MSc thesis in Management of Technology

Evaluating the maturity of companies in supplier master data management

The design of a maturity model

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TU Delft

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Evaluating the maturity of companies in supplier master data management

The design of a maturity model

Master thesis submitted to Delft University of Technology in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE
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by

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Preface

This thesis is the result of my graduation project for the Management of Technology master's programme at Delft University of Technology. After two years, this journey comes to an end.

First of all, I would like to express my sincere appreciation to my thesis committee. This preface is actually too short to thank you for all for the help you gave me. Anneke, thank you for your guidance and for your useful comments and feedback. I could not have completed this thesis without your positivity and motivation. Marcel, thank you for your trust and support. You were always there to guide me when I was unsure whether I was heading in the right direction. Last but not least, thank you Marijn for always finding time for me despite your full schedule. I would also like to thank everyone from the Supplier Lifecycle Management program in Philips, who helped me with this study.

Next, I would like to like to thank all my friends for the wonderful times we had together in Delft during these two years. Thank you all for always being there for me. And of course, thank you Nikolas for everything. You believed in me more than I did.

This thesis is dedicated to my family. Mom, dad and Anna, no words are enough to thank you for the unconditional love and support. I could have never achieved anything without you.

Ifigeneia Athanasiadou
November 2019

Executive summary

Master data is used to describe the critical entities of an organization, including customers, products, suppliers and employees. There are many challenges associated with the management of master data in large and distributed organizations. Master data management (MDM) has been proposed as way to integrate and combine data from different sources in order to provide a unified view for the main business entities. This study focuses on the supplier domain and aims to explore the challenges of managing the supplier information in large and international companies, within the supplier-organization collaboration and from an enterprise-wide perspective.

The identification of a supplier can result from the combination of accurate and complete name and address information. Problems in this information can be due to hybrid system landscape, multiple ERP kernels or lack of enterprise-wide uniform data rules and standards. Common supplier master data problems include the incomplete or inaccurate name and address combination, incomplete address information, international name or address and duplicated supplier records.

Although actions can be taken to manage these issues, a reactive approach to the supplier master data problems is not the optimal solution. A proactive mindset needs to be adopted by organizations to avoid these problems. There is need for the supplier information to be in a central place and with unified format and data rules, so that data redundancy and duplication problems can be eliminated. Therefore, supplier MDM is proposed to help organizations create and maintain consistent and accurate supplier information. This study aims to develop an assessment tool for companies to assess their supplier MDM practices and capabilities. Thus, the objective of this study is:

The design of a model to determine a company's maturity in the supplier MDM

This thesis uses the Design Science Research (DSR) approach to develop a supplier MDM maturity model. Five research questions are formulated toward this goal, each one representing one of the design science phases. For the research questions to be answered, academic literature is consulted, and a single-case study is conducted in the procurement department at Philips. The model is developed iteratively, starting from a systematic literature review. The literature review is conducted to develop a theoretical base for the development of the model. There is extensive literature that can be used to identify factors, benefits, challenges and barriers of MDM. However, supplier MDM specific factors cannot be identified in the existing body of knowledge.

Ten articles are chosen and used to provide knowledge in the area of master data management, master data quality, master data governance and master data architecture. Information is collected from these articles and translated into factors that can influence MDM. The theoretical base developed is used to conduct an expert survey, which results in the identification of the requirements for the design. Following this, exploratory semi-structured expert interviews are conducted. The analysis and coding of the interview transcripts provides a set of factors which can influence supplier MDM in organizations within the scope of the study.

The supplier MDM factors are categorized into groups (key concepts) and sub-groups (dimensions). Each dimension is described by a set of five supplier MDM capabilities. Based on these capabilities the maturity levels are defined, which are the 1. initial, 2. reactive, 3. defined, 4. proactive and 5. optimizing. The elements of the maturity model are then combined for the development of the supplier MDM maturity model. A maturity grid is presented, which describes the performance of companies in each

level of maturity, and it is complemented by a self-assessment questionnaire. The supplier MDM questionnaire can be used by companies to determine their as-is situation and develop an action plan for growing maturity in supplier MDM. Following this, the developed maturity model is evaluated based on its quality, efficacy and utility. Two evaluative expert interviews are conducted, and the model is improved by incorporating the received feedback.

Next, the conclusions of this thesis are presented and answers to the research questions are provided. The reflection of the study, based on the approach followed, the choices made, and the outcome of this research is also explained. First, the research approach is discussed based on the validity, reliability, researcher-independence and verifiability of the design. Second, the research choices are discussed, including the choice to follow a DSR approach, the choice to develop a stages-of-growth maturity model, the development of the supplier MDM factors, the choice to conduct a single-case study and the evaluation approach followed. Third, the reflection on the research outcome is presented.

This study considers the dual nature of DSR, aiming at both advancing the scientific knowledge base and providing results that are useful in practice. The thesis contributes to the theoretical base by adding factors that can influence supplier MDM. Moreover, these factors are used to develop a new maturity model, which is intended to determine a company's MDM maturity with regards to today's supplier master data problems. In terms of societal and managerial relevance, companies can create more meaningful supplier information by integrating and combining data from different sources. The supplier MDM maturity model can help companies determine their maturity in supplier MDM. The model serves also as a comparative basis for improvement. It provides an approach for increasing the supplier MDM maturity of the organization, by indicating the areas that need to be improved.

Finally, the limitations of this study are discussed. Based on these limitations, recommendations for future work are provided. A step toward an improved version of the model, is to conduct more case studies. Moreover, the maturity model development in this study, does not include the phases of deployment and maintenance. These steps are important to evaluate the applicability and efficacy of the developed model is in different environments.

Keywords: supplier master data management; supplier master data; maturity model; design science

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Chapter 1: Introduction and problem definition

1.1 Introduction

Due to recent technological advancements, the information storage and processing capabilities have significantly increased during the last few decades (Dyche and Levy, 2008). This results in a greater volume of data, which companies often find it challenging to manage (Vilminko-Heikkinen and Pekkola, 2019; Watts et al., 2009). Moreover, due to the rapid growth of application landscapes, there is significant dispersion of data among different systems (Cleven and Wortmann, 2010). This means that critical business information can be located across disconnected or legacy systems. Lastly, large and global companies are frequently held in disparate applications across multiple departments and geographies. Thus, it is highly possible that various versions of data for the same business entity exist within an organization.

Today's organizations experience problems in managing the quality of their core business data (Otto, 2015). This data is referred to as master data and it is used to describe the critical entities of an organization, such as customers, products, suppliers and employees (Loshin, 2010; Haug and Arlbjørn, 2013). Master data quality is fundamental for strategic business activities, such as the enterprise resource planning (Haug and Arlbjørn, 2013; Knolmayer and Röthlin, 2006; Otto, 2015). Problems in the quality of master data are common in distributed organizations, when different departments and business areas use subsets of the master data and systems are customized on local needs. (Knolmayer and Rothlin, 2006). Low quality master data can have negative impact on an organization "at operational, tactical, and strategic levels" (Knolmayer and Rothlin, 2006; p.363).

This study focuses on the quality of the supplier master data. High quality supplier master data enables companies to establish better relationships with the suppliers while their full profiles are defined through a complete, accurate and unique set of information (Loshin, 2010). According to Tseng (2014), the supplier relationship management (SRM) is strategic for firm survival. The supplier relationships are important to understand how companies apply knowledge management capabilities to improve the organizational performance (Tseng, 2014). It is important that organizations incorporate internal activities in their SRM plan (Karumsi, 2019). Effective SRM can result in mutually beneficial relationships for organizations and its suppliers from "a mindset of transparency and collaboration" (Karumsi, 2019; p.1). According to Hoek (2013), one success factors for effective supplier relationship management (SRM) is to "get the supplier data right" (p.16).

However, with the supplier master data being scattered over many departments, IT systems and tools, the value of supplier master data can be limited. Lack of coordination of the supplier related business processes or incorrect software implementation may lead to wrong, duplicated or incomplete supplier master data (Knolmayer and Rothlin, 2006). Data governance programs can help companies increase the value of the data (Khatri & Brown, 2010; Otto, 2015). By integrating data from different sources, companies can combine the supplier data into valuable information (Jhingran et al., 2002). Moreover, according to Loshin (2010), programs toward higher master data quality can change the way employees understand the value of data. They become aware that information can be treated as an asset for improving several business activities. Master data management (MDM) is used to "support capturing, integrating, and sharing accurate, timely, consistent, and complete master data" (Vilminko-Heikkinen and Pekkola, 2019; p.77). Large and global organizations are called to manage their master data in a centralized manner (Jonker et al., 2011). MDM help organizations with complex information

infrastructures to manage their data more efficiently (Silvola et al., 2011). Therefore, supplier MDM is proposed in this study as a way to provide a unified view of the supplier master data.

Otto (2015) examines how large organizations treat their master data and he concludes that it is a strategic resource for modern businesses, and therefore they take actions to manage it accordingly. Companies establish MDM departments or data governance teams. MDM development programs are suggested to increase the reliability and availability of the master data across the companies (Vilminko-Heikkinen and Pekkola, 2019). MDM is not only a technological issue (Vilminko-Heikkinen and Pekkola, 2019) and it shall place its focus on the business processes as well (Loshin, 2010; Sivola et al., 2011). These development programs often include organization-wide activities towards improved practices and technologies (Vilminko-Heikkinen and Pekkola, 2019). It is also important to raise awareness of the stakeholders involved in such activities and make people realize the benefits that such a change shall bring to their everyday work.

Development programs toward successful master data management require changes in a company with regards to its practices, processes, and technologies (Van de Ven and Poole, 1995). This study is based on the notion that successful organizational change can be realised by an assessment of practices and it proposes the design of a maturity model to evaluate the practices of companies in supplier MDM. Maturity models, as design artefacts, fall within the application area of design science and therefore the Design Science Research (DSR) approach is followed (Hevner et al., 2004).

1.2 Challenges in supplier master data management

There are many challenges associated with the supplier MDM, mainly due to the complex information infrastructures of modern businesses. To begin with, organizations experience challenges with improving the information flow within different departments and cross-functional processes. During the previous years, separate business units within the companies were focused on entering and tracking data to meet departmental needs (Loshin, 2007). Local systems with in-house supplier databases and limited data management practices often result in supplier data silos (Sivola et al. 2011). Consequently, companies need to manage a large amount of disconnected, underutilized or duplicated supplier data. To achieve this, they spend great resources and time to combine all the supplier information from different sources into a unified format (Sivola et al., 2011).

Second, it is important that the organizations find ways to improve the information flow within the different stages of the supplier-organization collaboration cycle. Many studies have explored the management of buyer–supplier relationships (Autry and Golicic, 2010; Yang, 2013). According to Yang (2013), companies are important to maintain a long-term stable relationship with the supplier, since “it brings effective communication, enhanced information sharing and trust, reduced cost and cycle time, and improved customer satisfaction” (Yang, 2013; p.1984).

In this study, the supplier-buyer collaboration is defined as the entire relationship of a supplier with the company. It refers to the whole process from choosing and contracting with a supplier, to tracking its performance and eventually phasing the supplier out, as it either does not meet the company's needs or requirements anymore. Most of the previous research on supplier data focuses separately on supplier selection, qualification and segmentation, while paying little attention to the entire supplier-buyer lifecycle. Based on discussions with practitioners, large volumes of data across multiple systems and departments result in complications in maintaining up-to-date supplier information. Each stage within

the collaboration cycle requires different data for the same supplier, which needs to be managed in a systematic way to provide accurate information at the right time to various stakeholders (Figure 1).

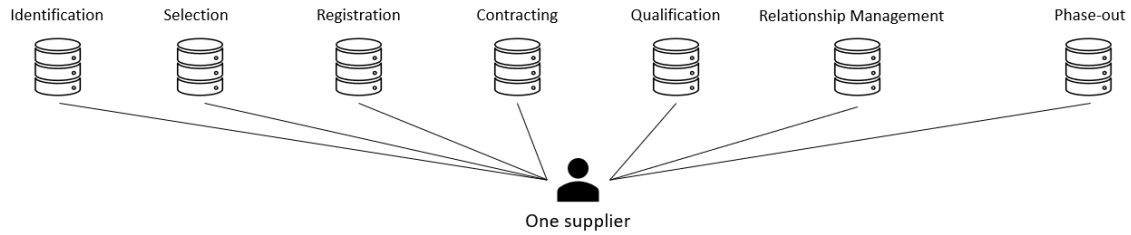

Figure 1: Supplier data in the supplier-organization collaboration

Lastly, modern companies which implement development programs for the supplier MDM are faced with the challenges followed by the introduction of new technology solutions. Digital transformation within the organization has impact towards existing procedures and capabilities (Katz, 2015). Although it might be relatively easy to decide on a digital strategy, it is often challenging for companies to execute it (Sebastian et al., 2017). A common misunderstanding is that effective supplier MDM can be achieved with the selection and implementation of an MDM tool (Jonker et al., 2011). MDM, however, starts with a clear organizational model, which needs to be developed and executed through a structured development program and with careful changes in the company's processes (Van de Ven and Poole, 1995).

1.3 Problems with supplier master data

The identification of a supplier can result from the combination of accurate and complete name and address information. Problems in this information can be due hybrid system landscape, multiple ERP kernels, non-standardized information, lack of enterprise-wide uniform and strict data rules and lack of awareness. Some of the most common data problems are the following:

I. Incomplete or inaccurate name and address combination
    a. A company can be in multiple locations when we refer to international businesses. Even if the supplier name is accurate, unclear information prevents the users from identifying which company's site is a supplier of the company.
    b. A location, such as a business park, can have multiple companies. The address is not adequate to identify a supplier.
    c. The same building, thus the same street name and number, can have many companies. Full address information is needed.
    d. A company might has changed its location. This need to be reflected in every system.

II. Incomplete address information
    a. All the data elements that comprise a full address description should be part of the supplier location. An example is the location identification using only the street name and number. This is an incomplete set of information, because the same street name and number can refer to an address in different countries or more than one times within the same country. The postal code needs to be included in the address as well.
    b. In some countries, when companies are located in industrial areas, business parks or rural roads, there is no street name and/or number to identify these locations. More information, such as the building name, needs to be included in the address description.
    c. When a company collaborates with suppliers from all over the world, it can be challenging to have a uniform supplier address database. Different countries have

different representation of sequence of the address information and some countries even lack a standardized system of addresses. For example, addresses in Costa Rica, can be 200 km west and 500 north of X Industrial Zone.

III. International name or address
    a. It is common that the name of address is in non-Latin characters, such as Arabic, Chinese, Cyrillic etc. This makes the supplier search difficult.

IV. Duplicated supplier records (same name and address)
    a. Some people within the company, either because of their location or their role in the organization, do not have access to all the supplier information. This results in creating the same supplier record again.
    b. A big problem is that people are not always aware of the importance of having a central source for the supplier master data. Some employees might work with suppliers directly and they practically know the supplier address and contact number by heart. Thus, they do not feel the need to share the information with the rest of the company. Lack of information for an existing supplier can lead to the creation of a new supplier record, resulting in inconsistent and duplicate supplier information.
    c. It is often that duplicates are created due to incorrect way of searching the suppliers and to the limited search options provided. People create new supplier records without checking if the supplier already exists or because they do not know how to check. It is also problematic when a system allows duplication.
    d. Multiple IDs for the same supplier in different ERP kernels increase the risk of duplicate creation.
    e. Not standardized way of entering information and complex or unclear data rules can result in non-easily identified supplier records. Supplier information can be in wrong fields or the information included in the fields can be vague. Abbreviations are often used. Moreover, the business types are not included, or they are presented in different ways (Microsoft Corp. vs Microsoft Co.).
    f. Typos or unnecessary punctuation marks.

When a company experiences some of these problems, a reactive approach is suggested. Common activities which can help organizations solve these issues, are data enrichment and data de-duplication. To enrich existing supplier records, a company needs to identify the records which lack the necessary data elements and to define a combination of data which fully and in any situation defines the location of the supplier. In order to achieve this, a combination of manual and automated processes is required. In some situations, the company needs to contact the supplier to verify the name and address.

Duplicated supplier information is often one of the biggest problems in companies with many data silos. A first step for a company to de-duplicate its supplier databases, is to identify supplier records with high similarity in the name, within the same or different systems. A survival record needs to be defined, and a de-duplication plan needs to be created, ensuring that the changes will be reflected to all systems. Following this, the company needs to define clear data rules and a certain format for entering name and address information, in order to maintain clean data.

Nevertheless, a reactive approach to supplier master data problems is not the optimal solution. A proactive mindset needs to be adopted by organizations to avoid these problems. The supplier related information is not only included in these two categories. A lot of information for multiple uses in different processes and in different stages of the supplier-organization collaboration, is created and stored in the company's systems. Thus, there is need for this information to be in a central place and with unified format and data rules, so that data redundancy and duplication problems can be eliminated.

1.4 Knowledge gap and problem statement

The knowledge gap identified in this thesis, based on review of previous studies, is that the existing literature is missing a supplier MDM maturity model. During the previous years, many MDM maturity models have been developed (e.g. Loshin, 2010; Kumar, 2010; Butler and Naidoo, 2011; Spruit and Pietzka, 2015; Zúñiga et al., 2018). These models aim to provide generalizable results or to explore MDM in a specific domain of interest. However, there is currently no maturity model that explicitly focus on the supplier domain.

It is said that the decisions the organizations make are no better than the data on which they are based on (Haug et al., 2009). Poor supplier master data can result in unnecessarily spent time and resources as well as in frustration of internal and external stakeholders because of long throughput times (Andreescu and Mircea, 2008). This study identifies the problems that organizations experience with the supplier master data in different processes and systems. There are several challenges associated with the cross-functional supplier related processes. Moreover, there is high complexity in the data flow within different stages of the supplier-organization collaboration. Companies can use MDM during the supplier data creation, storage, exchange and maintenance. The study raises the importance for the industry needs to be translated into meaningful factors that influence how organizations can successfully use MDM to manage the supplier master data problems and achieve consistent and accurate supplier information.

1.5 Thesis outline

This section provides an overview of the outline of this study, as presented in Figure 2. The first chapter of the thesis provides an introduction in supplier MDM and the needs and challenges of organizations. Literature search results that there is currently no assessment method for the supplier MDM and the study proposes the design of a model to determine a company's supplier MDM maturity.

The second chapter concerns the documentation of the research approach of this study. First, the research objective and research questions are defined. Following this, the maturity model development plan is presented, and the steps followed are explained based on the main decision points. Lastly, the Design Science Research (DSR) approach is introduced and the methods used to answer the research questions are presented.

The third chapter encompasses a systematic literature review. First, the existing body of knowledge is identified, including research in the maturity model development and MDM literature and discussion on previous MDM maturity models. Following this, a theoretical base is created based on selected articles and it is used to develop factors that influence MDM. Lastly, processing of the factors by conducting an expert survey, provide the requirements of the design, which are used as a framework to develop the maturity model in the fourth chapter.

The fourth chapter concerns the maturity model development. Semi-structured exploratory interviews are used to identify the needs and challenges of the case company in supplier MDM. Inductive data coding is used to analyse the interview data and develop factors that influence supplier MDM. The factors are then categorized into key concepts, dimensions and capabilities of supplier MDM maturity. The maturity levels are defined, and the components are combined into a maturity grid. Following this, the assessment tool is presented, and its use is discussed.

The fifth chapter is dedicated to the evaluation of the model based on its utility, efficacy and quality. After the evaluation approach has been developed, evaluative interviews are used to identify potential

improvement areas of the model. Some statements have been scored less positively than others. The model is improved incorporating the provided feedback.

The sixth and last chapter presents the conclusions of this study and the answers to the research questions. The reflection of the study is discussed based on the research approach followed, the choices made and the research outcome. The scientific contribution and the societal relevance of the study is explained, as well as the relevance of the research to the MOT studies. Finally, limitations of the study and recommendations for managers and for future research are discussed.

