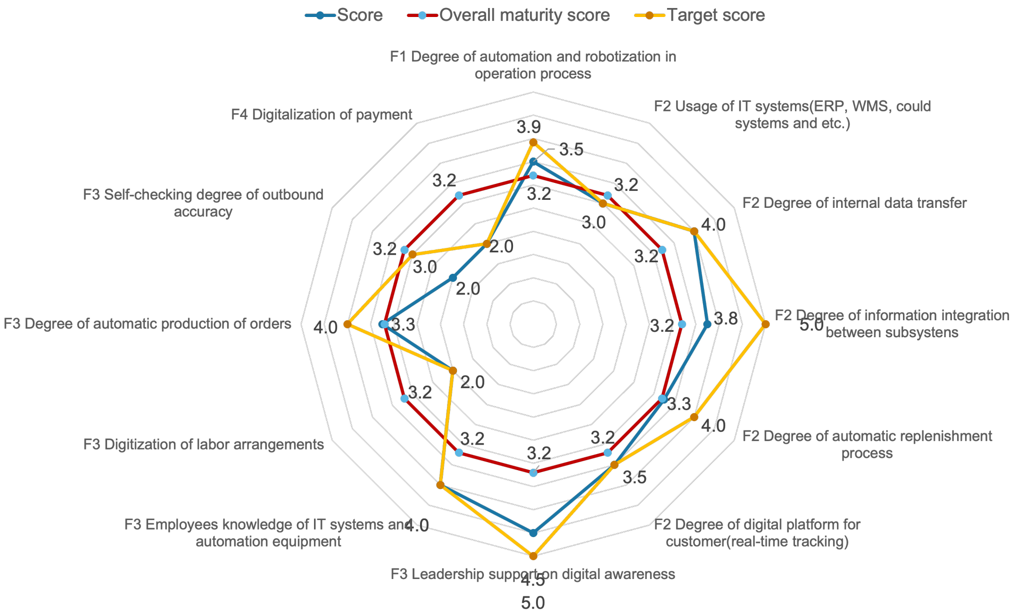


Figure 15: Maturity score in warehousing

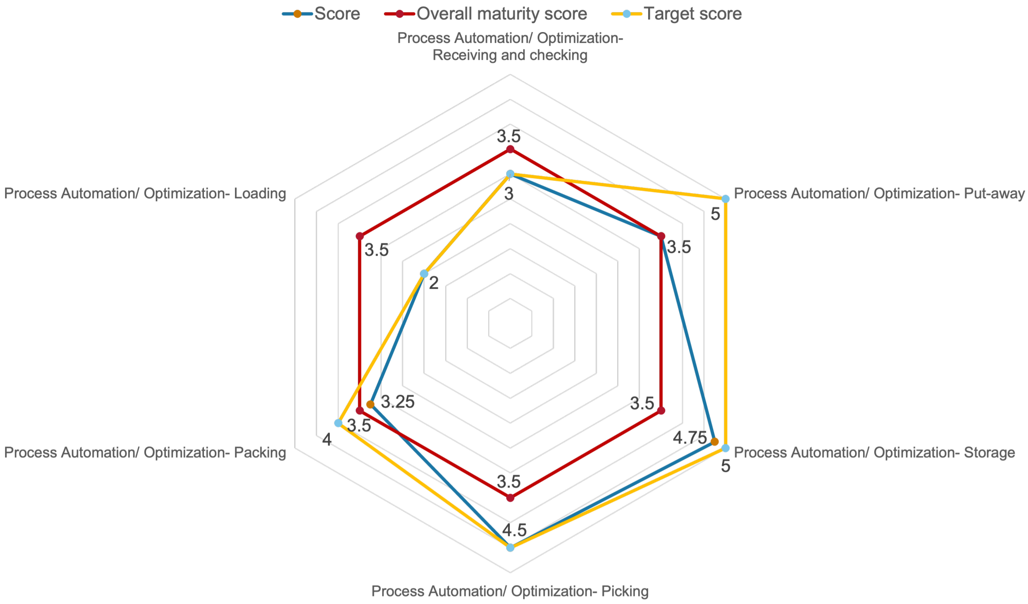


Figure 16: Maturity score of material flow in warehousing

The overall score for dimension of information flow is 3.5. Currently the basic functional processes of warehouse operations can be covered by IT systems, such as ERP, WMS and WCS. Respondents indicated that most of the order status still need to be changed manually in the system and would like to have more active screening and reminding functions. A case linked to that replenishment in the pick-up area requires employees to actively refresh the system from time to time to check replenishment requirements. In addition, employees expressed the desire to improve the reliability of data transmission between the warehouse system and external systems, sometimes data omissions occur.