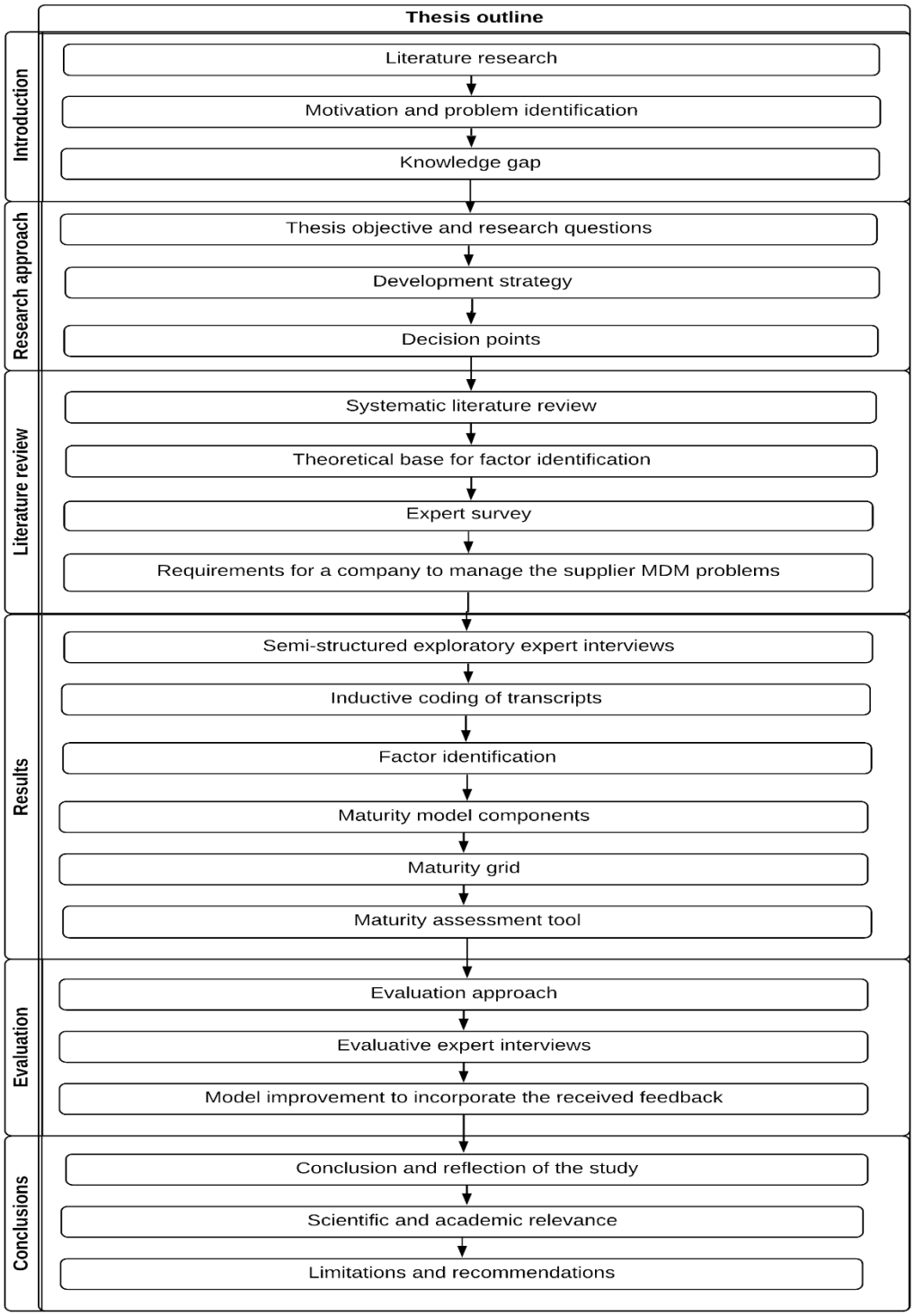

Figure 2: Thesis outline

Chapter 2: Research approach

2.1 Introduction

In this chapter the research approach is thoroughly explained. The first part presents the objective of the study and the research questions to be answered. The second part concerns the steps this study follows for the development of the model. Following this, the methods to answer the research questions are documented. Lastly, an extended outline of this thesis is presented.

2.2 Research objective and research questions

Based on the knowledge gap identified in the section 1.4, the objective of this study is defined. The objective of this study is:

The design of a model to determine a company's maturity in supplier MDM.

This model is designed to help organizations create and maintain consistent and accurate supplier information. This study follows the Design Science Research (DSR) approach for the formulation of the research questions. Each of the questions that the study is intended to answer corresponds to one of the five design science research phases: (1) the identification and explication of the problem, (2) the definition of objectives and requirements for an artefact, (3) the design and development of the artefact using the requirements, (4) the demonstration of the artefact and, (5) the evaluation of the artefact (Johannesson and Perjons, 2014; Peffers et al., 2007).

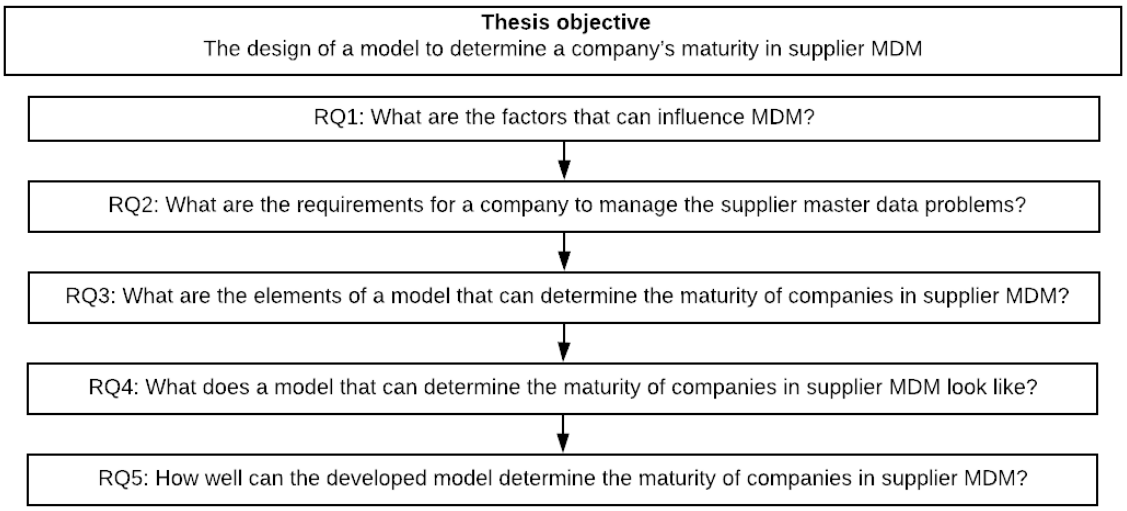

Figure 3: Research questions

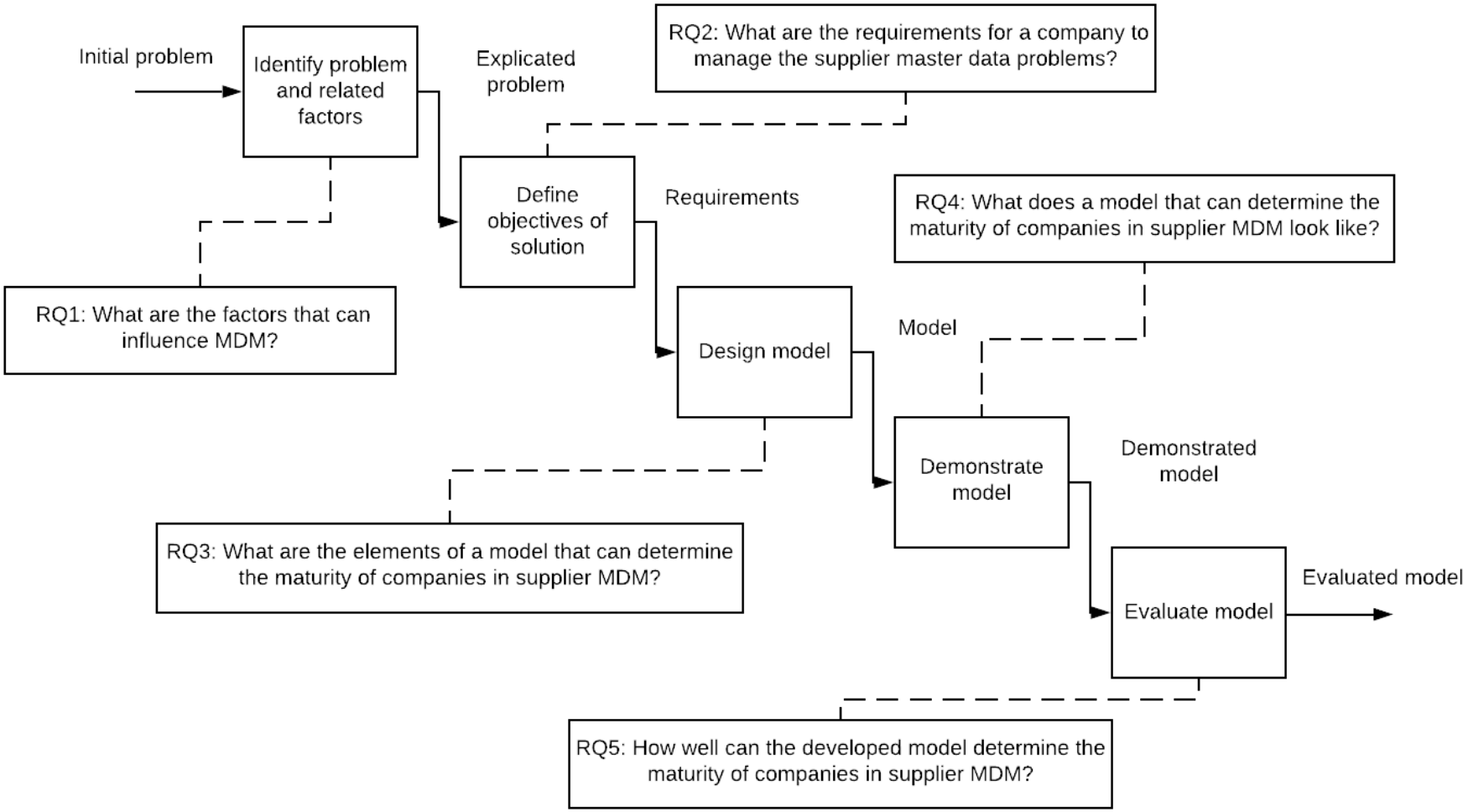

Figure 4: Design research phases and research questions

2.3 Maturity model development

For the development of the maturity model in this study, the input of methodologies as described by De Bruin et al. (2005), Mettler and Rohner (2009), Maier et al. (2012), Becker et al. (2009), Garcia et al. (2012) and Van Steenbergen et al. (2010) were consulted. In the following sections, the steps for the development and the decision choices are discussed. The development of the maturity model is based on the Design Science Research (DSR) approach (Hevner et al., 2004) and the procedure proposed by Becker et al. (2009) with respect to the DSR guidelines.

2.3.1 Maturity model development steps

Literature on the maturity model development is consulted in this study to ensure that the design method is in accordance with the academic requirements. Previous work has identified several methods for the development of maturity models. In this section, common elements of the proposed methods are defined and a procedure according to the purposes of this study is developed. The maturity model development in this study consists of five steps. The development starts with the identification of the objectives and scope and based on these decisions the development strategy is planned. Then the factors for the supplier master data management are developed and the model is designed. Afterwards, the developed model needs to be evaluated. The deployment and maintenance of the model are not in the scope of this study.

<table>
<tr><th>Model development steps</th><th>De Bruin et al. (2005)</th><th>Mettler and Rohner (2009)</th><th>Becker et al. (2009)</th><th>Maier et al. (2012)</th></tr>
<tr><td rowspan="2">Identify the objectives and scope</td><td rowspan="2">Scope</td><td>Problem identification and motivation</td><td rowspan="2">Problem definition</td><td rowspan="4">Planning</td></tr>
<tr><td>Solution objectives</td></tr>
<tr><td rowspan="2">Plan the development strategy</td><td rowspan="2">Design</td><td rowspan="4">Design and development</td><td>Comparison with existing maturity models</td></tr>
<tr><td>Determination of development strategy</td></tr>
<tr><td>Identify the factors</td><td>Populate components</td><td>Iterative maturity model development</td><td rowspan="2">Development</td></tr>
<tr><td>Design the model</td><td>Populate measures</td><td>Transfer and assessment</td></tr>
<tr><td>Evaluate</td><td>Test</td><td>Parameters configuration</td><td>Evaluation</td><td>Evaluation</td></tr>
</table>

Table 1: Comparison of the maturity model development steps

The development steps are presented in Figure 6. The first two steps concern the planning, the next two the development and the last one the evaluation of the model.

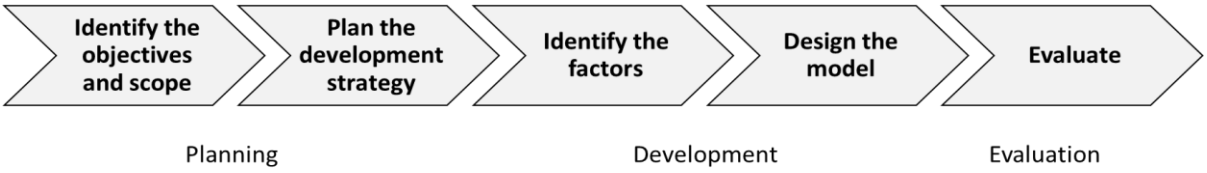

Figure 5: Steps of the maturity model development

2.3.1.1 Step 1: Identify the objectives and scope

The first step is to identify the objective of the design and to decide on specific parameters, such as the audience and scope of the design. Based on the objective of this study (as identified in section 2.2), the planning decision points, as proposed by Maier et al. (2012), are used for the first two phases of the development (Table 2).

Decision points	Decision options
Specify audience	Business process or master data managers in large international organizations
Define aim	Raise awareness among participants and evaluate their current practices
Clarify scope	Domain-specific: MDM in the supplier domain
Define criteria	Procedure for the development of maturity models (Becker et al., 2009)
	Structural and environmental qualities of the model (Johannesson and Perjons, 2014)

Table 2: Planning decision points

2.3.1.1.1 Scope

This study follows the work of Sivola et al. (2011), in which large companies are selected because of the greater amount of data. Sivola et al. (2011) support that in large organizations the master data management receives more attention since poor data can significantly affect the company's performance. Sebastian et al. (2017) refer to organizations as big when they have a mean size above 82,297. Moreover, organizations with global activities are within the scope of this study. Concluding, the scope is presented in Figure 6.

The companies within the scope of this study are:	Large
	International
	Toward a supplier MDM development program

Figure 6: Scope of the design

2.3.1.1.2 Audience

The study aims to develop factors that influence the supplier MDM in organizations within the scope of the study. These factors are used to develop a supplier MDM maturity model. The study is intended for master data managers. It is also intended for researchers and organizations that are interested in the factors affecting the planning and implementation of supplier MDM activities. These activities can be part of the master data management, supplier management or business information management in large and international organizations. Academics in the area of data management, IT management, business management and management of technology might also take an interest in this study.

2.3.1.1.3 Focus

As illustrated in Figure 7, different types of data refer to different activities in an organization. The transactional data refers to the business operational state, the analytical data refers to business performance and lastly the master data refers to the key business entities of an organization. The master data is further classified into customer, employee, product and supplier data.

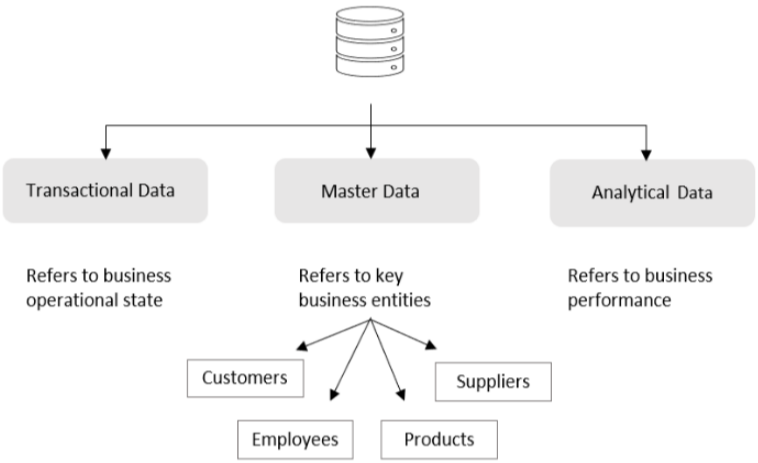

Figure 7: Types of data

This study focuses on the master data and specifically on the supplier domain. Further categorization by Cleven and Wortmann (2010), identifies three principal master data domains.

1) Party: Master data related to business partner information.
2) Thing: Master data related to the products, services and assets of an organization.
3) Location: Master data related to places, sites or regions.

The supplier information is part of the party and location master data. This study refers to supplier information as a set of data, such as the identification number, contact information and address, that represents the uniqueness of each supplier within the organization

2.3.1.2 Step 2: Plan the development strategy

The second step concerns the planning of the development strategy based on previous work and the available sources of information.

2.3.1.2.1 Model development guidelines

Becker et al. (2009) understand maturity models as artefacts and develop a catalogue of criteria for a design procedure that complies with the seven guidelines for design science, as proposed by Hevner et al. (2004). The study concerns these criteria for the maturity model development strategy (Table 3).

ID	Criteria for the maturity model development
1	Comparison with existing maturity models
2	Iterative model development
3	Evaluation of process
4	Employment of a variety of research methods
5	Identification of problem relevance
6	Problem definition
7	Targeted presentation of the results
8	Scientific documentation of process

Table 3: Criteria for the development of maturity models

The first criterion concerns "Guideline 1: Design as an Artifact" and "Guideline 4: Research Contributions" for the development of an innovative artefact that can contribute to the existing knowledge in the domain of interest. The second criterion is proposed based on the study of Peffers et al. (2007), which refer to the iterative development of the solution in the design science research. This can also be derived by "Guideline 6: Design as a Search Process" which suggests refinement and evaluation of the solution during its development. The sixth guideline combined with "Guideline 3: Evaluation", result in criterion three. The fourth criterion is developed based on "Guideline 5: Research Rigor", which support the use of multiple methodologies for the development of the solution. The criteria five and six concern the "Guideline 2: Problem Relevance", which refers to the relevancy of the addressed problem to the researchers and practitioners. Lastly, the criteria seven and eight reflect "Guideline 7: Communication of Research", which refers to the documentation of the process and communication of the results.

Regarding the model to be designed, a number of structural and environmental qualities, as defined by Johannesson and Perjons (2014), is selected for this study. A short definition of these qualities is presented in Table 4.

Qualities	Description
Coherence	The parts of the artefact are logically related
Conciseness	The absence of redundant components
Usability	The ease in use
Comprehensibility	The ease in understanding the artefact
Suitability	The extent to which the artefact is focused on the domain of practice
Expressiveness	The extent to which the artefact can represent the entities of interest
Customizability	The extent to which the model can be adjusted to specific users or needs

Table 4: Qualities of the model

2.3.1.2.2 Comparison with existing maturity models

After the problem has been identified and the purpose for the design has been explained, a first step for determining the development strategy is the comparison with existing maturity models (Becker et al.,

2009). Comparison with existing maturity models is necessary to plan the development strategy accordingly, either by advancing existing maturity models or by developing a new one (Becker et al., 2009). Garcia et al. (2012) use a preliminary activity diagram in the inception phase of the development strategy, as illustrated in Figure 9. Existing solutions were reviewed and a maturity model for supplier MDM could not be found in the existing literature. Therefore, this study focuses on the development of a new maturity model, as illustrated in Figure 8.

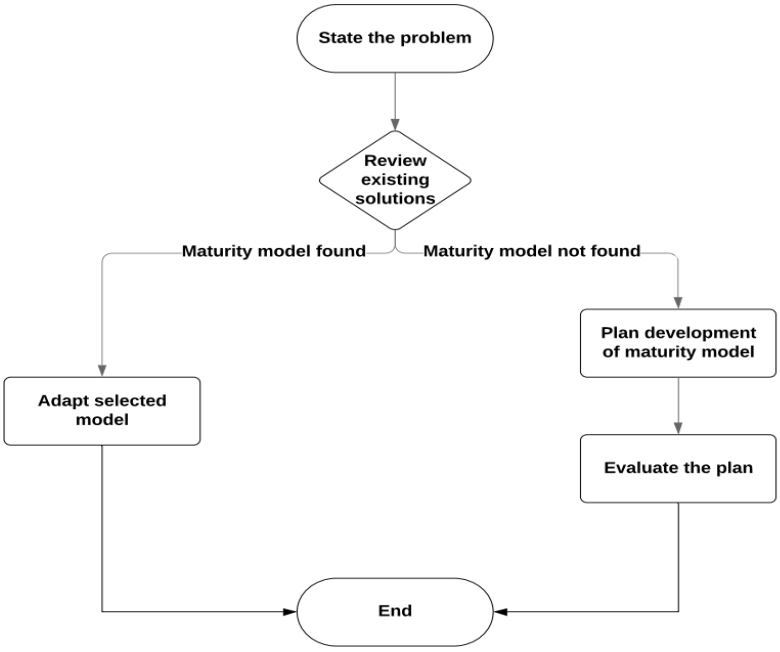

Figure 8: Comparison with existing maturity models

2.3.1.3 Step 3: Identify the factors

Following the development strategy, the third step concerns the identification of the factors that can influence supplier MDM in organizations within the scope of this study. These factors will be used to develop the components of the maturity model and finally the maturity grid and the assessment tool. Maier et al. (2012) suggest certain decision points that developers can use to decide on the design of the model. These decision points are used for the third and fourth phase of the development.

Decision points	Decision options
Select key concepts	The key concepts are formed based on the developed factors
Select maturity levels	Comparison of maturity levels used in previous MDM maturity models
Formulate cell text	Systematic literature review
	Expert survey and interviews in the case company
	Inductive coding of the interview data
Define administration mechanism	A non-exhaustive selection of factors
	A maturity grid
	A self-assessment questionnaire

Table 5: Development decision points

2.3.1.3.1 Iterative development of the factors

For the development of the factors, an iterative procedure is employed, as proposed by Becker et al. (2009), starting from the analysis of existing literature in the area through a systematic literature review. The next step concerns the selection of a limited number of these factors, based on the results of a survey with experts from the case company. The last step of the iterative development concerns semi-structured interviews, in order to evaluate the previous results and to generate new concepts. Towards the latter steps, the selection of factors is more targeted to the case company, whilst the first steps provide more generalizable results.