In terms of organization dimension, the digital awareness of employees and managers is high, and every employee uses the operating system in their area of responsibility. The labor scheduling aspect does not have a digital solution to assist managers in optimizing labor scheduling for the time being, but the interviewees indicated that they do not have this need at the moment due to the small change in the daily warehouse headcount. That said, managers indicated that in the inbound segment, a reservation system for goods arrival is a possible digital plan to help them prepare storage space arrangement and labor arrangement for receiving goods in advance. In addition, the quality of delivery in the warehouse lacks automated supervision and management, orders are manually loaded onto trucks after sorting, and sometimes mistakes of sending goods to the wrong place occur. Therefore, respondents gave a score of 2 for this piece, and since this can easily lead to unpleasant consumption experience for customers, respondents expressed the need for improvement.

Distribution

In response to the expanding demand for deliveries, the delivery department want to develop a dispatching system. On the one hand it helps to optimise the driver's route and on the other hand it facilitates the tracking of the real-time driver's delivery status.

The overall digital maturity performance of the distribution dimension is 2.25, and the target score for overall performance is 3.13, which has been shown in Figure 17. Ochama's distribution activities refer to the process of transport from the warehouse to the offline shops. Overall, the level of maturity is at a relatively low level and there are low expectations of digitalisation in the distribution sector. However, during the workshop, the interviewees stated that since at the beginning of the business Ochama only intended to do delivery routes with four offline shops, the scope of the business was relatively simple and no information and automation strategy had been considered. And Ochama uses outsourced drivers from third-party delivery companies and does not have a data interface with the outsourced delivery company's ERP system. Even though the delivery company supports the function of sharing delivery locations in real time, Ochama does not choose to use it. The digital maturity score for the delivery department's information flow is only 2.3, which the department says is also mainly due to the need to track the daily volume of deliveries and the distance travelled in real time. However, as Ochama is currently growing from 4 to 60 offline pick-up points, the distribution department said during the workshop that a distribution scheduling system is needed to help them save on transport costs by assigning drivers to routes more efficiently. The department is therefore looking for a breakthrough in the information flow dimension to reach a level of around 3.5.

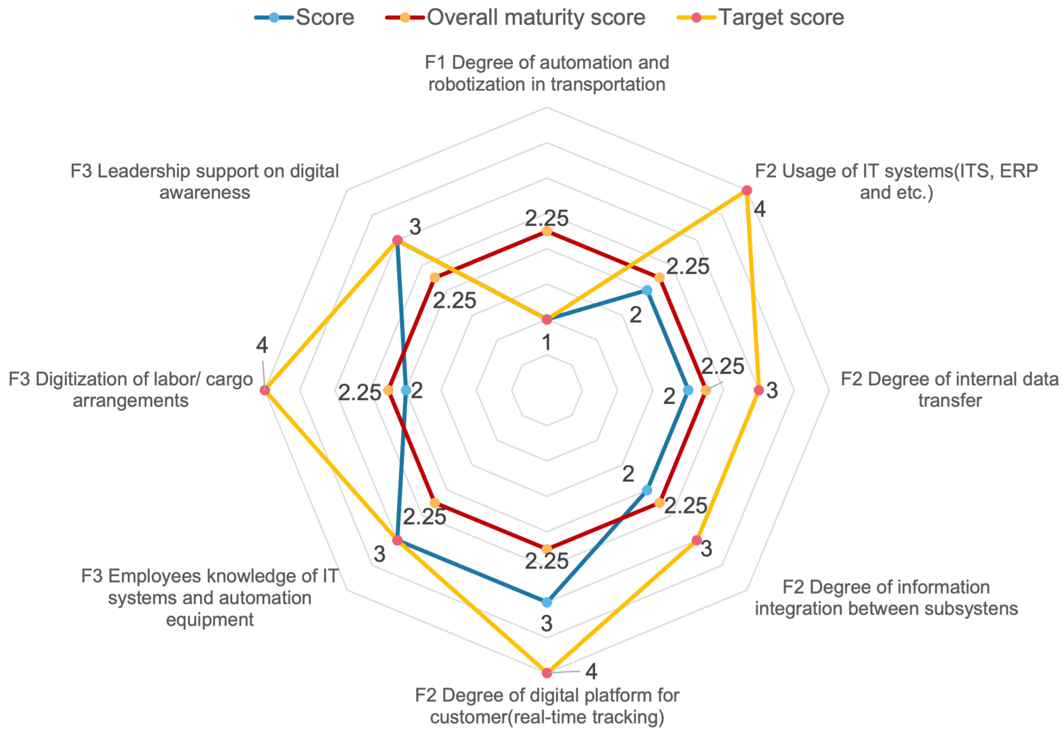


Figure 17: Maturity score in distribution

Management-wise, the department lacks advanced digital awareness. Due to the relative simplicity of the business, the department spends most of its time using shared documents on an online platform to exchange information and has not yet established an integrated information system to standardise the entire business process. Digital awareness in the department is at a Adopting level, with respondents admitting that they only think of using digital tools to solve urgent business needs when they arise.

Sales

Offline operation teams have a high target for digital maturity, and they believe that the digital performance of retail advanced technology contributes to the user experience of retail. Stores expect both automated devices and systems to be more stable, as they lack the ability to handle emergency exceptions, which can create a bad experience for guests.

The overall maturity score in sales is 3.9, while the target score of it is 4.6. The maturity items in this dimension presents in Figure 18. The offline stores use a complete set of automated and integrated equipment from receiving and storage to delivery. Orders are delivered to the appropriate storage location via conveyor belts and sensor scanning at each node. After the customer arrives at the store, they scan the pickup QR code to require delivery. The robot arm grabs the goods onto the conveyor belt and transports them to the customer. Although this integrated equipment allows store staff to be unattended most of the time, they said the equipment lacks stability. Sometimes the conveyor belt or the robot arm would break down. They therefore gave the store a 4 out of 5 for fully automated processes in terms of material flow. Store associates said they are helpless in the face of breakdowns because their ability to fix the equipment is limited, and when it is out of knowledge, the store's business comes to a partial halt. The expectation of their target score is that the stability of the automated equipment and emergency solutions can be further improved, which is how they describe their expectation of a 5.

The information flow of sales is highly correlated with the performance of the automated equipment, with an average score of 3.9. As containers with merchandise move on the conveyor belt, sensors on both sides upload the location and status of the containers to the system log in real time. In most cases the entire flow of container transport can be automatically tracked by the system, so the store gave a score of 4.5 for IT system usage. However, respondents indicated that there is a logical deficiency in the data transfer between the store's robotic system, IT system and Ochama's order management system, resulting in a mismatch between the system status of the order and the physical status of the order occurring in about 1.2% of orders per week on average. This situation would leave an unreliable impression on the guest's user experience, so the store gave a maturity score of 3.3 for data integration, but gave a higher target value, which hopefully could be the next step for digital optimization.

The overall maturity score for organization is 3.8. The overall digital awareness of the operation team is high, and the store manager conducts regular system and equipment training for all store staff. Duty scheduling in the stores is relatively simple and can be solved by using spreadsheets, so there is no other digital performance for the time being. In terms of money flow, customers can pay using a variety of digital payment methods on their mobile devices, saving them time in picking up goods. The ease and stability of payment deserve a score of 4.