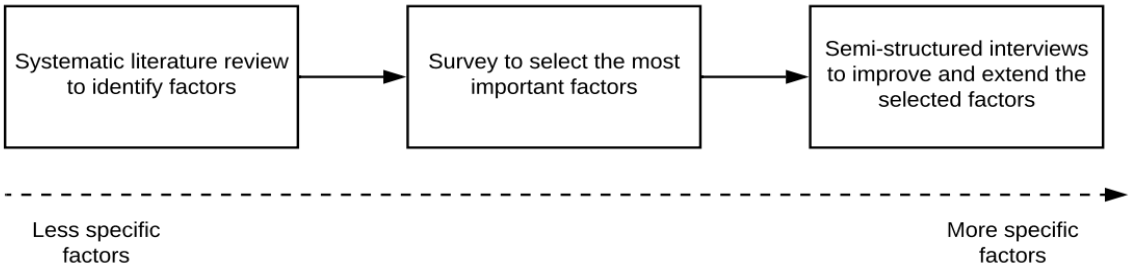

Figure 9: Iterative development of the factors

2.3.1.4 Step 4: Design the model

2.3.1.4.1 Elements of the model

Mettler and Rohner (2009) support that maturity models are not clearly defined based on the Design Science Research. However, numerous procedures for the maturity model design are proposed. Fraser et al. (2002) suggest that all maturity models share common elements, including the dimensions, the stages of maturity and description of the performance at each stage. Basic components of the maturity models are 1) a number of cumulative stages, usually three to six, 2) a name (descriptor) and a detailed description for each stage, 3) a number of key concepts, 4) a number of elements at each key concept, and 5) a clear explanation of the elements and the activities related to them at each stage (Mettler and Rohner, 2009).

The study follows this approach, focusing initially on the development and selection of the elements. The elements in this study are formed based on factors which influence supplier MDM, as they are developed based on the literature review and the coding of the interview data. These factors are seen as “levers for change” (Maier et al., 2002; p.154) and based on them the key concepts are formed (Maier et al., 2012). Each key concept is comprised of a number of dimensions, which result from categorization of the factors. Each dimension then provides five supplier MDM capabilities, which describe the performance of companies in these dimensions. Lastly, the maturity levels are defined to represent the developed supplier MDM capabilities.

2.3.1.4.2 Iterative development of the model

The procedure followed to develop the elements of the model in this study is illustrated in Figure 10. The first steps concern the collection of factors that can influence MDM. Following this, the analysis and inductive coding of the interview data provide new information for further development of the

factors. The next steps concern the categorization of these factors to develop the components of the model. Lastly, the components are combined and result in a maturity grid.

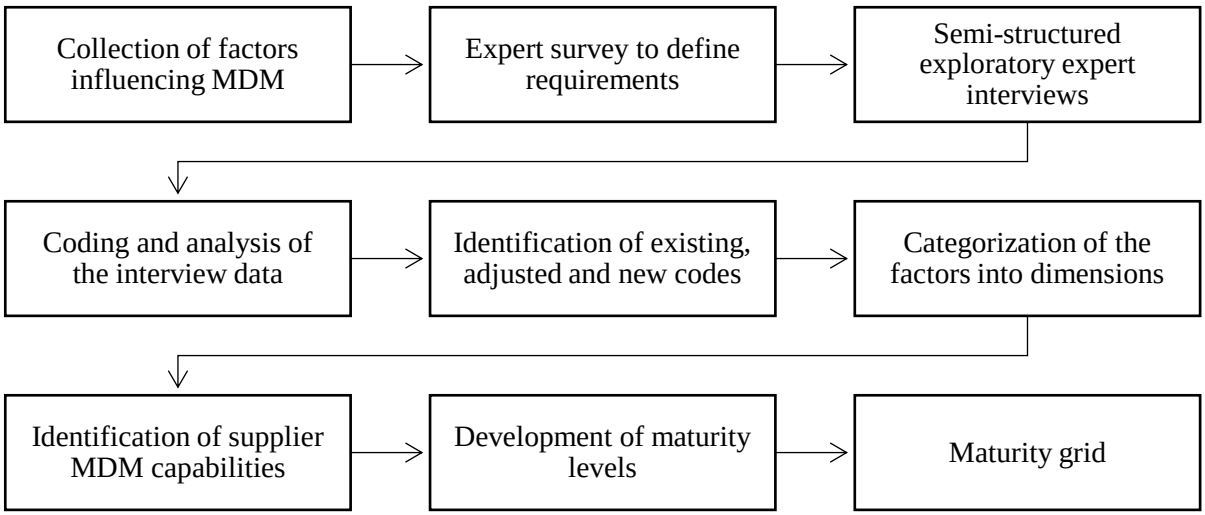

Figure 10: Process for the development of the model

2.3.1.5 Step 5: Evaluate

In the last step of the maturity model development, the decision points for the model evaluation are defined.

Decision points	Decision options
Subject of evaluation	Evaluation of the design process and the design product
Time frame	Ex-ante
Evaluation method	Naturalistic

Table 6: Evaluation decision points

2.3.1.5.1 Evaluation of the model

Venable et al. (2012) identify two types of evaluation of the artefact: the naturalistic and the artificial. A naturalistic evaluation refers to the performance of the artefact in its real environment, involving real users and systems. Methods in this evaluation vary from case studies to field studies and surveys. The naturalistic evaluation can increase the internal validity of the design. An artificial evaluation refers to the performance of the artifact outside of its real environment. This evaluation can be performed with laboratory experiments or mathematical proofs. The artificial evaluation aims toward higher scientific reliability, which can be achieved though "better repeatability and falsifiability" (p.6) of the design (Venable et al., 2012). Venable et al. (2012) further classify the evaluation into ex-ante and ex-post. Ex post evaluation is the evaluation of an artefact before its deployment and ex ante evaluation refers to an artefact that has already been deployed (Johannesson and Perjons, 2014). The model in this study is evaluated with experts within its environment. Moreover, the deployment of the model is out of the scope of this study and therefore the artefact is evaluated before its deployment. Thus, the evaluation is

naturalistic and ex-ante. This places the evaluation of this study in the top left quadrant of the matrix (Figure 11).

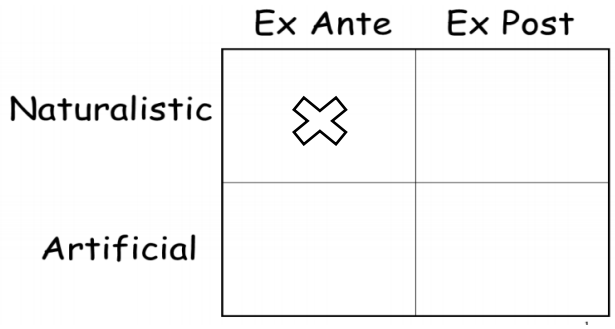

Figure 11: Dimensions for the design product evaluation (Adapted from Venable et al., 2012)

2.3.2 Design science research in the maturity model development

As it has been already discussed in previous sections, the model in this study is developed in accordance with the DSR guidelines as described by Hevner et al. (2004). According to March and Smith (1995), DSR aims at the development of artefacts to improve the problem-solving capabilities in the area they are utilized. These artifacts can be constructs, models, methods, and instantiations (March and Smith, 1995). Mettler and Rohner (2009) support that maturity models in information systems are in-between models and methods. A model reflects the status-quo of a specific application domain (Mettler and Rohner, 2009), which in maturity models is the definition of the predefined maturity levels and factors of the research area. A method proposes a systematic way for improvement (Mettler and Rohner, 2009; Brinkkemper, 1996).

The artefact to be constructed in this study is a maturity model for the evaluation of the supplier master data management. The maturity model development based on the design science approach is targeted toward the identification of solutions in unsolved problems (Hevner et al., 2004, Mettler et al., 2009). Becker et al. (2009) understand maturity models as artefacts which intent to solve organizational problems by identifying the capabilities of companies in order for improvement actions to be proposed. They therefore place maturity models within the application area of the DSR guidelines developed by Hevner et al. (2004) and propose a procedure for the development of maturity models, which is prerequisite for successful design of the model in this study. The study takes also into account the design science phases (Johannesson and Perjons, 2014; Peffers et al., 2007) for the identification of the research questions.

DSR suggests the use of theories and methods to provide theoretical grounding for the artefact (Walls et al. 2004). These theories are referred to as kernel theories. However, not everyone considers the use of kernel theories necessary to establish the rigor of artefact construction (Fischer et al., 2010). Hevner et al. (2004) suggest that the need of an IS knowledge base to construct design science artifacts, but not necessarily the use of a kernel theory. Goldkuhl (2004) supports “I do not conceive kernel theories (explanatory theories) to be indispensable parts of design theories” (p. 66). Lastly, March and Smith (1995) do not refer to the use kernel theories in the construction of the artefact. This study uses a theoretical base to develop the supplier MDM factors and the components of the model, and the design is not based on a kernel theory.

2.4 Methods used in the study

The study is a qualitative dominant mixed methods research, while quantitative data collection and analysis will be incorporated in an otherwise qualitative research. According to Johnson et al. (2007): "Qualitative dominant mixed methods research is the type of mixed research in which one relies on a qualitative, constructivist-poststructuralist-critical view of the research process, while concurrently recognizing that the addition of quantitative data and approaches are likely to benefit most research projects." (p. 124).

Mixed research is used in this study, as a synthesis that includes ideas from qualitative and quantitative research. Systematic literature review and a single-case study are employed for the identification of the factors influencing the supplier master data management. Qualitative research often use open-ended strategy for obtaining the data, allowing for flexible inquiry and adaptation of the questions to the interviewee's particular experiences. This helps to better understand the uniqueness of each interview (Elliott and Timulak, 2005). Grounded theory research is used in this study for the analysis of the case study information. (Corbin and Strauss, 1990). Dooley (2002) and Eisenhardt (1989) support that a case study can combine both qualitative and quantitative methodologies. Therefore, the study addresses the research questions combining different data collection methods; qualitative data through the literature review and expert interviews and quantitative through the data collection and analysis of the questionnaire survey and the analysis of the evaluation results.

2.4.1 Research questions and research instruments

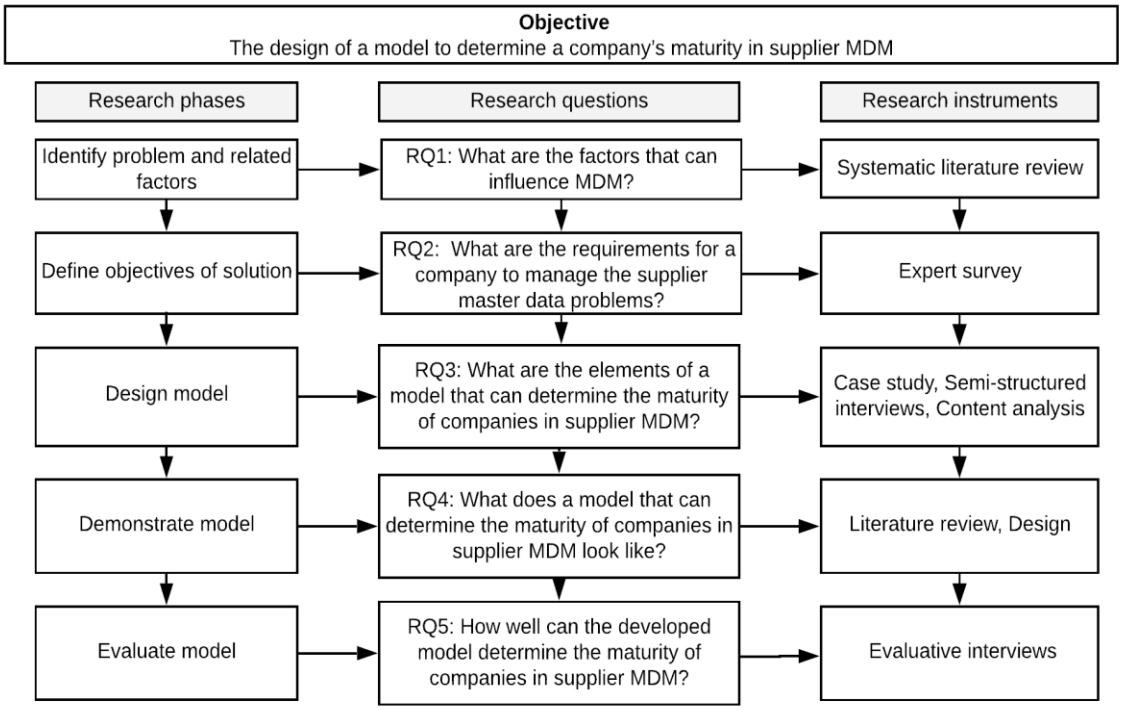

Figure 12: Research flow

2.4.1.1 Research question 1: What are the factors that can influence MDM?

This question concerns the development of a theoretical base for the maturity model design. The current literature is missing studies that specifically address the supplier MDM. Therefore, this phase of the design concerns the analysis and synthesis of the factors identified in ten selected articles in the area of MDM, through a systematic literature review. The outcome of this activity is a set of factors that influence the MDM.

2.4.1.2 Research question 2: What are the requirements for a company to manage the supplier master data problems?

To answer the second research question an expert survey is conducted. The experts are invited to rate the MDM factors identified in the first research question, according to the importance for the supplier domain and the highest rated factors are selected. The result of this activity represents the requirements for the maturity model design, and it is used as a framework for the development of the supplier MDM factors.

2.4.1.3 Research question 3: What are the elements of a model that can determine the maturity of companies in the supplier MDM?

The first part in this phase of the design concerns the development of the supplier MDM through a single-case study. Nine semi-structured interviews are conducted to understand the needs of the case company in the area of supplier MDM. Following this, the interview transcripts are analysed though inductive coding of the raw data and three types of codes are identified: existing, adjusted and new. The theoretical base defined in the previous research questions is used for theory-driven coding of the interview data, resulting in a set of existing and adjusted codes. This is followed by data-driven coding aiming to identify new codes for the study. The codes are combined and comprise the supplier MDM factors. During the second part, the factors are categorized into key concepts and dimensions. Each dimension provides a set of supplier MDM capabilities, which describe the performance of the organizations. Lastly, the maturity levels are defined based on the supplier MDM capabilities.

2.4.1.4 Research question 4: What does a model that can determine the maturity of companies in supplier MDM look like?

After the elements of the model are developed, this question concerns their combination toward the development of a maturity grid. Following this, the assessment tool is presented and an example of its use is provided.

2.4.1.5 Research question 5: How well can the developed model determine the maturity of companies in supplier MDM?

The last question of the study is about the evaluation of the design. Expert interviews are conducted to evaluate the qualities of the model, as defined by Johannesson and Perjons (2014), and to assess the model's quality, utility and efficacy (Hevner et al., 2014). Following this, the model is improved, incorporating the provided feedback

2.5 Thesis outline (extended)

The extended outline of this thesis is presented in Figure 13, including the main steps followed. The figure illustrates the structure of the study, the DSR phases and the maturity model development steps.

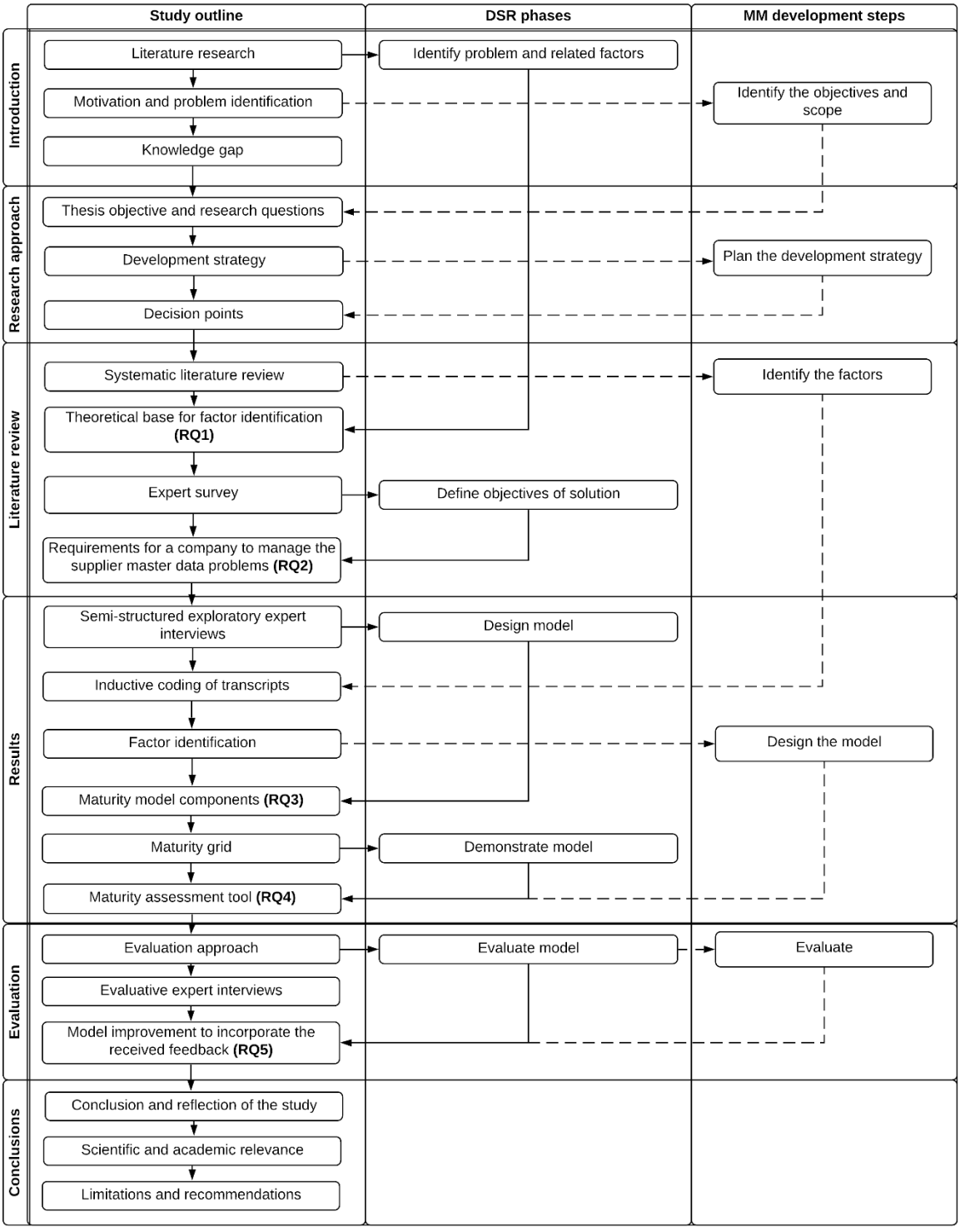

Figure 13: Thesis outline (extended)

Chapter 3: Literature review

3.1 Introduction

This chapter aims to answer the first two research questions. A systematic literature review is followed. The first part of the review provides an analysis of the approach that is used to conduct this literature review. In the second part, relevant concepts for this study are explained and previous studies are discussed. The third part presents a selection of factors that can influence MDM and define the theoretical base of this study, answering the first research question, namely: "*What are the factors that can influence MDM?"*. In the fourth and final part of the literature review, the factors developed in the first research question are used as a framework to identify requirements for the supplier MDM from an expert survey. The selected set of factors is the final product of the systematic literature review, which provides answer to the second research question, namely *"What are the requirements for a company to manage the supplier master data problems?"*.

3.2 Literature review approach

At this section the input of methodologies as described by Kitchenham et al. (2009), Levy and Ellis (2006) and Webster and Watson (2002) is used. A systematic literature review is important so that critical knowledge gaps are recognized to identify questions for further investigation (Kitchenham, 2004; Webster and Watson, 2002). Moreover, it can be used to develop a structured framework for new research activities (Kitchenham, 2004). The study follows Levy and Ellis (2006), which suggest a three-step literature review process, which are the 1. inputs, 2. processing and 3. outputs of the review. The detailed process followed in this study is illustrated in Figure 14, and thoroughly explained in the next sections.