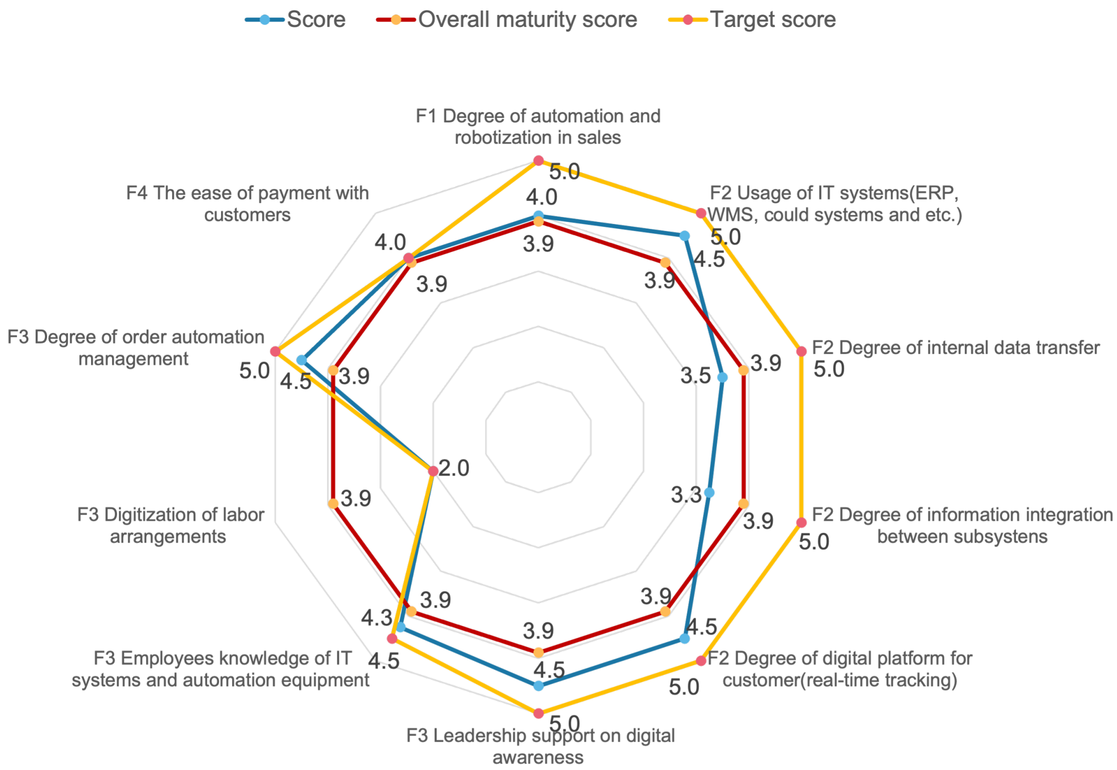


Figure 18: Maturity score in sales

8.3 Conclusions & Improvements

Chapter 8 shows the process of demonstrating and testing this digital maturity model at Ochama. Relative to individual interviews or questionnaires, author believe that group interviews are more intend to obtain objective opinions. Since author realizes that not all business performance is necessary to achieve the best performance in the industry, the workshops also collected the current target scores of the respondents. In the previous section, author showed the key ratings of respondents in each subsystem and expectations for the next steps in digital development. These scores not only reflect how far Ochama is from the benchmark in the retail supply chain, but also the current digital development needs in the business.

The differences in maturity scores between different subsystems in Ochama's supply chain indicate that the digital performance of the company's supply chain is uneven. Even though information technology and automation technologies are well spread in some operations, there are still some tasks, such as in distribution, that are neglected for digital development. Author continually emphasizes that the digital maturity model is an objective tool for companies to assess their digital readiness, and while scholars agree that digital maturity has a strong positive correlation with a company's operational performance, it is not absolute. This is also illustrated by the target scores given by employees. The (S_3, F_1) has a maturity score and a target score of 1. This indicates that although the automation of distribution is underperforming, the department indicates that the current scale of transportation does not require investment in this area for the time being, and that everything is currently going through the transportation process without problems. Conversely, maturity items with a larger difference between the target and actual scores need to be given attention. For example, the delivery supervisor keeps track of all delivery needs and driver schedules in a spreadsheet, but as the business expands she has trouble supporting it. This is the reason that she wants a delivery scheduling system that would help her reduce the workload and increase efficiency.

On top of that, Ochama overall neglected to optimize the reliability of digital technology. Each department was dissatisfied with the level of data integration between information systems, mainly because of the problems that occur with data transfer between different platforms. Upon further understanding by author, the root cause is the logical contradictions and omissions in the ICT architecture used by different systems in the enterprise. When data transfer errors occur, controllers need to be able to proactively identify the problem, otherwise it can easily lead to customer experience. This is also reflected in the store operations. The data transfer between the store's system and the warehouse system is bottom-up, and when data transfer fails, employees are unable to update data from the top down. These logical irrationalities lead to some extra work for employees. Moreover, author found that although the stores had highly integrated automation and information delivery equipment, the stability of the equipment is also lacking, and store employees felt that some equipment anomalies were beyond their ability to handle and even their job responsibilities. They set high expectations for an emergency backup plan for equipment anomalies and for engineers to provide regular preventive maintenance of equipment (see the (S_4, F_1)).

Therefore, author argues that users should use the model to discover the digital readiness of an organization, and that comparisons between companies of different business types and sizes are meaningless. Author believes that a retail company is supposed to follow the theoretical framework proposed by the model to sort out their business modules and the corresponding business activities in material flow, information flow, organization and capital flow, and then make the next digital optimization decisions and investments after gaining a comprehensive understanding of the organization's digital performance.

9 Conclusion and recommendations

To conclude this thesis project, the conclusion presents in Section 9.1. Then important limitations and future research are presented in Section 9.2. A reflection on the thesis project from the author prospective is given in Section 9.3.

9.1 Conclusion

Recent studies have shown that there is a gap between theory and practice in the digital transformation of the supply chain, with companies constantly reflecting on the level of digital development of their businesses without a tool that would help them to assess and reflect on their digital performance in the face of challenges. As a result, how effectively organizations promote the use of DSC is important to their success. This includes how to use digital technology to continuously optimize costs and improve stakeholder and customer satisfaction, among other things. Furthermore, many obstacles suggest that the DSC still lacks guidance in its practical implementation, meaning that the DSC's potential has yet to be fully realized and effectively demonstrated with empirical data in real-world situations. In the process of building a digital strategy, the organization is constantly repositioning itself in order to help people grasp the phenomenon and function as a boundary object to communicate objectives amongst the various parties involved (Berghaus & Back, 2016a).

Based on the inadequacies listed above, the retail industry need a tool that can assess the evolution of its supply chain and aid managers in making the appropriate decisions about digitization. The digital maturity model is a useful tool for assessing the existing degree of digitalisation in supply chains and guiding businesses toward improvement. Furthermore, the digital maturity model can serve as a benchmark for the digitization process, allowing frameworks to be provided to establish the direction as well as objectives for future activity. Digital maturity models have been discussed and studied by academics in many technical fields and industries, but in the retail supply chain, there is almost a research gap. This thesis project aims to fill this gap. Therefore, the objective of this project is to devise a digital maturity model in the retail supply chain.

The project has gone through five main research phases. The first three phases are considered to be the conceptual design, or the preparation phase before model design.

In the first phase, author categorised the factors that were the focus of discussion in the retail sector into two types, based on the research of academics. The first type is a process unbundling that divides the main activities of retailing into four subsystems, namely purchasing, warehousing, distribution and sales. The second type is the division into the flow of goods, the flow of information, the flow of capital and the flow of management through the content of the main activities. These two types are considered to be the two aspects of the dimensions of the retail supply chain, and all business activities in the retail supply chain can be further classified by these two dimensional types.

In the second phase, author reviewed and presented the definition and scope of discussion of digitisation in this thesis project and present the important elements of digitisation in the retail supply chain, such as digital awareness, the degree of automation of processes, the degree of automation in making decisions, etc., as well as the main innovations. These generalisations provide the theoretical basis for the design of the maturity items of the model.

In the third phase, author presented the concepts, components, and limitations of current maturity model research by means of a literature review. A review of relevant research in recent years is also presented. Then, based on the first three phases, the author summarized their requirements for the design of a digital maturity model for the retail supply chain. These requirements are divided by the author into two categories: those that are need-to-have and those that are better-to-have.

The fourth phase developed the model design. Based on the preparatory work done in the first three phases, author presented in this phase the framework of the dimensions, the five important maturity levels, the framework of the maturity model, 15 maturity perspectives and the specific 43 maturity items.