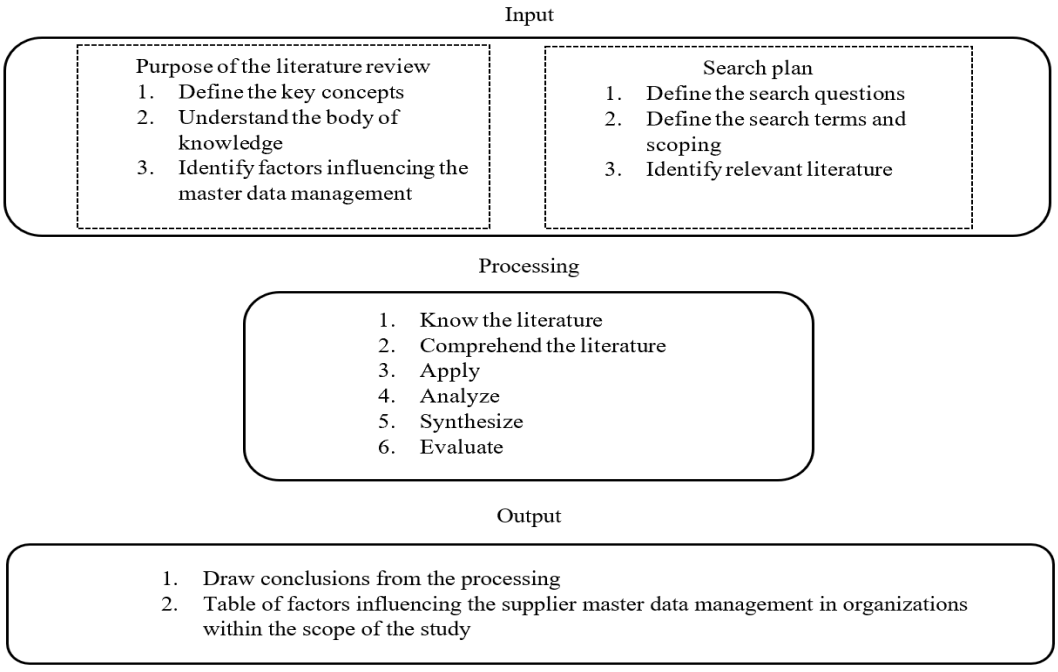

Figure 14: Literature review approach

3.3. Systematic literature review

3.3.1 Input phase

3.3.1.1 Define the purpose of the literature review

The input phase starts by explaining the motivation for the literature review, as proposed by Webster and Watson (2002). The purpose of a systematic approach for this study is first to develop a solid theoretical basis (Levy and Ellis, 2006). Second, it is used to understand the existing body of knowledge (Levy and Ellis, 2006). Processing of the input results in a collection of factors that can influence MDM. Then, the theoretical base developed is used to identify the requirements of the design. Lastly, the output of this literature review is a framework that can be used to identify the supplier MDM factors.

3.3.1.2 Develop a search plan for the literature review

A second part of the input phase is the search phase. Kitchenham et al. (2009) suggests that clear documentation of the search strategy is a significant part of the systematic review so that readers can access its thoroughness and completeness. The study combines guidelines from existing literature for a well-documented search plan, and the steps followed in this part are documented below:

3.3.1.2.1 Define the search questions of the study and relevant concepts related to the search questions

After the rationale of the literature review has been defined (RQ1 and RQ2), the questions that the review is intended to answer are presented (Kitchenham, 2004). The search activities are summarized in the following five questions: 1. How can master data management be defined?, 2. What are the maturity models?, 3. What are the existing maturity models for master data management?, 4. Which factors influence the master data management according to previous studies?. The first four questions are used to define the existing body of knowledge and the concepts of this study, as proposed by Levy and Ellis (2006). The fifth question aims to answer the first research question and to propose a framework for the next steps of the model development.

3.3.1.2.2 Define the search terms and scoping of the study

Based on the search questions, several keywords were used and combined to find relevant literature. The search terms are: management, supplier information, master data management, supplier master data, data quality, data governance, data architecture, data integration, one master data, master data management maturity model, factors, conditions, benefits, challenges, barriers, success and combination of these.

3.3.1.2.3 Identify relevant literature

This study follows Webster and Watson (2002) who recommend a structured approach for defining the relevant literature. They suggest that an author first needs to determine some major contributions on the topic. Following this, this study goes backward in literature, to review prior work that has been used for the key articles. The author can also go forward in literature to explore articles that has cited the key articles. This study follows this approach using as key articles, the MD3M: The master data

management maturity model by (Spruit and Pietzka, 2015) and the Managing one master data – challenges and preconditions (Jonker et al., 2011).

The first four search questions of this literature review define the key topics of the selected articles: MDM, maturity model development and existing MDM maturity models. This study aims to answer the fifth search question by exploring MDM related articles and previous maturity models. In addition to this, the search for master data management factors was further extended to (master) data governance, (master) data quality and (master) data architecture (Figure 15). Moreover, articles which explore MDM from an enterprise scope and discuss the practitioners' experiences with the supplier master data are prioritized in the selection phase of this study.

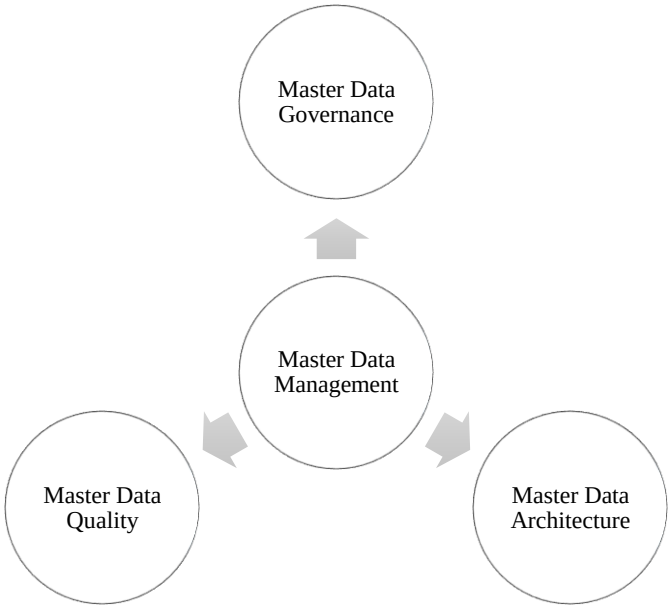

Figure 15: Concepts used to develop the theoretical base

3.3.1.3 Identify the key concepts and existing body of knowledge

This part provides the explanation of the main concepts that comprise the body of knowledge of this study. First, the concept of master data management is explained. Following this, the development of maturity models is discussed. Lastly, the study focuses on the maturity models that have been specifically designed for the MDM.

3.3.1.3.1 Master data management

The master data management (MDM) is the management of the key data objects of the organizations, referred to as master data. (Vilminko-Heikkinen and Pekkola, 2019). The master data represents core business entities, such as the customers, products, employees and suppliers, on which the activities of the organization are based on (Spruit and Pietzka, 2015; Loser et al., 2004). Vilminko-Heikkinen and Pekkola (2019) define master data as "the most important, trusted, and unique version of enterprise data" (Vilminko-Heikkinen and Pekkola, 2019; p. 77). This type of data is created once and is rarely being changed (Spruit and Pietzka, 2015; Knolmayer and Rothlin, 2006). However, there is not a universal definition of master data, since it can be understood in different ways among different organizations or systems (Jonker et al., 2011).

Organizations of a significant size often deal with the question of how to manage information from different sources in a centralized manner (Sivola, 2010). Berson and Dubov (2007) define master data as the information that "has been cleansed, rationalized and integrated into an enterprise-wide system" in order to be used across multiple business processes. Many business processes and transactions depend on the availability and accuracy of the master data (Knolmayer and Rothlin, 2006). However, master data is often fragmented and distributed across numerous databases and silos (Knolmayer and Rothlin, 2006; Vilminko-Heikkinen and Pekkola, 2019). Thus, "master data frequently lack not only consistency but also immediacy" (Loser et al., 2004; p.1). MDM is used to "support capturing, integrating, and sharing accurate, timely, consistent, and complete master data" (Vilminko-Heikkinen and Pekkola, 2019; p.77).

MDM enables enterprises to combine and associate their master data to a single reference platform and provides a single source of truth (Haneem et al., 2017). Smith and McKeen (2008) refer to master data management as a process for providing a unique set of guidelines for the management the key company data in order to create a consistent and unified view. According to Tuck (2008), MDM helps organizations "to exploit the value of their data assets, regardless of where that information was collected" (Tuck, 2008; p. 218). A list of a selection of MDM definitions is presented in Table 8.

Recent research on the area of MDM, includes the study of Otto (2012), which presents a case study at Bosh organization, exploring the master data architecture design. Otto proposes four different approaches to the MD architecture: the analytical, transactional, coexistent and parallel approach. The same year, Van Unen et al. (2012) from the KPMG IT Advisory group, discussed the dos and donts of the matser data management, refering to common mistakes and misunderstandings in this area. One year later, Otto collaborated with Hubert and other authors towards a reference model for the master data lifecycle management, aiming to help organizations achieving higher quality master data (Ofner et al., 2013). The same year, Haug et al. (2013) conducted a study to identify barriers to high quality master data and explore the importance of these factors in different types of organizations. Allen and Cervo (2015) on their work for the multi-domain MDM, provided detailed guidance to businesses to plan and implement MDM development programs. Later, Puzey and Latham (2016) explored the problems and inefficiencies caused by poor quality master data, focusing on oil and gas companies. The same year, Knolmayer and Röthlin (2016) published their study on the impact of the quality of master data on distributed ERP systems. They resulted that the MDM strategy shall be in accordance with the business goals but shall also concern possible IT constraints. Haneem et al. (2017) conducted an extended systematic literature review, exploring common master data quality issues and how MDM can help in resolving them. The same year, Vilminko and Pekkola (2017) explored the challenges of companies in implementing MDM practices and identified 15 obstacles in total. The same authors two years later, published a study on the changes in the master data roles and responsibilities during the MDM development programs (Vilminko and Pekkola, 2019).

Source	Definition of MDM
Loshin (2010)	"Processes for consolidating variant versions of instances of core data objects, distributed across the organization, into a unique representation." (p.1)
Spruit and Pietzka (2014)	"The management of the consistent and uniform subset of business entities that describe the core activities of an enterprise." (p.3)
Vilminko-Heikkinen and Pekkola (2019)	"An ensemble of data management methods that target fragmented data, stored in numerous databases and siloes, and are orchestrated by key stakeholders, other participants, and business clients." (p.77)

Table 7: Definitions for MDM

3.3.1.3.2 Maturity models

Maturity models have flourished across multiple different domains after the concept of measuring maturity was introduced with the Capability Maturity Model (CMM) from the Software Engineering Institute (SEI) (Paulk et al., 1993). Since then, studies have shown that more than a hundred different maturity models have been proposed (De Bruin et al., 2005). As previously stated, maturity models are widely used "to assess the as-is situation of a company and to assign it a specific quality or degree of maturity" (Becker et al., 2009; p.213). Paulk et al. (1993) define maturity as "the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective." (p.4). Mettler and Rohner (2009) refer to maturity, citing the oxford dictionary by Simpson and Weiner (1989), as "the state of being complete, perfect or ready" (Mettler and Rohner, 2009; p.3). According to Fraser et al. (2002), maturity refers to well-understood and well-defined processes, supported by documentation and training.

Maturity models are described by Fraser et al. (2002) as a set of constructs which are used to define aspects of maturity of a design domain. They represent a specific category of models, which can support decision makers with organizational change and development processes, mainly in the area of information systems (Ofner et al., 2009). Typically, they consist of a domain model and an assessment model. The first presents a set of discrete units to be evaluated. The second comprises of the assessment dimensions for the evaluation of maturity (Ofner et al., 2009). Although there are different types of maturity models, "they share the common property of defining a number of dimensions or process areas at several discrete stages or levels of maturity, with a description of characteristic performance at various levels of granularity" (Fraser et al., 2002; p.3). Maturity models aim to define the stages of the improvement and indicate maturity pathways (Fryt, 2019). They can be descriptive, normative or comparative. Maturity models are descriptive when they are used for assessment as such. Maturity models can also be normative when they indicate ways to grow maturity levels and provide improvement roadmap and guidelines. Lastly, there are comparative maturity models which are used for internal or external benchmarking (Fryt, 2019).

Maturity models which are based on "the assumption of predictable patterns of evolution and organizational change" (Fryt, 2019; p. 53), suggest step-by-step evaluation of a company's maturity in the respected domain of interest and are called stages-of-growth models or stage models. This is the most common type of maturity models, such as the CMM model. According to Paulk et al. (1993), these models are used to specify a path of development of the design domain. Staged maturity models distinguish a number, usually 3 to 6, of generic maturity levels and each maturity level is associated with a number of activities. Staged models can be used for benchmarking. They place an organization at a maturity level by assessing the extent to which a number of processes are implemented (Van Steenbergen et al, 2010). However, there are also continuous models which are used to review "certain quality features" (Ofner et al., 2009; p.6) of the design domain at regular intervals and conclude to suggestions for improvement (EFQM, 2009). Van Steenbergen et al. (2010) proposes the focus area maturity models, supporting that the staged maturity model cannot sufficiently express the interdependencies between the processes. Focus area maturity model are based on the concept of incremental improvement by suggesting the development of a number of steps in the form of progressively mature capabilities.

Although maturity models usually provide a process improvement approach, there is no empirical evidence that an improvement in process maturity yields improvement in overall organizational maturity (Gomes et al., 2013). Meetler and Rohner (2009) support that internal and external factors may constrain the applicability of maturity models in a standardized version. Criticism on staged maturity models, in particular, refers to the fact that the step-by-step approach "oversimplifies reality and has no empirical basis" (Fryt, 2019; p 53). Additionally, these models consider only one single path for maturity growth, neglecting possible equivalent maturity paths (Gomes et al., 2013; Fryt, 2019).

Moreover, common base for critic is that maturity models indicate a direction toward a predefined end-state, without considering the possibility of evolution and change of the factors (King and Kraemer, 1984). According to Maheshwari et al. (2011), the translation of stages-of-growth models for maturity assessment and benchmarking purposes is not always easy. A "high-level growth path" (p. 74) is indicated, while there should not be uniform approach. Case specific customization is suggested to achieve more reliable results (Maheshwari et al., 2011).

According to Pöppelbuß and Röglinger (2011), there are too many maturity models that some of them are almost identical. Maturity models often lack empirical evidence to support the suggested maturity measures or a theoretical basis (Gomes et al., 2013) or clear documentation of the design process (Pöppelbuß and Röglinger, 2011). This study considers the criticism on maturity models and uses a systematic literature review and a solid theoretical base to develop the supplier MDM maturity model. The design process is clearly documented and supported by existing literature in the area of maturity model development and in the DSR approach. Supplier MDM is a highly complex topic, as it involves many cross-functional processes and it is influenced by many functions and departments within an organization. This do not allow for specific customization within the time frame of this study, as proposed by Maheshwari et al. (2011).

3.3.1.3.3 Previous master data management maturity models

Numerous maturity models have been developed during the last years for different purposes. This section focuses on the MDM maturity models for general application, starting from 2010 until the most recent studies. These models provide useful background knowledge for the development of the supplier MDM maturity model of this study.

In 2010, Loshin proposed the components MDM maturity model. Loshin (2010) considers the MDM application as a company's evolution "through a number of transitional information management stages" (p. 1). He develops six architectural levels: architecture, governance, management, identification, integration and business process management. Each one of these levels is comprised of a number of different aspects and guidelines for companies for developing an implementation roadmap based on them. Loshin's model has five maturity levels: initial, reactive, managed, proactive and strategic performance. According to Spruitz and Pietzka (2014), this model lacks granulated distinction within its elements. The same year, Kumar (2010) presented a high-level maturity model, based on five key areas. Kumar model has six maturity levels, ignorant, initial, isolated, organized, unified, and optimized. Each level of Kumar model has its own characteristic to be met. Criticism on Kumar's model includes the opinion of Zúñiga et al. (2018) which support that the model's areas are more aligned to a technical framework. Spruitz and Pietzka (2015) said that Kumar's model gives a good insight and prove of some experience in the topic.

One year later, Butler and Naidoo (2011) developed a maturity model addressing key focus areas of MDM: the profiling data source, the definition of a data strategy, the definition of a data consolidation plan and the maintenance and utilization of data. The model has four maturity levels: marginal, stable, best practice, and transformational. According to Spruitz and Pietzka (2015), the model provides only broad areas of interest, but it gives a good overview of the progress from inconsistent isolated ideas to department-wide solutions. Jonker et al. (2011) presented a maturity model for the effective master data management in organizations. Practical experience of KPMG's implementation of MDM models is incorporated into the model. The model has four domains (governance, process, content and systems) within three organizational levels (strategic, tactical and operational). The model introduces five levels to assess the quality of an MDM quality improvement project. Lastly, Spruitz and Pietzka (2014) developed a focus area master data management maturity model aiming at a generalizable model, incorporating previous more targeted approaches. MD3M has five key topics: the data model, data

quality, usage and ownership, data protection and maintenance. There are five levels of master data management maturity: initial, repeatable, defined process, managed and measurable, and optimized. Every maturity level has a description of achievements.

Model	Source
MDM Components and the Maturity Model	Loshin (2010)
MDM Maturity Model	Kumar (2010)
KPMG MDM model	Jonker et al. (2011)
Oracle MDM Maturity Model	Butler and Naidoo (2011)
MD3M: The master data management maturity model	Spruit and Pietzka (2015)

Table 8: Recent MDM maturity models

3.3.1.4 Identify factors influencing master data management

A selection of existing articles is consulted, and the factors derived from these articles are analyzed and processed.

3.3.1.4.1 Selection of articles

There are numerous articles exploring the management of enterprise master data from different perspectives. Four articles that refer to the master data management from an enterprise perspective are selected to develop the theoretical base for this study. The first article is from the KPMG IT Advisory group and discusses factors for effective MDM through the experience of the managers and advisors of the group in related projects (Jonker et al., 2011). The second is an article by Loshin (2010) for DataFlux, which explores MDM capabilities beyond the implementation of a set of best practices. In the last article, major challenges and common mistakes in the area of MDM are explained, again from the perspective of the KPMG IT Advisory group (Van Unen et al., 2012). The study uses this article by translating the challenges into factors that can possibly influence MDM in today's organizations. Lastly, the work of Sivola et al. (2011) is selected because it discusses MDM by exploring the challenges of large high-tech organizations.

There is also a significant number of articles presenting MDM maturity models. However, this study has different scope than the previously developed MDM maturity models and therefore the same factors cannot be used directly. One maturity model is selected for the development of the factors, from the work of Spruit and Pietzka (2014), who developed a generally applicable MDM maturity model.

The study identifies the risk of partly overlapping information in selecting factors from the same area of research. Thus, it intends the collection of a large and variant set of master data management factors and its component areas. The decision to extend the master data management articles and search more specifically for factors influencing the master data quality, governance and architecture is because the factors for these component areas have been selected from a different perspective and scope in previous research. The collected factors are discussed with experts in the area of the supplier master management in the case study organization, which fully satisfies all the requirements within the scope of this study. In this way, the factors in the component areas are explicitly selected for the purpose of this research.

With regards to the quality of master data, useful information is derived from the work of Haug and Arlbjørn (2013), who explore the barriers to master data quality. These barriers are translated into factors influencing the master data quality and by extension MDM in organizations. Silvola et al. (2016) further classifies data quality issues in issues related to the item, company, people and service/asset and supply chain management data. This study explores the supplier MDM and thus the factors related to

item, company and supply chain management data are selected. Lastly, the study follows the later work of Marco Spruit and consults a recent approach to the master data quality from Spruit and Van der Linden (2019).

Alhassan and Sammon (2019) introduce a theory building approach for the development of critical success factors for the data governance in modern organizations and present some interesting results. Moreover, design options for the master data architecture, as proposed by Otto and Schmidt (2010), are used for the development of the factors. A review of the selected articles and the main findings used in this study are presented in Table 9. After the selection of the articles, this study follows Webster and Watson (2002) and proposes a concept-centric approach for the processing of the selected articles, as presented in the Appendix A.

Article	Source	Main findings used in this study
Master Data Management: dos and don't	Van Unen et al. (2012)	• Challenges translated into master data management factors
Managing one master data - challenges and preconditions	Silvola et al. (2011)	• Master data management factors
Critical Success Factors for Data Governance: A Theory Building Approach	Alhassan and Sammon (2019)	• Data governance factors
Data quality assessment and improvement	Silvola et al. (2016)	• Data quality factors • Specify for item, company and supply chain management data
BIDQI: The Business Impacts of Data Quality Interdependencies model	Spruit and Van der Linden (2019)	• Data quality factors
Barriers to master data quality	Haug and Arlbjørn (2013)	• Barriers translated into master data quality factors
MD3M: The master data management maturity model	Spruit and Pietzka (2014)	• Master data management factors • Maturity levels
Effective master data management	Jonker et al. (2011)	• Master data management factors
MDM Components and the Maturity Model	Loshin (2010)	• Master data management factors
Enterprise master data architecture: Design decisions and options	Otto and Schmidt (2010)	• Master data architecture factors

Table 9: Articles used to develop the theoretical base

3.3.2 Processing phase

The second phase of the literature review is about the processing of the literature search results (Levy and Ellis, 2006). This study follows the steps of the processing phase proposed by Levy and Ellis (2006). It is first important to examine the literature and extract useful and meaningful information. The next step refers to comprehension of the literature which includes activities such as "summarizing, differentiating, interpreting, and contrasting" (Levy and Ellis, 2006, p.175).

Another important step in this phase is the classification of the selected literature. In the previous section, a concept-centric approach was followed (Webster and Watson, 2002). This part of the review presents an analysis and synthesis of the literature for combining different concepts and developing a comprehend approach on the master data management factors. In this step, a synthesis strategy is selected (Kitchenham, 2004) and thorough analysis of the selected literature leads to comparison, connection, combination, modification and integration of the factors, for the purposes of the study (Levy and Ellis, 2006).

3.3.2.1 Synthesis of the factors

The factors are classified into broader domains based on the categorization proposed in the selected articles. The categorization in this phase is only used for understanding purposes and it will not be used for the final design of the maturity model. All the factors derived from the 10 selected articles are integrated into the synthesis of the factors, either as dimensions, sub-dimensions or factors based on whether they are part of a broader category or not. This review identified 80 factors that can influence MDM (Tables 11-18). The result of this synthesis provide answer to the first research question, namely *"What are the factors that can influence MDM?"*.

Domain	Factors	Source
Policies	Standardized easy-to-follow data policies	Alhassan and Sammon (2019)
	MDM policy and strategy	Jonker et al. (2011)
	Common process descriptions	Jonker et al. (2011)
	Data rulebooks	Jonker et al. (2011)
	Guiding principles	Jonker et al. (2011)
	Focused and tangible data strategies	Alhassan and Sammon (2019)
	Business rules	Loshin (2010)
	Clear data processes and procedures	Alhassan and Sammon (2019)

Table 10: Synthesis of factors, Policies

Domain	Factor	Source
Data governance	Common role descriptions	Jonker et al. (2011)
	Established data roles and responsibilities	Alhassan and Sammon (2019)
	Managerial support	Jonker et al. (2011)
	Hierarchy management	Loshin (2010)
	Identity management	Loshin (2010)
	Data Usage	Spruit and Pietzka (2014)
	Data Ownership	Spruit and Pietzka (2014), Otto and Schmidt (2010), Jonker et al. (2011)
	Data stewardship	Loshin (2010)

Table 11: Synthesis of factors, Data governance

Category	Name	Source
Data model	Identity search and resolution	Loshin (2010)
	Record linkage	Loshin (2010)
	Conceptual master data model	Otto and Schmidt (2010), Van Unen et al. (2012)
	Master data mapping across system	Jonker et al. (2011)

	System and data landscape	Spruit and Pietzka (2014), Jonker et al. (2011)
	Master data object definition	Spruit and Pietzka (2014), Otto and Schmidt (2010)
	Master data operations	Otto and Schmidt (2010)
	Data object sheets	Jonker et al. (2011)
	Clear inclusive data requirements and standards	Alhassan and Sammon (2019), Loshin (2010)

Table 12: Synthesis of factors, Data model ,

Category	**Name**	**Source**
Data integration	Migration rules	Jonker et al. (2011)
	Migration plan	Loshin (2010)
	Conversion plan	Jonker et al. (2011)
	Synchronization rules	Jonker et al. (2011)
	Metadata management	Otto and Schmidt (2010), Loshin (2010)
	Data cleansing	Jonker et al. (2011)
	Merging and consolidation	Loshin (2010)
	Real time master data processing	Otto and Schmidt (2010)
	Application integration and synchronization service layer	Loshin (2010)
	MDM component service layer	Loshin (2010)
	Master data application topology	Otto and Schmidt (2010)
	Master data distribution	Otto and Schmidt (2010)
	Interface automation	Jonker et al. (2011)
	Business process integration	Loshin (2010)
	MDM business component layer	Loshin (2010)
	MDM system architecture	Loshin (2010)

Table 13: Synthesis of factors, Data integration

Category	**Name**	**Source**
Data quality	Master data lifecycle	Otto and Schmidt (2010)
	Delegation of responsibilities for maintenance of master data	Haug and Arlbjørn (2013)
	Data storage	Spruit and Pietzka (2014)
	Data believability	Silvola et al. (2016)
	Data security	Spruit and Pietzka (2014), Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data value-added	Silvola et al. (2016)
	Data accessibility	Spruit and Pietzka (2014), Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data accuracy	Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data relevancy	Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data timeliness	Silvola, et al. (2016), Spruit and Van der Linden (2019)

	Data completeness	Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data reputation	Silvola et al. (2016)
	Data consistency	Silvola, et al. (2016), Spruit and Van der Linden (2019)
	Data representation	Silvola et al. (2016)
	Data objectivity	Spruit and Van der Linden (2019)
	Data understandability	Spruit and Van der Linden (2019)
	Data conciseness	Spruit and Van der Linden (2019)
	Data quality technical rules	Van Unen et al. (2012)
	Data quality business rules	Van Unen et al. (2012)
	Data quality routines	Jonker et al. (2011)
	Data validation checks	Jonker et al. (2011)
	Master data control routines	Haug and Arlbjørn (2013)
	Assessment of data quality	Spruit and Pietzka (2014)
	Awareness of quality gaps	Spruit and Pietzka (2014)
	Rewards for ensuring valid master data	Haug and Arlbjørn (2013)

Table 14: Synthesis of factors, Data quality

Category	Name	Source
Monitoring	Preventive measures	Van Unen et al. (2012)
	Detective measures	Van Unen et al. (2012)
	Corrective measures	Van Unen et al. (2012)

Table 15: Synthesis of factors, Monitoring

Category	Name	Source
Organization	Employee competencies	Haug and Arlbjørn (2013), Alhassan and Sammon (2019)
	Organizational structure	Sivola et al. (2011)
	Organization embedding	Jonker et al. (2011)
	Information systems	Sivola et al. (2011)
	Culture	Sivola et al. (2011)

Table 16: Synthesis of factors, Organization

Category	Name	Source
Technology	Common tools	Jonker et al. (2011)
	Flexible data tools and technologies	Alhassan and Sammon (2019)
	Data quality tooling	Van Unen et al. (2012)
	Data integration tooling	Van Unen et al. (2012)
	Data governance tooling	Van Unen et al. (2012)
	User-friendliness of the software that are used to manage master data	Haug and Arlbjørn (2013)

Table 17: Synthesis of factors, Technology

3.3.2.2 Selection of the factors

The factors that could possibly affect the supplier MDM in organizations within the scope of this study is extracted from relevant literature in the previous section. In this section, three experts are invited to rate these factors, based on what can help the company with the supplier master data issues. The result

of this activity is presented in Appendix B, B1. The 50% highest rated factors were selected, based on the average score (Appendix B, B2).

3.3.3 Output phase

The third and last phase of this literature review concerns the output (Levy and Ellis, 2006). The result of the selection, according to the expert survey, is presented in Table 19. This provides answer to the second research question, namely *"What are the requirements for a company to manage the supplier master data problems?"*. This information will be used as framework in the following steps of the maturity model development, to identify the factors that influence supplier MDM.

Dimensions	Factors
Policies	• Standardized easy-to-follow data policies • MDM policy and strategy • Data rulebooks • Clear data processes and procedures
Data governance	• Established data roles and responsibilities • Data Ownership
Data model	• Record linkage • (Conceptual) master data model • Master data mapping across system • System and data landscape • Master data object definition • Clear data requirements and standards
Data integration	• Synchronization rules • Data cleansing • Merging and consolidation • Master data distribution • Business process integration • MDM system architecture
Data quality	• Master data lifecycle • Data believability • Data value-added • Data accessibility • Data accuracy • Data completeness • Data consistency • Data conciseness • Data quality technical rules • Data quality business rules • Data quality routines • Data validation checks • Master data control routines • Assessment of Data Quality • Awareness of Quality Gaps • Rewards for ensuring valid master data
Monitoring	• Preventive measures • Detective measures • Corrective measures
Technology	• Information systems

	• Common tools • Data quality tooling • Data integration tooling • Data governance tooling • User-friendliness of the software used to manage master data

Table 18: Output of the literature review

Chapter 4: Results

4.1 Introduction

This chapter concerns the design and presentation of the model. The third and fourth research questions are answered, namely *"What are the elements of a model that can determine the maturity of companies in supplier MDM?"* and *"What does a model that can determine the maturity of companies in supplier MDM look like?"*. First, a single case study is conducted to identify the factors that influence supplier MDM in organizations within the scope of this study. Following this, the components of the supplier MDM maturity model are developed, based on these factors. The factors are categorized into key concepts and dimensions. Each dimension is comprised of a set of supplier MDM capabilities. Based on these capabilities, the maturity levels are defined, and the elements are combined into a maturity grid. Lastly, a maturity assessment tool is presented.

4.2 Case study

The case study is used in this study as a method to determine the factors for the supplier MDM. The following sections provide information of the case study selection and the information sources used. Following this, the background of the case company is discussed, and the objectives of the company's current supplier MDM program are presented. The presentation of the case company follows the analysis of the expert interviews. First, the interview protocol is presented and then the methods used for the transcript analysis and coding are explained. The last part concerns the results of the transcript analysis and the processing and analysis of the developed factors.

4.2.1 Case study selection

Following on from the literature analysis, this study aims to understand how the supplier MDM is applied in practice. It is important to understand what the actual challenges for successful end-to-end management of the supplier information are. The supplier MDM concerns the management of a specific set of data and therefore the existing literature does not specifically provide the required information for this study. The study aims to explore the particular challenges associated with the supplier MDM in different systems and different stages of the supplier-organization collaboration.

This raises the need to 1) explore which of the factors that were derived from the existing literature better represent solutions to the supplier master data problems (theory testing) and 2) develop new industry-driven factors that reflects the needs of today's businesses (theory generation). Eisenhardt (1989) refers to case study as a research strategy employed to explore the dynamics present within single settings. Case study is used within the context of this thesis to test existing theory (Pinfield, 1986) and generate theory (Eisenhardt, 1989). Theory building from a case study is suggested when there is not adequate previous literature or empirical evidence (Eisenhardt, 1989; Dooley, 2002).

Case studies can include single or multiple cases (Yin, 2017). A single-case study is chosen for this thesis for the in-depth examination of the needs of the case study organization. Yin (2017) suggests using a single-case study when selecting a critical case for the studied theory. He supports that a single case study can be used to confirm, challenge and extend the existing theory. After the number of cases is selected, it is important to select an appropriate case for this study. According to Eisenhardt (1989),

there are two ways for selecting a case: the statistical and theoretical sampling. The selection of the case in this study is based on theoretical sampling, selecting a situation in which there are opportunities to fill theoretical gaps and extend existing theory.

Koninklijke Philips N.V. is selected as a case company for this study. Philips is selected mainly for two reasons. First, the company aligns with all the requirements within the scope of this study, as explained in section 2.3.1.1.1. Second, in the healthcare industry, the quality of supplier master data has great impact and thus more activities towards higher quality are expected.

Eisenhardt (1989) supports that the selection of cases is important to identify the generalizability of the findings. This study aims to design a maturity model incorporating the challenges of today's businesses regarding the management of supplier data. There are many perspectives that need to be considered in order to achieve this. A case company that adequately represents the problems discussed in Chapter 1 is selected. The selection criteria in this study are the following:

I. The case company experiences problems with the supplier information creation, storage and maintenance.
II. The case company is international and large.
III. The case involves supplier MDM practices and activities.
IV. There is an ongoing development program towards higher quality supplier master data.
V. The development program allows the participation of employees from different functions and departments.

4.2.2 Case study information sources

The case study conducted in the procurement department of Philips, in Eindhoven. The information sources used for the design of the maturity model are an expert survey and interviews within the Philips Supplier Lifecycle Management program. Other information sources were used for the exploration of the problems with supplier data and the identification of the need for this study. These include documents, archival records and observations. The sources presented in Table 19 are used for 1. the exploration of the supplier master data problems, 2. the development of the maturity model elements, or 3. both.

Information used in this study / **Information source**	**Problems with the supplier data**	**Elements of the maturity model**
Documents and archival records	√	
Semi-structured exploratory expert interviews	√	√
Structured evaluative expert interviews		√
Expert survey		√
Observations	√	

Table 19: Information sources

4.2.2.1 Documents and archival records

A case study is conducted in Philips, Netherlands. This provided the author with access to internal documentation, which allowed for the collection of some useful information for this study. The findings of this activity provided insights into the problems with the supplier data and the actions that the organization takes against these problems.

Type of information source	Information source used	Description
Power point presentations	Philips SLM Compendium	A detailed description of the objectives and activities of the SLM program, presented in 1013 slides.
	Philips SLM Handbook	A short description of the SLM program, in 67 slides.
Datasets	Philips Supplier Master Record Layout	Includes almost 700 supplier data fields, explained, analyzed and categorized.
	Datasets extracted from current master data tools	Datasets with duplicated, incomplete and/or incorrect supplier data.
Websites	Philips intranet	PDF files and text from the intranet, used to understand: • The structure of the organization • The connection of tools and processes • The vision and future objectives of the organization
	Philips Procurement Knowledge Center	Information sharing platform for all the procurement departments.

Table 20: Documents and archival records

4.2.2.2 Survey and interviews

During the case study, the author communicated with employees of Philips to explore the industry needs and get information for the maturity model design. First, a survey with three experts was conducted as a part of the second research question of this study. Following this, nine exploratory interviews with Philips employees from Poland and the Netherlands took place within a period of two-week, to provide information for the third research question. The selection of the interviewees was based on their functions, so that they have different experiences and view on the supplier master data. Lastly, two evaluative interviews were conducted with Philips employees from the Netherlands, to answer the fifth research question.

Type of information source	Function of experts	Experts
Semi-structured exploratory expert interviews	Sourcing & Project Specialist	Interviewees 1,4 and 8
	Procurement Business Process Expert	Interviewees 2,3 and 7
	Business Information Manager	Interviewee 5
	Supplier Account Manager	Interviewee 6
	Senior Platform Specialist	Interviewee 9
Structured evaluative expert interviews	IT Project Manager	Interviewee 1
	Business Information Manager	Interviewee 2
Expert Survey	Procurement Business Process Expert	Participants 1 and 3
	Procurement Business Process Owner	Participant 2

Table 21: Survey and interviews

4.2.2.3 Observations

The case study provided plentiful opportunities for communication with team members and employees from other programs and/or departments. Moreover, the author participated in several activities to help the company manage the supplier data problems. These activities provided information on the supplier MDM and hands-on experience on the problems experienced by the organization.

Type of information source	Approximate duration of the activities	Description
Participation in data migration activities	4 months	Data de-duplication and data enrichment activities.
Observations during team meetings	5 months	Team meetings to discuss the weekly progress of the team and set the new goals.
Development of a supplier MD relational model	3 months	Analysis of the Supplier Master Record Layout to connect all the information with a unique ID.
Cross-departmental communication	2 months	Communication with employees from other departments.
Communication with team members	5 months	Collaboration with employees of different functions within the Supplier Lifecycle Management team.

Table 22: Observations

4.2.3 Case study background

Royal Philips, headquartered in Amsterdam, is a Dutch multinational health technology company. Currently, it has two core divisions: Philips Consumer Health and Well-being and Philips Professional Healthcare. Philips employs almost 78,000 employees in more than 100 countries. The company generated EUR 18.1 billion sales in 2018 (Company - About | Philips, 2019).

Philips aims to revitalize its offerings and its way of working by adopting new technologies through an ongoing digital transformation program. Philips 6.0 has been introduced recently, which will focus on health technology aiming to improve the lives of its customers. A main pillar of Philips 6.0 is digitization, in which value is shifting from stand-alone products to solutions comprising systems, smart devices, software and services. This study aims to explore the master data management with regards to supplier information, and therefore the activities of Philips in this area will be the main focus of this section.

Before the introduction of the digital transformation program, the supplier data collection was unnecessarily complex for both Philips and its suppliers and the supplier data management model was missing automated control. A lot of processes and data transferals were managed manually and in different procurement departments which led to increased costs and inefficiencies. Moreover, each Philips function engaged with the supply base on its own terms and using its own data collection methods and data points. Therefore, during the purchasing cycle, 3783 data elements were collected via 74 data collection points to create or edit supplier records, in many disconnected processes and tools. Due to the hybrid system landscape and the silos of supplier databases, there were no holistic supplier data management.

The complex IT landscape and immature processes resulted in many supplier data quality issues. The data across the ERP kernels was highly heterogeneous which significantly slowed the operations and complicated reporting. Through the years, unique identification of suppliers became challenging. Multiple entries of the same supplier resulted from a great amount of vague, incorrect or incomplete supplier information. Findings showed that an approximate 30 percent of the supplier data were duplicated and 30 to 40 percent were obsolete. This resulted in 30 percent of the collected data to be available for further use.

Philips launched the Supplier Lifecycle Management program almost three years ago to have a central source of truth for all the supplier information. The program aims to create holistic, lean, simple and transparent supplier data management. This will be realized by an interconnected master data model with efficient processes, effective controls, which will be supported by a new IT architecture. The integration of a new ERP software with the existing systems will provide Philips with a common interface to overlook all supplier data under one view. Core aspect of the Philips vision is also the supplier engagement, which will be able to self- administer and maintain their own information via the new software. This can provide the company with a higher degree of confidence in the data. The desired outcome of this program is a profitable relation within and between the suppliers and the internal parties, to provide Philips customers with products and services of a better quality.

The success of the Supplier Lifecycle Management program in Philips highly relies on unique and accurate supplier records. A first and vital step towards this goal is the de-duplication of the existing supplier database and the enrichment and standardization of all the supplier information. This time-consuming process aims at clean databases with correct data which can reflect the needs of the company. Next step is the unique supplier identification across the Philips supply base and the company-wide harmonization and standardization of the data rules per supplier-related field. Following this, the correct supplier data needs to be migrated to the designated places. Lastly, clear processes are needed to maintain a clean database.

To deliver the Philips Supplier Lifecycle Management vision, a transformation program introduced six supporting pillars: governance, process re-design, data model and management, IT architecture, change management and performance management. Ten work packages were developed to support the processes within these pillars, which are the following:

1. The definition and design of the Supplier Lifecycle Management processes based on the principles of unique identification and self-registration of suppliers.
2. The simplification of the existing supplier master data model and re-definition of the supplier master record layout.
3. The analysis of the information related to the Supplier Lifecycle Management process gathered via different tools.
4. The development of a new solution of IT architecture which integrates the new ERP software into the existing systems.
5. The establishment of unique identification of suppliers in a tool agnostic way, both for legacy and new processes and tools.
6. The qualification and segmentation of suppliers based on different performance criteria.
7. The definition of purchasing and procurement controls
8. The monitoring of the business processes of suppliers to assess their performance.
9. The internal and external preparation and communication of all the changes.
10. The implementation of the new operating model and the identification of the data managers.

4.2.4 Supplier master data in the case company

In the case company, different supplier data is needed:

1. For different stages of the supplier-buyer collaboration. For example:
    - Identification: Name, Street, Time-zone, Tax number, PO Box, Language, etc.
    - Registration: Telephone number, Average number of employees, Net Turnover, etc.
    - Qualification: Supply type, Regulated authority, Conflict mineral status, etc.
2. For different data domains that defines a supplier's profile. For example:
    - Performance: Supplier innovation score, Savings last 12 months, etc.
    - Certification: ISO 14001, Safety incident history, etc.
    - Tax: Tax type, Tax country, VAT liability, etc.
3. For different processes of record. For example:
    - Perform supplier selection: Business partner qualification, Financial risk score, etc.
    - Collect supplier information: Name 1, Name 2, Golden Record Identification (GRID) number, etc.
    - Execute supplier segmentation: Quality risk class, Business partner entity type, etc.

Some of the main company's problems with supplier data, as well as the objectives of the company with regards to these problems, are presented in Table 23.

Problem	**Objective**
The processes for the supplier creation and maintenance need be in line with the company's procurement policies and directives. There is no unique place where all the guidelines are and not everyone is aware of the rules that need to be followed.	• A central source of evidence for all the local and global policies. • Both supplier and the company follow the official company's rules and they are aware of their importance.
The development program is not understantable by all the stakeholders. There is a gap between the description of the concepts and their implementation.	• Make the future system tangible and the planned changes understandable. • Get confirmation from the future users of the system for the proposed ideas and layouts.
There are different identification numbers for the same supplier in different systems. This results in many duplicates.	• Unique supplier identification across the company's supplier database all the local applications.
Intentional duplicates are allowed in different kernels for specific reasons.	• Clear guidelines for accepted and unaccepted duplicates.
In many suppliers' records the address information is vague, incorrect and/or incomplete. This situation prevents the unique identification of suppliers.	• Complete, correct and standardized address information of suppliers. • Governance to standardize address information.
The search options for existing suppliers into the system are not efficient. If the user fails to find a supplier, he/she will create a supplier duplicate.	• Extend search concept to all search relevant supplier data elements. • Create more intuitive search options.
The quality of the supplier master data is poor due to the hybrid system landscape and the lack of clear data rules. The use for the same field may vary across the ERP kernels.	• Develop a single source of truth for all supplier master data including clear and strict data rules per field. • Reduce the complexity of the data model.

There are many supplier duplicates within the ERP kernels. Duplicate is a supplier record if it has the same name and address. Moreover, the data across the kernels are highly heterogenous.	• Define one unique supplier record for all the supplier creation and maintenance processes. • Cleanse the data and develop correct and homogenous supplier data. • Enrich incomplete supplier records. • Remove the duplicated information.