In the fifth phase, the designed model was demonstrated at Ochama using a case study approach. The demonstration included preparation for the use of the model, such as the organisation of the workshop, the list of participants, and the formula for calculating the data. In order to improve on the subjective nature of data collection in previous studies, author proposed the use of structured group interviews in which data was collected in the workshop. At the end of the chapter author analysed the findings of the study on digital performance in Ochama and suggest improvements.

Author next reviews the research contributions of this study to both theoretical and practical applications.

9.1.1 Contributions to research

This thesis project proposes an assessment model for the development of digital supply chain maturity in the retail industry, with the aim of better enabling decision makers to make decisions based on a comprehensive understanding of the current stage of digitisation in their organisations. As digital integration automates many inventory, ordering and scheduling tasks, efficiency increases and costs decrease. However, the digitisation of the supply chain still faces challenges in business. Maturity models are contributing to the progress of digitisation in the supply chain.

The concept of maturity has spread to various management areas, but more research is still needed to meet the domain gap in supply chain Cheshmberah and Beheshtikia (2020), and the retail sector is included. Author proposes a novel theoretical framework for a digital maturity model for retail supply chains and one that supports subsequent research on agile maturity models. In the review of the literature, author found that although scholars continue to add dimensions to maturity models, most lack theoretical explanations of their model frameworks and the dimensions assessed lack rigorous structure and thus lack persuasiveness. Author addressed this limitation by proposing a dimensional framework that encompasses the majority of the retail supply chain's business scope. This provides scholars with a more comprehensive understanding of the architecture of the retail industry. Although author mentioned the limitations of the framework in Section 9.2, it presents a new framework of ideas for the design of maturity models that subsequent scholars can use to iterate and add to.

9.1.2 Contributions to practice

This thesis project implemented an assessment of the degree of digitization of the supply chain in Ochama. In the proposal of this project, this is a process that is considered as a two-way contribution. On the one hand, the assessment helped to validate the usability and value of the model in real cases. This makes this research consistent with the scientific approach of design-science research (Hevner et al., 2004). On the other hand, it helped Ochama to objectively review the company's level of supply chain digital development in this year of entrepreneurship, to validate the correctness of its digital strategy development and to provide recommendations for the company's future digital development.

Although author acknowledges certain limitations in this thesis project, the experiment received positive comments from the respondents. The leader of the logistics group said, "This project provided a comprehensive understanding of our present digital performance. This perspective of thinking about the problem is something we never had before and gave us a lot of inspiration. Workshop provided us with a good communication platform to help us rethink and discuss the pros and cons of digitalisation in current phase. More importantly, I got a lot of employees' needs for digitization in the business through the workshops, which provided us with references for subsequent digital investments and improvements." An employee in charge of operations in a store said, "We encounter some data transmission errors when using IT systems in our daily business, but most of the time we are used to it, and we are not sure if the benchmark that is doing well in the industry also encounters such problems. But in this workshop, we found out that this is perhaps a stage that all in the industry go through in the digitalisation process, and it made us understand the issue better."

Based on the digital maturity framework provided in this project, the scores for current digital readiness and target scores of the 41 maturity items were collected in the workshop. This was acknowledged by the leaders. One of Ochama's top leaders said, "We do have some clear digital development strategies, but they are obviously not comprehensive enough. The results of this assessment made me revisit our goals, especially the target scores for our employees. It also made us aware of some operational details that we had previously overlooked."

9.2 Limitations and recommendations for future research

The maturity model has limited capabilities. These limitations may affect the model from being applied in limited practical cases. While the model is applicable to a typical retail supply chain, retail businesses are objectively diverse. As mentioned in the previous sections, the simplification of the framework and dimensions in this model may leave out the evaluation of other specific businesses. For example, author acknowledges that the dimensions and maturity items design neglected to assess the digitization of reverse logistics and did not consider the handling of returned goods after they become salvage. It is suggested that subsequent studies could fill in this gap. Therefore, author advocates that users can make appropriate adjustments to the maturity items based on the model framework for practical use, and the calculation formulas and results will not be affected.

Although author is aware that a more perfect maturity model needs to take into account objective factors such as geographical and cultural conditions in the context of maturity model use, author has not succeeded in addressing this limitation in this model design. Author hopes that scholars who refer to this maturity model will consider this issue in their subsequent designs. For example, retail supply chains in developed and developing countries could be discussed separately and different assessment methods could be proposed. One possible solution could be to extend the description of the maturity levels or to propose two different sets of scoring criteria, and the developed country may use a more stringent one. In addition to this, author suggests that companies could be categorised and assessed differently for small and medium-sized enterprises and large enterprises respectively.

In the Ochama evaluation, the way in which the data was collected was still questioned as being more subjective. The way the data was collected in this group interview was that people from the same department discussed it in a workshop and presented the author with the results of that discussion. Although it was an open discussion, the employees still listened more to their leaders' views and therefore the results presented were still personally biased. However, it has to be admitted that the leader has a more comprehensive understanding of the actual performance and his opinion is sometimes more informative. One of the leaders has said, "Although Workshop removes a certain amount of uncertainty compared to personal interviews, there is still a certain amount of subjective opinion, but I realise that this is difficult to remove."

Therefore, for future research, regardless of the digital maturity model of any industry, a more optimised way of collecting data is desired to go further in eliminating bias.

In order to better validate the general applicability of this maturity model, more types of retail businesses are desired to be evaluated for this maturity model. The maturity model in this thesis project has been tested in only one developed country grocery retailer and has not been replicated for the same type of business. The internal and external validity have not been fully unproven. Thus author hopes that the maturity items of this model can be iterated and supplemented with more real practical validation. In addition to this, author believes that even companies that are at the same maturity model at an overall level have differences in performance between their subsystems or different streams, so a side-by-side comparison is recommended.

9.3 Reflection

I am grateful that this project served as a finale to my MOT master programme, it allowed me to apply the methods and ideas of the project used in the previous year's topic and allowed me to apply them to my area of interest in the supply chain. I encountered a number of challenges in the beginning stages. Firstly, this was the first time I had to design a maturity model from scratch, which required a reorganisation and exploration of my body of knowledge. At the same time, this was different from a structured test experiment in that it had no clear tutorial for the experiment and required me to find my own way through it. During the design process, many new ideas emerged and at times I had to go back to the starting point to reflect on my research framework. It was after many iterations that the model gradually came to a first draft.

Some of the courses from MOT program are useful for my thesis project, SEN9725 Supply Chain Gaming and SEN9720 Logistics and Supply Chain Innovation made me realise that the supply chain is a complex and dynamic system. This led to the idea of proposing a maturity model for the retail supply chain at the beginning of my thesis project proposal. However, I was not clear on the current maturity model's specific definition and research progress. More importantly, I was unclear about the scientific approach that should be used to assign value to the maturity model for the retail supply chain. While searching the relevant literature, I reviewed the explanations and definitions of different research methods in MOT2312 Research Methods, which made me objectively aware of the strengths and limitations of various research methods. Some of these limitations are understandable given the research environment and the time available for the study. However, I still hope that some changes can be made to optimise the issues currently raised by scholars. For example, I used structured group interviews instead of individual interviews to remove some of the subjectivity. Also, MOT2312 Research Methods course made me realise that a new model requires a larger sample than I thought to verify its external and internal validity. This made me realise that my own case study was only a starting point for validation. So I asked for my research to be replicable to help support the future research. In addition to this, although I did not use a strict BPMN to dismantle specific business processes, MOT1531 Digital Business Process Management made me realise that process dismantling can help companies solve real business problems. This idea was also approved by my Ochama mentor. Thus I have applied this idea of process unbundling to the design of a dimension framework.

I find it interesting to see how knowledge collides across disciplines. I wanted to make an innovative contribution to my design, both in theory and in practice. Therefore, during the completion of my project, I asked my first supervisor Marcel at faculty and my mentor at Ochama for advice on a weekly basis. Marcel's advice on building a body of knowledge and scientific research helped me to reorganise my research framework very well. My graduation

team is a great help to me in guiding my thesis project. Marijn made me realise the limitation of the current MM study, which is inspiring for my modeling innovations. I also listened to my corporate mentor Owen, who has seven years of practical experience in the logistics industry in China, and he gave me advice that was more oriented towards practical business. Their help gave me a wide range of knowledge on the subject, as well as providing many different perspectives. I am very grateful for all the help they have given me.

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