Table 23: Problems in the case company

4.2.5 Expert interviews

Nine semi-structured expert interviews were conducted at Koninklijke Philips N.V. with employees involved in the program of Supplier Lifecycle Management. All the interviewees are experienced in the supplier master data management, having different positions in the organization: sourcing and project specialists, procurement business process experts, business information managers, platform specialists. The diversity of the interviewees was highly beneficial for this study, because they have different view on the data and the importance of MDM in organizations. These interviews were conducted between 17 July and 29 July of 2019. The interviews lasted 45-60 minutes. The interview questions were developed with respect to the challenges of organizations in supplier MDM, as discussed in Chapter 1. The interviewees were asked for permission for recording the interviews. The recordings were transcribed and analyzed. The developed transcripts were documented and coded. Table 24 provides the number and date of the interview, the role of the interviewees and their experience in supplier data management and/or master data management in Philips or outside.

Interview number	Interview date	Interviewee role	Interviewee experience
1	17-07-2019	Sourcing and Project Specialist	5 years
2	18-07-2019	Procurement Business Process Expert	32 years
3	18-07-2019	Procurement Business Process Expert	7.5 years
4	19-07-2019	Sourcing and Project Specialist	1.5 years
5	22-07-2019	Business Information Manager	2-3 years
6	23-07-2019	Supplier Account Manager	1 year
7	24-07-2019	Procurement Business Process Expert	3 years
8	25-07-2019	Sourcing and Project Specialist	3 years
9	29-07-2019	Senior Platform Specialist	7-8 years

Table 24: Information about the interviewees

4.2.5.1 Interview protocol development

The interview protocol (Appendix C) was developed in collaboration with the academic advisor for this thesis and the interview guidelines and questions were presented to members of the supplier lifecycle team program in Philips for further adjustments. Following this process, a pilot interview was conducted and then the final interview script was developed and used for the remaining interviews.

For developing the interview protocol, inputs from Castillo-Montoya (2016) and Jacob and Furgerson (2012) were used. Castillo-Montoya (2016) suggests a four-phase interview protocol framework: 1. Align interview questions with the research questions, 2. Develop an inquiry base conversation, 3. Ask for feedback on the developed interview protocol, and 4. Prepare the interview protocol.

Phase 1: Align interview questions with the research questions

With regards to the first phase, the aim of the interviews is to answer the second research question of this study, namely: What are the requirements for a supplier master data management maturity model?. The interviews are exploratory in nature and the interview questions seek answers on how a holistic and unified view on the supplier data can be achieved during the supplier-organization collaboration.

Phase 2: Develop an inquiry base conversation

A necessary ingredient for the maturity model developed in this study is to explore how supplier master data management is applied in practice. For this purpose, in-depth interviews with open-ended questions are used and the script is open to follow-up questions. Therefore, with regards to the second phase, the interview protocol is developed as a conversation to provide this study with an insight to the interviewees' experiences and ideas.

Phase 3: Ask for feedback on the developed interview protocol

The third phase suggests that the interview protocol is evaluated by a third person to be considered a reliable research instrument (Castillo-Montoya, 2016). In order to refine the protocol, feedback sessions with this study's supervisor were held after the interview protocol was developed. Feedback is used in this study to understand how comprehensive and clear the interview questions are. Interns in Philips Supplier Lifecycle Management program were asked to provide feedback. Lastly, a pilot interview with an individual with managerial position at Philips SLM team was conducted and the feedback received was considered before conducting the next interviews.

Phase 4: Prepare the interview protocol

After the interview protocol is developed, the following introductory steps are followed:

- Send invitation e-mail
- Schedule appointment with interviewees
- Send consent form to be signed by the interviewees
- Conduct the interviews
- Send e-mail to thank the interviewees for their participation

4.2.5.2 Interview transcript analysis

Coding technique is used in this study to evaluate and generate concepts from the interview transcripts (DeCuir-Gunby et al., 2011), following the grounded theory approach. Grounded theory suggests three types of coding, the open, axial and selective coding (Strauss and Corbin, 1990). This study uses open coding for analyzing the transcripts. Open coding is used to break down data in an analytic manner (Strauss and Corbin, 1990). It is also used for the "exploration the ideas and meaning that are contained in raw data" (DeCuir-Gunby et al., 2011; p.138-139). Labels are assigned to the selected data and similar information is grouped together (Strauss and Corbin, 1990). ATLAS.ti software is used to analyze the interview data, as suggested by Stafford et al. (2009). The procedure followed, resulted in three types of codes (Figure 16).

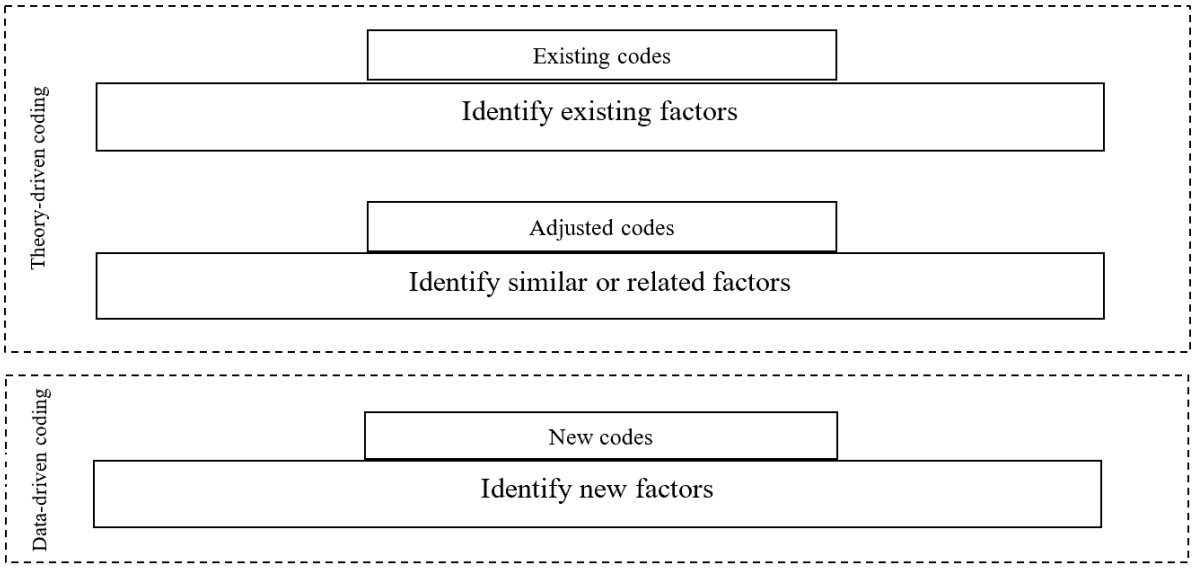

Figure 16: Coding of transcripts

The first step of the transcript analysis was to read each transcript sentence by sentence and follow theory-driven coding. DeCuir-Gunby et al. (2011) suggest coding as a way to assign codes to a set of raw data which have been previously defined. Theory-driven development of codes is followed to detect factors that had been previously identified through the literature review. The factors developed in the previous chapter of this study are used to define the set of codes for the theory-driven development phase. Two types of codes emerged during this process; the identification of existing factors and the adjustment of existing factors based on the interviews. The first refers to the situation where the interviewees described an identical concept of one of the previous factors, based on the description given by the respected article. However, according to DeCuir-Gunby et al. (2011), coding can be also used for data expansion, transformation and reconceptualization. Therefore, the second type of codes concerns the identification of concepts in the interview data which is a more comprehensive and/or improved and/or extended version of a previously developed factor. In this case, the factor as perceived by the interviewees were selected over the factor provided by literature, and the latter was adjusted.

The second step concerns data-driven development which aims to the development of codes that emerge from the raw data (DeCuir-Gunby et al., 2011). This technique is used to develop new codes that have not been identified during the literature review phase of this study. Some of these new codes were developed with "in vivo" coding, using labels created by the original words of the interviewees (Glaser and Strauss, 1967) and some of them where assigned with labels relevant to the concepts. The two steps of coding followed in this study resulted in the creation of a codebook, which is "a set of codes, definitions, and examples" (DeCuir-Gunby et al., 2011; p.138). DeCuir-Gunby et al. (2011) suggest the combination of theory- and data-driven codes to establish reliability, using Boyatzis's framework (Boyatzis, 1998) (Figure 17). Following this, when a concept was reoccurring, we used labels from the developed list of codes. This phase of the study resulted in a set of factors, combining new and existing information, which represent the factors that determine the maturity of organizations in the supplier master data management (Table 27).

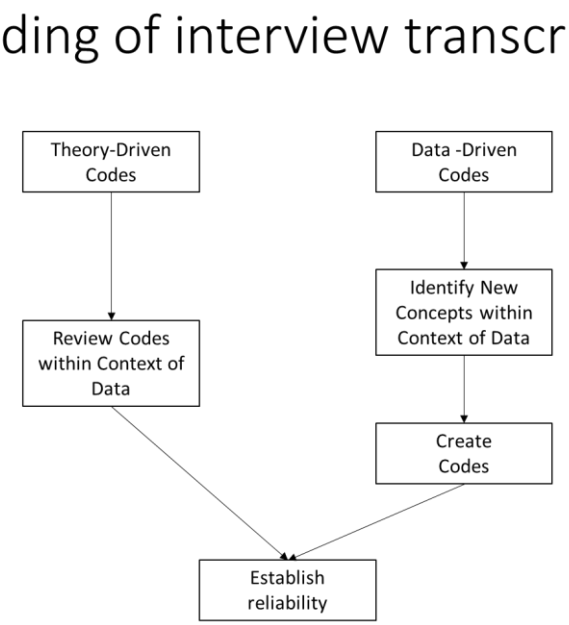

Figure 17: Codebook development (Adapted from DeCuir-Gunby et al., 2011)

4.2.6 Results from the transcript analysis

4.2.6.1 Problems with the supplier master data that resulted from the interviews

The problems that the case company experiences with the supplier data are already identified based on internal documents. However, the interviewees have different functions and perform different actions toward the improvement of the supplier MDM in the company. Thus, the understanding of the problems and the needs of the organization varies among different interviewees. The interviewees were invited to discuss the supplier data problems they have experienced while working in the case company (*Question 4: Did you experience any problems with the supplier data?"*) and their results are presented in Table 25.

Problem ID	**Problem**	**Example**
1	***Local supplier IDs***	"Each and every tool have a local ID and it's not always easy to identify if we speak about the same supplier from each and every tool." I7
2	***Intentional duplicates***	"In Philips there are multiple kernels and multiple company codes. Sometimes one supplier needs to have records created in all of the kernels…We have something that we call here intentional duplicate… Because sometimes it's very hard hard to tell whether this is duplicate that was created because of the mistake or whether it was intentionally duplicated." I4
3	***Inconsistent supplier data in different systems***	"We lack the consistency of supplier data between different systems. And as you know we have a lot of them. It might be the case that in one system we have one master data for one supplier, in another system we have different address, the name is not consistent…" I1
4	***Too many data silos***	"Because today or as the program was started there were too many silos in Phillips regarding supplier lifecycle management … we have more than 60 different IT tools which are using supplier master data and in every tool or in almost every tool you have to create the supplier master data again. There is no connection, everything is in silo always which then leads to multiple entries multiple time of effort to manage data to keep it in sync which is not efficient." I3

5	***Low supplier data quality***	"The improvement of data quality, consistency well the clearness of data so how are they clear for the standard user, fixing gaps in the processes but also fixing gaps in the in the data itself." I8
6	***Lack of global visibility***	Within every department that we have within Philips everybody worked with supplier master data in their own way. But in the end, it all needs to go together in SLP in our kernels for transactional purposes. Whilst we or we whilst most employees do not have access level of making extractions out of SLP tool for their own purposes the visibility for a global level was missing. So everybody looked in their own domain in their old file but never upon a global scale. I2
7	***Wrong supplier data***	"We do not have for all suppliers the correct address or the correct country information or sometimes we have it in different tools and there are not in sync and yes we have we have issues daily issues with wrong supplier master data." I3
8	***Incomplete supplier data***	"Not sufficient information from a supplier so only a city name in a country so incomplete the mandatory address, localization records, contact details from a key person within the supplier missing and also always treated as confidential so therefore not everybody could access that." I2
9	***Duplicated supplier information***	"Also, we have a big number of duplicates. Not only between systems, but also within each and every separate system." I1

Table 25: Supplier data problems in the case company

Following this, the supplier data problems, as presented by the interviewees, were related to three key supplier master data processes: 1. Create supplier (supplier onboarding), 2. Update supplier (supplier management), 3. Deactivate supplier (supplier offboarding).

Problem ID	Create supplier	Update supplier	Deactivate supplier
1	√	√	
2	√		
3	√	√	√
4	√	√	
5	√	√	√
6	√		√
7	√	√	
8	√	√	
9	√	√	√

Table 26: Categorization of supplier data problems in the case company

4.2.6.2 Supplier MDM factors that resulted from the interviews

The findings of the study are presented in Table 22. The table includes 1) the codes resulted from the theory- and data-driven coding of the interview transcripts, 2) the source of the codes (the interview number), 3) the type of the codes (existing, adjusted, new), 4) an example of relevant information discussed in the interview and 5) broader groups of the codes.

Group	Code	Source	Type	Example
Data	Data consistency	I1, I2, I4, I8	Existing	"We lack the consistency of supplier data between different systems. And as you know we have a lot of them. It might be the case that in one system we have one master data for one supplier, in another system we have different address, the name is not consistent, and we have so many IDs for one supplier in different

			systems that it causes a huge headache." I1
Data completeness	I3, I6	Existing	"Then really cleansing means checking which kind of supplier information do we already have. Is this valid, is it accurate, is this correct, and which one is missing? And then this has to be enriched and completed" I3
Relational master data model	I8	Adjusted	"Maybe for the data model but I'm not sure if this is connected a little bit though you have a record linkage so maybe I'm not sure if you talk about this but I would say that it is very important to have relational master data models. So, for example we know that the ID number 123 is linked to the other ID which is 856 within obviously the same or different tools. So, the data model should be relational basically." I8
Dashboard view of the supplier data in all kernels	I2, I6, I7	Adjusted	"With the dashboard you can see exactly, let's say the data between the tools… So you can easily check in which tool data is fault. So, I would add to monitoring just the dashboard. Dashboard view let's say" I6
Unique identification of the supplier data	I2, I3, I7, I6	New	"Because there are too many procurement tools in which one of those tools you have the supplier record and very often these records are not equal, are not the same in every tool" I6
Supplier involvement in the supplier data creation and maintenance	I4, I5, I6	Adjusted	"Maybe we can give the job working on the data quality on the supplier side. Like if they have self-managing tool then they will need to know that if they put correct data into the system then they will get money they will get paid and their business relation with Philips will be better…They will have this realization that depending on the data I put here it will have a direct impact on my relation with Philips basically" I4
Global visibility and accessibility of the supplier data	I2	Adjusted	"So everybody looked in their own domain in their old file but never upon a global scale. Seeing the benefits here now is that everything will be visible on a global level entering via one door and then being routed to the different systems in order to always speak about the same supplier master data." I2
Master data validation checks	I8	Adjusted	"I don't see quite difference between data quality routines, data validation checks and master data control routines. For me it should be in one and maybe it should be called basically MD validation checks and that's it." I8
Data harmonization and standardization	I3, I5, I7, I9	Adjusted	"Because it is also not possible to connect all the tools immediately, so you also have some requirements there which we have to fulfill, sometimes also the same supplier master data has different technical requirements. Name can be max 35 characters for example in other cases can be 100 characters." I3
Preventive measures	I6	Existing	"But you know on the other side having by definition, the cleanse theme is not the issue because the definition should be

				that you do not lead to the situation that you have dirty records in your database. So if you should do everything to prevent having this team." I6
	Data consolidation and centralization	I9	Adjusted	"When you are dealing with so many businesses each of them having their own version of the truth about vendor data, then you can imagine that we have a lot of issues in consolidating this information" I9
	Data conciseness	I1, I3, I4, I9	Adjusted	"So I would say ask supplier only once for what you need and try to ask only necessary things because I think that sometimes the suppliers is asked for things that are not necessarily important" I4
	Data accuracy	I2, I3, I4	Adjusted	"The most important in order to have the data quality. The supplier master data always starts with the data accuracy. Always. That's one because without that you cannot do your next steps." I2
	Data roles and responsibilities	I3, I4	Adjusted	"And then the data governance can also be merged with the policies. Sometimes you have a policy where the content is described but also the governance is described. Who owns which data and then also the rules and responsibilities. I think one role and responsibility is the ownership, so I think this is also a category of this one." I3
	Data rulebook	I4	Adjusted	"Yeah, but if we have one entry point then we need to have rules for the data. So each field that we create should have defined ruleset of what kind of values we can put into that and then also it should be approved somehow but with approval" I4
Processes	One gate for entering and maintaining all supplier information	I1, I2, I3, I4, I6, I8	New	"That means you need to identify all the open doors in every system, in every landscape in order to make sure that nobody is able to pollute the data again" I2
	Business process integration	I8	Existing	"So what is important first the integration of processes that are current, into a new model that will be obviously improved in many areas basing on the expertise of people that used to work with such systems or processes." I8
	Alignment and connection of the supplier related processes	I1, I2, I3, I5	New	"There are some problems. So more or less deal with the transitioning from being a non-centralized kind of architecture to a centralized architecture. Because once you have a centralized architecture more or less, you have some local things, or you have local configurations or local processes that are different and that need to be aligned with a centralized way of working. That is one of the major concerns or major constraints. In order to achieve this centralized way of working in the supplier lifecycle management." I5
	Valid path for supplier phase-out	I3, I4, I5, I6	Adjusted	"So, systems need to be connected so when we know that that we're not working with one supplier, when let's say phase him out in one system you want to

				make sure that that information will go to all the other systems… And for the case when we just want to switch the supplier I think that might not have big impact but what if we decided to phase out supplier because his quality was not good or I don't know he didn't follow this sustainability agreement that we had with him. That's a risk did that can occur with that." I4
	Clear and simple processes	I2, I4, I7	Adjusted	"They have to really know what they do. It should be simple for them. So not to create a complex process" I7
	Alignment of new supplier creation with the commodity strategy	I1	New	"But even before, we need to know whether having a new supplier is aligned with the commodity strategy. It might be the case that we might be in the program of reducing the supplier amount. So adding new supplier to the portfolio might not be required. That why we have approval by commodity managers when creating the supplier." I1
Change and communication	Support teams	I2, I8	New	"What is more we obviously will have to engage some supportive teams that would make sure that everything is going smoothly and on its right way." I8
	Training of users	I4, I6, I7, I8	New	"But also, the quality of data can be improved by providing good trainings for the users." I4
	Holistic model for change management	I2, I3, I5	New	"The second one was looking at the end goal process rather than the processes in silos." I5
	Incremental change	I2, I3, I9	New	"In implementation you have to do it step by step. So, it is not possible to do it with a big bang, implementing everything in such a global organization like Philips is. Then you have to do it step by step, department by department, cross-function by cross-function, IT tool by IT tool." I3
	Alignment of the interests of internal stakeholders	I7, I8	New	"The team itself consists of experts from different areas and fields of processes and different tools as well so the main thing is to integrate all those people." I8
	People awareness of processes and tools	I3, I8, I9	New	"It's very important to clarify the relation of these new tools with the existing ones to your users, especially when it's an add-on to these systems. Like what we do, this master data management, in most cases you bring something new not necessarily replacing something but just bring new tools that are supporting those users in getting clean data and keeping it clean. Then it is very important that you show them relationship between all those systems, the interactions and the interfaces all that comes with those introductions" I9
	People awareness of master data management	I3, I4, I6, I7, I9	New	"In the past they were only looking at their kingdom, at their own realm and I think also here Philips employees have to understand that they are part of a big global company and also the supplier master data re shared in the whole company " I3

Technology	Software compatibility	I1, I8	New	"Why Software A? The main reason for that is as I already mentioned that we have three maybe four modules in this platform and that it is probably the reason we selected Software A." I1
	User-friendliness of the software	I8	Existing	"It's coming from simple thing that we still lack, the instructions or nice look and feel, interfaces that will be easy that will show how to navigate in the tools." I8
	System settings	I1, I3, I9	New	"Maybe some kind of supporting features. Like I mentioned the duplicate check. Or some other notifications that can support you with maintenance of the supplier data expiration date of certificates, something like that. It is probably covered it with a more general term." I1
	System scalability	I5	New	"Speaking strictly in terms of technological process, I think scalability would be the first thing that needs to be considered before getting a new system or introducing a new system" I5
	System flexibility	I5	New	Second thing is to make sure how flexible it is because you have many systems, multiple ERPs and flexibility is one of the major concerns that makes you go slower it in terms of your digital maturity." I5
	MDM system architecture	I1, I3, I4, I6, I7	Existing	"So, I would say exactly the one entry gate. However, you have to remember that it should be connected with finance, with supplier quality, with legal, with risk management and so on" I6

Table 27: List of codes

4.3 Development of the supplier MDM factors

4.3.1 Processing of the factors

The factors that resulted from the second research question, namely *"What are the requirements for a company to manage the supplier master data problems?"*, were confirmed, advanced or adjusted to reflect the supplier data problems, using information derived from the exploratory interviews. The interviews were comprised of two parts. First, the interviewees were invited to discuss their experiences with supplier data problems and ways to manage these problems. Second, they were asked to express their opinion on the factors developed in the second research question, which resulted in confirmation, merging or deletion of some factors.

The analysis of the interview transcripts concluded in:

1) New factor development from the interview data
2) Adjustment of previous factors by
    - Changing of name and/or meaning
    - Merging
3) Confirmation of previous factors with two ways
    - Extracted from raw data
    - Evaluated by asking the interviewees if they agree
4) Deletion based on the suggestions of the interviewees

The first 3 categories are presented in Table 28 and represent the factors that are used in the model. The last category represents the factors that are not used in the model, as explained in Table 29. The explanation for all the factors that are used in this model, as reported in the existing literature and discussed during the expert interviews, is presented in Appendix E.

Factor ID	Type of factor	Name of factor	Comments
1	***New***	Unique identification of the supplier data	Created from raw data
2		One gate for entering and maintaining all supplier information	
3		Alignment and connection of the supplier related processes	
4		Alignment of new supplier creation with the commodity strategy	
5		Clear and simple processes	
6		Support teams	
7		Training of users	
8		Holistic model for change management	
9		Incremental change	
10		Alignment of the interests of internal stakeholders	
11		People awareness of processes and tools	
12		People awareness of MDM	
13		Software compatibility	
14		System settings	
15		System scalability	
16		System flexibility	
17	***Adjusted***	Relational master data model	Previous (Conceptual) master data model
18		Dashboard view of the supplier data in all kernels	Previous Detective measures
19		Supplier involvement in the supplier data creation and maintenance	Previous Data believability
20		Global visibility and accessibility of the supplier data	Previous Data visibility
21		Master data validation checks	Combination of Data quality routines, Data validation checks and Master data control routines
22		Data harmonization and standardization	Previous Data quality technical rules
23		Data consolidation and centralization	Combination of Synchronization rules, Record linkage, Master data distribution and Merging rules
24		Data conciseness	Merged with Data value-added
25		Data accuracy	Merged with Data cleansing
26		Data roles and responsibilities	Merged with Data ownership

27		Data rulebook	Combination of Clear data processes and procedures, Clear data requirements and standards and Data quality business rules.
28		Valid path for supplier phase-out	Merged with Master data lifecycle
29	***Existing***	Corrective measures	Confirmed by evaluation of the literature factors
30		Awareness of quality gaps	
31		System and data landscape	
32		Master data object definition	
33		Rewards for ensuring valid master data	
34		Data quality tooling	
35		Data integration tooling	
36		Data governance tooling	
37		Information systems	
38		Data consistency	Confirmed by raw data
39		Data completeness	
40		Preventive measures	
41		Business process integration	
42		User-friendliness of the software	
43		MDM system architecture	

Table 28: Factors that are used in the model

Factor name	**Explanation**
Standardized easy-to-follow data policies	"So, for policies I think what is important would be the last one, clear data processes. So when you have lets say clear and understandable data processes and procedures defined then I think everything else will follow from the factors in this column. Also data rulebooks is also important." I4
MDM policy and strategy	
Common tools	"Common tools...it doesn't really say anything. I would remove that." I9
Master data mapping	"So, record linkage and master data mapping across the system. I think this is the same." I3

Table 29: Factors that are not used in the model

4.4 Design of the maturity model

This section is meant to answer the third research question, namely "*What are the elements of a model that can determine the maturity of companies in supplier MDM?"*. First, the factors are categorized into key concepts and dimensions. Following this, each dimension is expressed by a set of increasing supplier MDM capabilities. Lastly, based on the developed capabilities, the maturity levels are defined. All the components are combined, and the maturity grid is presented.

4.4.1 Key concepts of the supplier MDM maturity model

The key concepts of this maturity model are decided based on the developed factors, which as previously stated are seen as "levers for change" (Maier et al., 2002; p.154) in this study. During the

analysis of the interview transcripts, four groups of codes emerged, which are used as the key concepts of the supplier MDM maturity model. These are the 1. data, 2. processes, 3. change and communication and 4. technology (Figure 18).

The first key concept concerns the activities that have direct impact on the quality of the supplier master data. The previous domain of data quality is extended to a more general term, incorporating also the governance and monitoring of data. The second key concept includes all the activities related to the decisions of the companies on the processes and procedures to be followed. Processes for successful master data management are discussed in previous literature and during the interviews in the case company, as well as ways that these processes can be coordinated and performed in the organization. The third key concept, namely communication and change, refers to introduction of new technologies for the management of the supplier MD and to the related changes in the way of working. It is first highly important that the need for these changes is well understood from all the stakeholders. It is also necessary that good communication is established within the members of the development team. Moreover, even after the successful implementation of change, there is a period of adaptation of the employees to the new conditions, when help and guidance by the company is required. Lastly, the key concept of technology concerns the desired characteristics of the software used and the MDM system.

Figure 18: Key concepts

4.4.2 Dimensions of the supplier MDM maturity model

In this section, the factors that are developed by answering the second and third research question of this study, are shortly described (full description is provided in Appendix E) and categorized into the dimensions of the supplier MDM maturity model. Therefore, each key concept includes a number of dimensions, which are defined based on the factors that they are comprised from.

4.4.2.1 Dimensions of data

Dimension	Factor	Description
	Data accuracy	The supplier data is correct and reliable.

Quality of supplier records	Data consistency	Data is the same and with same format across the all organization and for all the stages of the supplier-buyer collaboration cycle.
	Data completeness	There are no blank or incomplete supplier records.
	Data conciseness	The supplier records contain only the required information.
Uniqueness of supplier records	Unique identification of the supplier data	Every supplier is defined through a unique set of information, assigned to a unique identifier.
	Relational master data model	The company has a model describing all the supplier related data objects and their relationships.
	Master data object definition	Shared understanding on the supplier data is established across the organization.
Monitoring of supplier master data quality	Corrective measures	The company takes initiatives to solve the supplier data issues that are detected through data monitoring activities.
	Awareness of quality gaps	The company knows where the data quality problems are and the reasons why these problems arose.
	Master data validation checks	The supplier data is checked frequently for complying with the defined data quality regulations.
	Preventive measures	The company takes actions to prevent problems with the supplier data.
	Dashboard view	The company uses dashboards to monitor the quality of the supplier data in different tools and systems.
Unified view of the supplier master data	Data harmonization and standardization	The supplier data is in same format and under the same technical rules they can be consolidated without pre- or post-processing.
	Data consolidation and centralization	The supplier data is collected through all silos to a centralized database.
	Data rulebook	The data standards and the data rules for creating and maintaining the data are clear and well-defined.
	System and data landscape	The data landscape of the company allows for single representation of the supplier data elements.
Use and ownership of the supplier master data	Data roles and responsibilities	There is a solid role-based foundation that defines the accountability for how employees produce and use supplier master data.
	Global data visibility and accessibility	The supplier data is visible and accessible globally across the organization.
	Supplier involvement in the supplier data creation and maintenance	The suppliers can self-register and maintain their data.

Table 30: Dimensions of data

4.4.2.2 Dimensions of processes

Dimension	Factor	Description
One central gate for the supplier data	One gate for entering and maintaining all supplier information	All the supplier data can be created and maintained in one place.
	Valid path for the supplier phase-out	The supplier phase-out is performed in all the systems and tools across the organization.
Strategic alignment of the cross-functional supplier related processes	Alignment and connection of processes	All the cross-functional processes regarding the management of supplier master data are connected.
	Business process integration	The systems are integrated, and the supplier data is shared across the applications easily and with security.
	Alignment of new supplier creation with the commodity strategy	The supplier data need to be created when it aligns with the commodity strategy of the organization.
Simple processes within the supplier-organization collaboration	Clear and simple processes	Easy to understand and simple processes for the supplier data creation and maintenance.

Table 31: Dimensions of processes

4.4.2.3 Dimensions of communication and change

Dimension	Factor	Description
Change management pre-implementation	Holistic model for change management	There is clear view of the objectives and the needs of all the stakeholders involved and of all the actions that need to be taken in order for the development program to be successful.
	Incremental change	The change is implemented step by step, department by department, IT tool by IT tool etc.
	Alignment of the interests of different stakeholders	All the stakeholders involved in the development program need are on the same page and their interests are aligned.
Change management post-implementation	Support teams	There are supporting groups to help the users with the changes in the supplier MDM processes and systems.
	Rewards for ensuring valid master data	The company provides incentives to the employees for managing the supplier data according to the defined rules.
	Training of users	There is training offered to the users to help them become familiar with the new processes and systems.
People awareness of supplier MDM	People awareness of processes and tools	The employees of the company fully understand the supplier MDM processes and systems suggested by the organization.
	People awareness of master data management	The employees understand the benefits of master data management and they are aware of ways to maintain the supplier master data.

Table 32: Dimensions of change & communication

4.4.2.4 Dimensions of technology

Dimension	Factor	Description
Software used for the supplier MDM	Software compatibility	The software used for the supplier MDM can operate with the existing systems in the same environment.
	Software scalability	The software can handle a scalable business model.
	Software flexibility	The software can cope with the changes and potential additional processes.
	User-friendliness of the software	The software has easy-to-use interfaces and clear instructions.
Supplier MDM system	MDM system architecture	The target systems are linked to provide a common point of reference for the supplier master data.
	Information systems	The applications used to collect and distribute supplier data are aligned in a way to ensure that the supplier data remains unchanged during the supplier-organization collaboration.
Supplier MDM features and tools	Data quality tooling	Tools for the management and monitoring of the supplier data.
	Data integration tooling	Tools to extract and transform the supplier data.
	Data governance tooling	Tools for the maintenance of the master data and the master data ownership.
	Customized features	There are customized features, such as certification update and duplication check for the supplier master data.

Table 33: Dimensions of technology

4.4.2.5 Presentation of the supplier MDM key concepts and dimensions

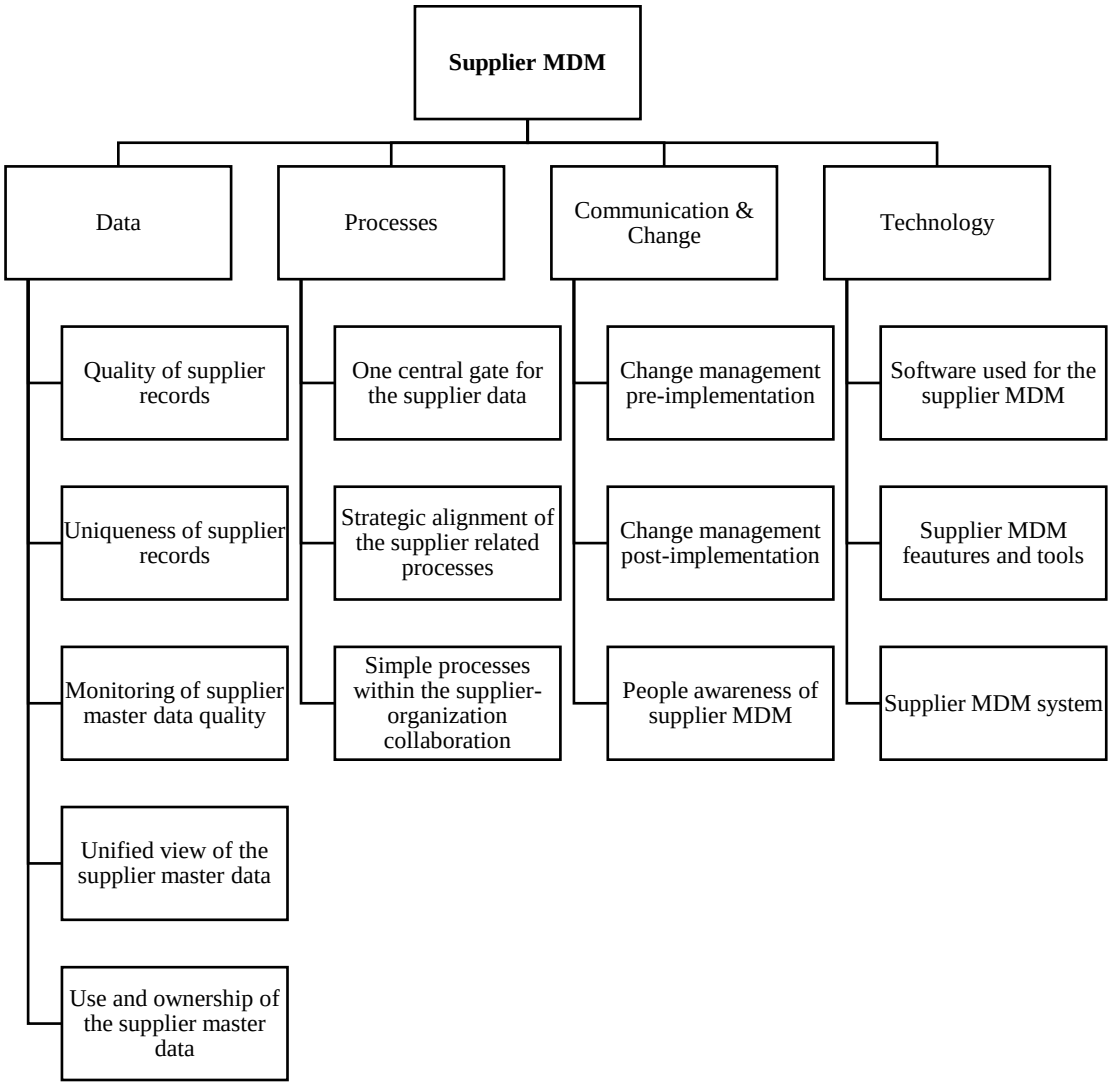

Figure 19: Key concepts and dimensions of the supplier MDM maturity model

4.4.3 Capabilities of the supplier MDM maturity model

This section describes 5 capabilities for each dimension of the model. These capabilities represent increasing performance of the company in the respected areas. The way the capabilities are developed in this study allows for gradual progression of a company's performance. The company, for example, needs to have all four capabilities of a dimension to be able to consider the fifth capability.

Dimension	Capability	Description
		Data
Quality of supplier records	SRQ-A	The company is aware of the supplier data problems.
	SRQ-B	Problems with duplicated or wrong supplier data are managed locally when they are detected.
	SRQ-C	A systematic approach has been developed to ensure high quality master data in each system.
	SRQ-D	The suppliers are defined through a complete, accurate and concise set of information.

	SRQ-E	An accurate and unified view of the supplier master data is reflected globally across the organization. The supplier master data quality is a KPI for all the process and data owners.
Uniqueness of supplier records	SRU-A	There is no standardized way to identify the suppliers in the company's systems.
	SRU-B	Each supplier is identified per system or use.
	SRU-C	There is some knowledge about how the supplier master data objects of different business functions relate.
	SRU-D	The supplier master data objects are connected, and common definitions are shared across the organization.
	SRU-E	Every supplier is defined through a unique set of information, which is assigned to a unique identification number.
Monitoring of the supplier master data quality	SDM-A	The company does not monitor the supplier master data quality. The data users are in charge of monitoring the quality of the supplier data they work with.
	SDM-B	The company does not regularly monitor the supplier master data quality. Actions are taken when data inaccuracy or duplicated records are detected in a database.
	SDM-C	Dashboard view of the supplier data allows monitoring of the supplier data across all systems and applications.
	SDM-D	The supplier data is checked regularly, and actions are taken to prevent the data problems.
	SDM-E	The reason why the supplier data problems occur is known and the company takes initiatives to manage this situation.
Unified view of the supplier master data	UDV-A	There are no defined data rules and standards.
	UDV-B	Data rules and standards are defined for each system and application.
	UDV-C	The supplier data is in same format and under the same technical rules across the organization.
	UDV-D	There are uniform data rules and standards. The supplier data is harmonized and standardized across all the systems and applications.
	UDV-E	The supplier data is consolidated into a centralized database and there is single representation of the supplier data elements.
Use and ownership of the supplier master data	SDO-A	The are no defined roles and responsibilities for using and maintaining the supplier data.
	SDO-B	The supplier master data are logically owned by the related roles and department.
	SDO-C	The people that are responsible for the supplier master data are clearly defined and they have documented responsibilities.
	SDO-D	There is a solid role-base foundation that defines the accountability for how employees produce and use the supplier data.
	SDO-E	The supplier data roles and responsibilities are clearly defined. The supplier data is visible and accessible globally across the organization. The suppliers can self-register and maintain their data.

	Processes	
One central gate for the supplier data	OCG-A	There are multiples entries for the supplier data creation and processing.
	OCG-B	There is one entrance for the supplier data for each department, but processing is allowed also from other systems and applications.
	OCG-C	The supplier data is created and managed centrally for each department.
	OCG-D	There is one gate for all the supplier related processes, from the supplier onboarding to the supplier phase-out.
	OCG-E	There is one entry gate for all the supplier related processes, and all the other gates have been successfully closed.
Strategic alignment of the cross-functional supplier related processes	ACF-A	The supplier data related processes are not connected to each other.
	ACF-B	The supplier data related processes are only partially connected to each other.
	ACF-C	The supplier cross-functional processes are aligned.
	ACF-D	All systems are integrated, and the supplier data is shared across the different applications easily and with security.
	ACF-E	All the supplier related business and technical processes are connected and automated.
Simple processes within the supplier-organization collaboration	SPR-A	The supplier related processes are unnecessarily complex.
	SPR-B	The supplier related processes are complex but well-documented and explained.
	SPR-C	The supplier related processes are clear and well-documented.
	SPR-D	Most of the supplier related processes are clear, simple and easy to understand.
	SPR-E	All the processes for the supplier data creation and maintenance are clear, simple and easy to understand.
	Communication & Change	
Change management pre-implementation	CPR-A	Change of the systems and processes has been proposed as a solution to the supplier master data problems.
	CPR-B	The company takes action to communicate the need for supplier MDM to the stakeholders.
	CPR-C	A strategic approach to change management has been developed, which incorporates the interests of different business functions.
	CPR-D	All the stakeholders involved in the change are on the same page and their objectives are aligned.
	CPR-E	A systematic plan and improvement roadmap toward gradual implementation of change has been developed.
Change management post-implementation	CPO-A	New systems and processes have been introduced to the organization.
	CPO-B	The company provides informative material and technical help for people who experience troubles adjusting to the changes.
	CPO-C	An adjustment period of trainings, seminars and workshops is defined.

	CPO-D	All the people in the organization are trained to the new system and processes, and support groups are assigned to provide continuous help and monitoring.
	CPO-E	People are used to the new systems and processes. Incentives are provided for managing the supplier data according to the new defined rules.
People awareness of supplier MDM	PAW-A	People rely on their knowledge and way of working to manage the supplier data.
	PAW-B	The benefits of the supplier MDM are communicated across the organization.
	PAW-C	People are aware of the MDM processes and tools an know how to use and maintain the supplier data.
	PAW-D	People understand the importance of the supplier MDM and try to maintain clean supplier data.
	PAW-E	People understand the impact of wrong supplier data in their work and the organization and try to prevent misuse of the supplier data in their working environment.
		Technology
Software used for the supplier MDM	MDS-A	The need for a supplier MDM software is identified and communicated with the organization.
	MDS-B	A supplier MDM software is introduced to the organization to solve specific supplier data problems, but it is not fully compatible with the existing applications.
	MDS-C	The supplier MDM software is compatible with the existing software applications.
	MDS-D	The supplier MDM is compatible with the existing applications and it is user-friendly.
	MDS-E	A compatible with the existing applications and user-friendly supplier MDM software is used. The software is scalable, and it can cope with changes and additional processes.
Supplier MDM systems	SMS-A	There is an overview of the systems that are used to create or manage supplier master data.
	SMS-B	The first steps towards alignment of the target systems and applications have been implemented.
	SMS-C	The applications used to collect and distribute supplier data are aligned.
	SMS-D	The target systems are aligned with a centralized MDM architecture to provide a common point of reference for the supplier master data.
	SMS-E	All supplier master data has been cleansed, transformed and loaded into the hub. The target systems and applications are aligned in a way to ensure that the supplier data remains unchanged during the supplier-organization collaboration.
Supplier MDM features and tools	MFT-A	Although there are data management tools, the company has no specific tools for the supplier MDM.
	MFT-B	Some tools for the supplier MDM are introduced, but their use has not yet been established in the organization.

	MFT-C	MDM tools are introduced and used by the employees. However, there is still need for more tools to support them with the supplier MDM practices.
	MFT-D	There are all the necessary tools for the supplier master data quality, integration and governance to support the employees with the supplier MDM practices.
	MFT-E	There are all the necessary tools for the supplier master data quality, integration and governance. There are also customized features according to the needs of the company, such as certification update and duplication check for the supplier master data.

Table 34: Supplier MDM capabilities

4.4.4 Levels of the supplier MDM maturity model

A common way to represent maturity in staged maturity models is through a fixed number of cumulative levels. The higher levels of maturity build on the requirements of lower levels (Maier et al., 2011). According to Fraser et al. (2001), a different number of maturity levels can be defined, mainly based on the ability of the developer to identify description which differentiates the one level from the next. The maturity levels in this study are developed to represent the supplier MDM capabilities, as described in section 4.4.3. Each dimension is described by five increasing capabilities. Therefore, five maturity levels are developed to reflect the performance of companies in supplier MDM, based on these capabilities.

After the number of levels has been decided, the study uses a comparison of the maturity levels used in the previous MDM maturity models, as presented in Table 35. The maturity levels used in this study is a combination of the CMMI levels (Team, C. P., 2006) used by Zúñiga et al. (2018) and the levels used by Loshin, 2010 and Jonker et al., 2011. The CMMI levels are easily adaptable and broadly used for data governance (Zúñiga et al., 2018).

Levels	*Loshin (2010)*	*Kumar (2010)*	*Jonker et al. (2011)*	*Butler and Naidoo (2013)*	*Spruit and Pietzka (2015)*	*Zúñiga et al. (2018)*
1	Initial	Initial	Initial	Marginal	Initial	Initial
2	Reactive	Isolated	Reactive		Repeatable	Managed
3	Managed	Organized	Active	Stable	Defined process	Defined
4	Proactive	Unified	Proactive	Best practice	Managed and measurable	Quantitatively Managed
5	Strategic performance	Optimized	Strategic performance	Transformational	Optimized	Optimized

Table 35: Comparison of maturity levels in previous MDM maturity models

A level representing lack of awareness of the topic is out of the scope of this study, since the use of the model is limited to companies that implement development programs for the supplier MDM. This study considers as first level of maturity an initial level of awareness of supplier MDM. More actions towards high quality and consistent supplier data are represented in higher levels. As it has been discussed earlier in this study, it is not only important for companies to get high quality master data, but also to find ways to prevent the supplier master data problems. These two approaches to supplier MDM define the second

and fourth maturity level of this model. Moreover, it is significant to define a standardized approach for the supplier MDM so it can be communicated across the organization. Thus, the third level in this model represents a defined approach. Lastly, a company needs to continuously improve and develop its supplier MDM capabilities. This is described in the fifth and final maturity level of the model.

Concluding, the supplier MDM maturity model has five cumulative maturity levels: initial, reactive, defined, proactive, optimizing. Companies need to fulfill all the requirements of the previous level to go the next one (Figure 22) The levels of the maturity model for the supplier master data management are the explained below, with level 1 representing the lowest and level 5 the highest level of maturity:

- **Level 1 - Initial**: A first awareness for the supplier MDM has been raised and there is some recognition of duplicated and polluted data in the systems (Jonker et al., 2011). Organizations in this level, can often find ways to operate and achieve the desired results by employing local supplier MDM practices. However, they do not always provide a stable environment to make these processes repeatable (Team, C. P., 2006).
- **Level 2 - Reactive**: In this level, organizations do not only recognize the pollution in data, but they also take action to resolve the problem (Loshin, 2010; Jonker et al., 2011). Nevertheless, these attempts usually take place locally, neglecting the need for comprehensive enterprise-wide harmonization (Jonker et al., 2011). In addition, they usually rely on the use of new tools to get the supplier data clean, but they tend to overlook the source of the problem (Loshin, 2010). Therefore, organizations are not able to provide a permanent solution.
- **Level 3 - Defined**: A strategic plan toward effective supplier MDM has been developed and actions take place on a tactical level (Spruit and Pietzka, 2014). There is a clear and well documented process which defines the activities, roles, responsibilities and guidelines for achieving this goal (Team, C. P., 2006). The defined process includes processes, tools, and methods (Team, C. P., 2006) but an enterprise-wide approach is still missing (Jonker, 2011). Communication and common understanding within the stakeholders may not have been well-established during the early steps of the program.
- **Level 4 - Proactive**: There is an integrated framework for the supplier MDM in the organization and the existing silos for the supplier data maintenance are aligned with a master repository (Jonker et al., 2011). The value of supplier master data is well-understood, and the internal and external stakeholders are aware of the importance of the program. (Loshin, 2010). Organizations in this level develop a proactive approach to maintain accurate and updated supplier information. This enables them to establish better relationships with the suppliers while their profiles are defined through a complete, accurate and unique set of information (Loshin, 2010).
- **Level 5 - Optimizing**: This is the highest level of maturity and indicates the harmonization of all the applications, processes and information which concern the suppliers of an organization. The supplier master data quality is "a KPI for all process and data owners" (Jonker et al. 2011; p.67). The introduction of new processes and tools for the supplier MDM to the organization has been successful and accompanied by the necessary training. The supplier MDM is efficient and holistic and there is a single source of truth for the supplier master data. The supplier information is consistent through all the stages of the supplier-organization collaboration and in all the systems and tools within the organization. CMMI level 5 of maturity, is characterized by monitoring and continual improvement of the processes. This can be realized with new innovative approaches and technological solutions (Team, C. P., 2006).

Companies need to have all the capabilities of the previous level to be able to go to the next level of maturity. The first levels focus mostly on the activities of organizations to create accurate, complete and unique supplier master data. Towards the latter levels, the organizations take also actions to prevent the supplier master data problems, in order to maintain high quality supplier master data.

Level ID	Descriptor	Description
1	***Initial***	• A first awareness for the supplier MDM has been raised • There is some recognition of duplicated and polluted data in the systems • Local supplier MDM practices • The processes are not repeatable
2	***Reactive***	• Broader recognition of the pollution in data and first actions to resolve the problem • Introduction of new tools for the supplier MDM • Strategies might overlook the source of the problem • Not permanent solution
3	***Defined***	• Strategic planning toward effective supplier MDM • Clear and well documented processes • Communication and common understanding within the stakeholders are not well-established • An enterprise-wide solution is still missing
4	***Proactive***	• The internal and external stakeholders are aware of the importance of the program • Proactive approach to achieve and maintain high quality supplier master data • The suppliers are defined through a complete, accurate and unique set of information
5	***Optimizing***	• Harmonization of all the applications, processes and information • The supplier master data quality is a KPI for all process and data owners • The supplier MDM is efficient and holistic • Monitoring and continual improvement of the supplier MDM processes

Table 36: Definition of the supplier MDM maturity levels

4.4.5 Supplier MDM maturity model

The components of the supplier MDM maturity model, presented in sections 4.4.1 to 4.4.5, are combined into a maturity grid. The maturity grid of this study, including the description of the capabilities of companies at each maturity level, is presented in Appendix I. This answers the fourth research question, namely *"What does a model that can determine the maturity of companies in supplier MDM look like?".*

Dimensions \ Levels		Level 1 *Initial*	Level 2 *Reactive*	Level 3 *Defined*	Level 4 *Proactive*	Level 5 *Optimizing*
Data	Quality of supplier records	SRQ-A	SRQ-B	SRQ-C	SRQ-D	SRQ-E
	Uniqueness of supplier records	SRU-A	SRU-B	SRU-C	SRU-D	SRU-E
	Monitoring of supplier master data quality	SDM-A	SDM-B	SDM-C	SDM-D	SDM-E
	Unified view of the supplier master data	UDV-A	UDV-B	UDV-C	UDV-D	UDV-E
	Ownership of the supplier master data	SDO-A	SDO-B	SDO-C	SDO-D	SDO-E
Processes	One central gate for the supplier data	OCG-A	OCG-B	OCG-C	OCG-D	OCG-E
	Strategic alignment of the cross-functional supplier related processes	ACF-A	ACF-B	ACF-C	ACF-D	ACF-E
	Simple processes within the supplier-organization collaboration	SPR-A	SPR-B	SPR-C	SPR-D	SPR-E
Communication & Change	Change management pre-implementation	CPR-A	CPR-B	CPR-C	CPR-D	CPR-E
	Change management post-implementation	CPO-A	CPO-B	CPO-C	CPO-D	CPO-E
	People awareness of supplier MDM	PAW-A	PAW-B	PAW-C	PAW-D	PAW-E
Technology	Software used for the supplier MDM	MDS-A	MDS-B	MDS-C	MDS-D	MDS-E
	Supplier MDM system	SMS-A	SMS-B	SMS-C	SMS-D	SMS-E
	Supplier MDM features and tools	MFT-A	MFT-B	MFT-C	MFT-D	MFT-E

Table 37: Supplier MDM maturity grid

4.4.6 Assessment of the supplier MDM maturity

According to De Bruin et al. (2005), maturity models can be used as a comparative basis for improvement. The aim of the maturity model in this study, is twofold. First, it serves as a supportive tool for organizations to evaluate their supplier MDM, by assigning a specific degree of maturity. Second, it provides an informed approach to achieve a higher degree of maturity, by indicating the areas that need to be improved to grow the supplier MDM maturity. To help companies determine their

supplier MDM maturity, the maturity model presented in section 4.4.5 is complemented by an additional assessment tool. A self-assessment questionnaire is presented in Appendix J.

In the self-assessment questionnaire, each dimension is described by a set of five capabilities. Users are invited to decide which of the five descriptions most adequately reflects the organization's current capability. The capabilities are in an increasing order from A to E. If a capability is selected in the questionnaire, it is directly assumed that the capabilities before the selected one are implemented. Based on this, the user can indicate the implemented and missing capabilities in each supplier MDM dimension.

After the level of maturity has been estimated, the company can set its goals and targets for a higher maturity level. When companies know where they are and where they want to be, they can plan the necessary activities to get there. The model can be used to guide the company's actions toward a higher supplier MDM maturity level. First, the results of the questionnaire can be presented to the stakeholders to discuss the strengths and weaknesses of the company in the supplier MDM. Following this, a consensus workshop would produce a gap analysis and recommendations to attain the next required level of maturity. The outputs of this phase are priorities, and an action plan that is agreed and understood by the key stakeholders. Lastly, when everyone is on the same page, the systematic approach to be followed is defined and communicated with the organization.

The maturity model development procedure in this study does not cover the implementation of the model. However, it is important that the intended use of the model is clear. An example of the suggested use of the self-assessment questionnaire is presented. This example is not representative of the case company and does not reflect the reality. First, the capabilities in the supplier MDM questionnaire are selected. Second, the matrix as presented in Table 38 is completed with the implemented and missing values. A radar chart is used to demonstrate the actual and level of maturity in each dimension (Figure 20). A maturity level has been achieved in a key concept of the supplier MDM, when all the capabilities are implemented in this concept (Figure 21). The company then can plan its actions to grow its maturity in the dimensions where there are one or more missing capabilities. If the target score is lower than the actual score in a dimension, then actions need to be taken to improve the capabilities in this area.

There are many activities that can help organizations grow their maturity in supplier MDM capabilities. However, the discussion of these activities is out of the scope of this study. An example is used to demonstrate what are the actions that can help a company increase its maturity in the "uniqueness of supplier records" dimension. As it has been discussed in section 4.2.4, different supplier data is needed in the case company for 1. different stages of the supplier-buyer collaboration, 2. different data domains that defines a supplier's profile and 3. different processes of record. A suggestion for the case company to grow its maturity in this dimension from level 3 to level 4, is presented in Appendix F and concerns the development of a relational master data model to uniquely identify the suppliers in all the systems and applications with a single Golden Record Identification (GRID) number.

		A	B	C	D	E
Data	Quality of supplier records	Implemented	Implemented	Implemented	Implemented	Implemented
	Uniqueness of supplier records	Implemented	Implemented	Implemented	Missing	Missing
	Monitoring of supplier master data quality	Implemented	Implemented	Implemented	Implemented	Missing
	Unified view of the supplier master data	Implemented	Implemented	Implemented	Missing	Missing
	Use and ownership of the supplier master data	Implemented	Implemented	Implemented	Implemented	Missing
Processes	One central gate for the supplier data	Implemented	Implemented	Implemented	Missing	Missing
	Strategic alignment of the cross-functional supplier related processes	Implemented	Implemented	Implemented	Implemented	Missing
	Simple processes within the supplier-organization collaboration	Implemented	Implemented	Implemented	Missing	Missing
Communication & Change	Change management pre-implementation	Implemented	Implemented	Implemented	Missing	Missing
	Change management post-implementation	Implemented	Implemented	Missing	Missing	Missing
	People awareness of supplier MDM	Implemented	Implemented	Implemented	Missing	Missing
Technology	Software used for the supplier MDM	Implemented	Implemented	Implemented	Implemented	Implemented
	Supplier MDM system	Implemented	Implemented	Implemented	Missing	Missing
	Supplier MDM features and tools	Implemented	Implemented	Implemented	Missing	Missing

Table 38: Example use - Implemented and missing capabilities

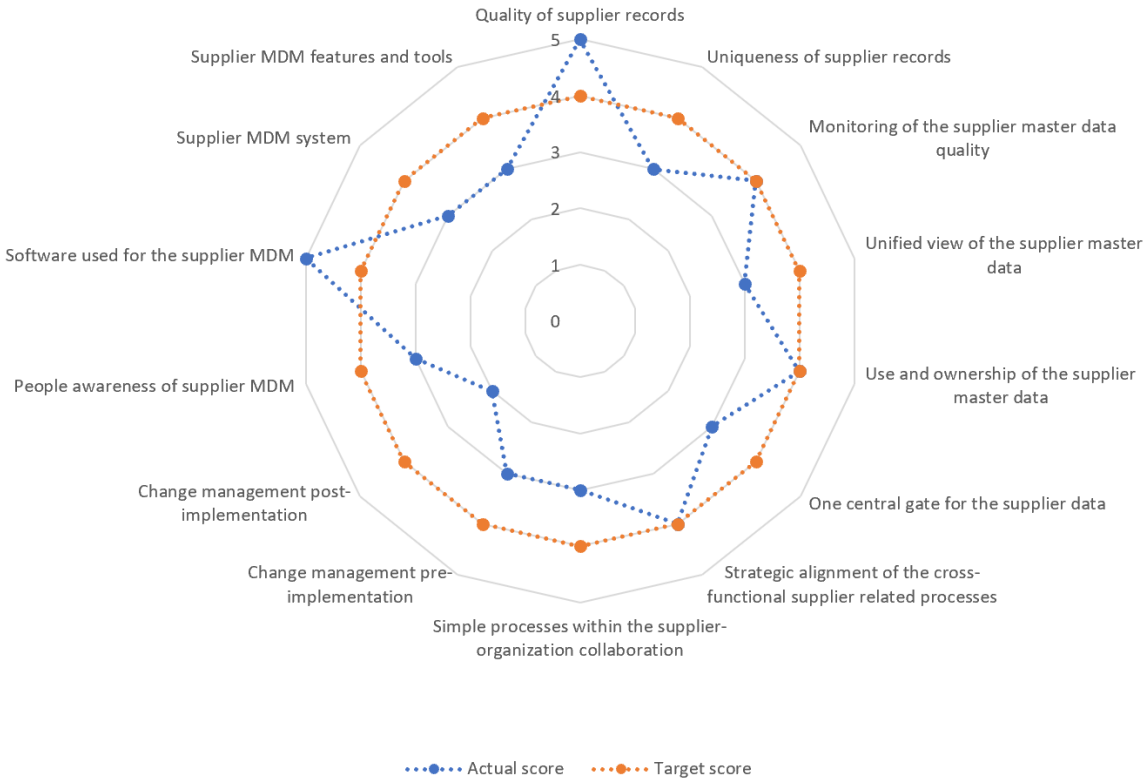

Figure 20: Example use - Maturity radar chart (maturity in each dimension)

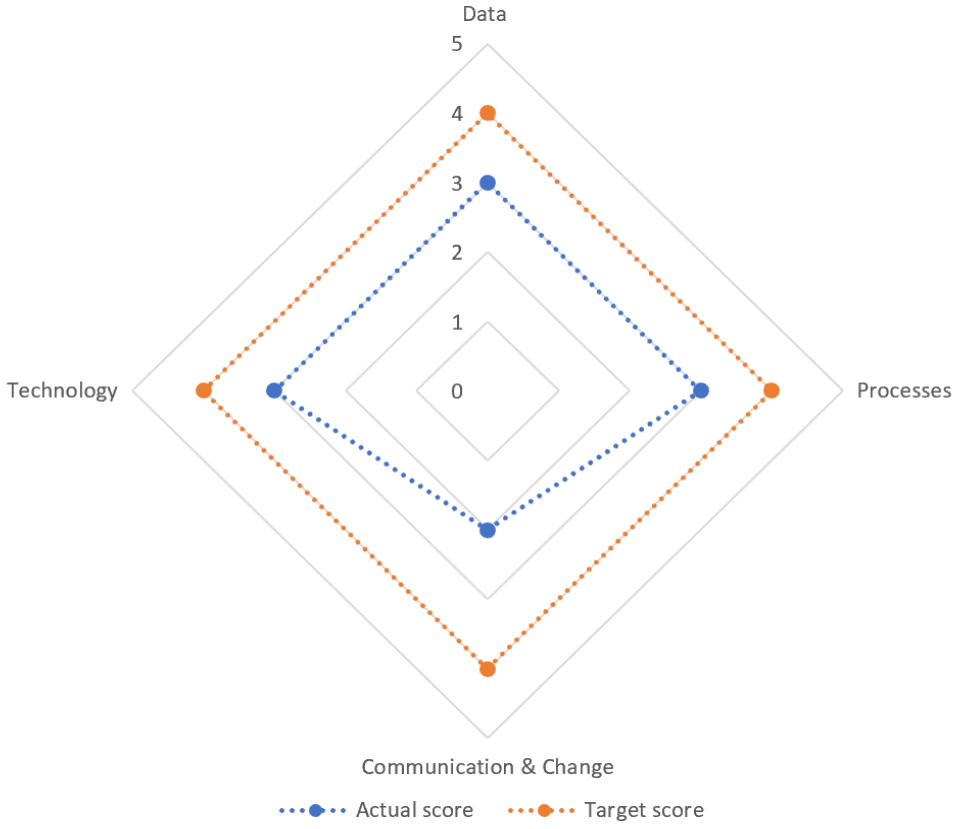

Figure 21: Example use - Maturity radar chart (maturity in each key concept)

Chapter 5: Evaluation

5.1 Introduction

This chapter concerns the evaluation of the developed maturity model based on the guidelines of Hevner et al., (2004). The chapter aims to answer the fifth and last research question, namely *"How well can the developed model determine the maturity of companies in supplier MDM?".* Two expert interviews are conducted to evaluate the developed model based on its quality, efficacy and utility. For the development of the evaluation method Verschuren and Hartog (2005), Venable et al. (2012) and Johannesson and Perjons (2014) were consulted.

5.2 Evaluation approach

March and Smith (1995) define evaluation as "the process of determining how well the artifact performs" (p. 254). Verschuren and Hartog (2005) refer to the evaluation as a process "to compare separate parts of a designing process with selected touchstones or criteria (in the broadest sense of the word), and to draw a conclusion in the sense of satisfactory or unsatisfactory" (p. 738). The evaluation of the artefact requires to understand how well it supports a solution to the identified problem (Peffers et al., 2007). Performance measures are identified, and they can be the artefact can be evaluated using a variety of methods, such as focus groups, interviews, surveys and workshops according to the type and time frame of the evaluation (Peffers et al., 2007; Venable et al., 2012).Venable et al. (2012) refer to different methods for evaluation based on whether the evaluation is naturalistic or artificial and on whether it is ex-ante or ex-post, as explained previously in section 2.3. The evaluation in this study is naturalistic and ex-ante, as it is performed in its natural environment and before the deployment of the model. Venable et al. (2012) suggest for the evaluation selected in this study, the methods of action research or focus group. However, because of the time frame of the study and the availability of the employees in the case company, this was not possible.

The evaluation in this study is performed with evaluative expert interviews in the case company. According to Hevner et al. (2004) and the third guideline for Design Science in IS Research, "The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods" (Hevner et al., 2004; p. 85). Therefore, the design product and process are evaluated based on the utility, quality, and efficacy (Hevner et al., 2004). The qualities of the artefact as defined earlier (Section 2.3.1.2.1, Table 4) based on the study of Johannesson and Perjons (2014), are evaluated in the model design phase (statements 8-15). The performance measures are presented in Table 39. These measures are used to develop the evaluation questionnaire, which is included in Appendix G, G2. The interviewees are invited to discuss these statements and by means of a Likert scale to express the extent to which they agree with them (Appendix G, G3).

Model development steps	Evaluation Criteria	Statements
Identify the objectives and scope	Efficacy	S1: The objective of the model is clear.
		S2: The scope of the model is clear.
Plan the development strategy	Quality	S3: The development of the model does not lack any important phases.
		S4: The phases of the development are structured in a logical way.

Identify the factors	Quality	S5: The factors used in the model are clear and understandable.
		S6: The set of the developed factors is complete.
	Efficacy	S7: The factors used in the model influence the maturity of the supplier MDM in large and international companies.
Design the model	Quality	S8: The parts of the model are logically related.
		S9: There are no redundant components in the model.
	Utility	S10: The model is easy to understand
		S11: The model is easy to use
		S12: The model represents the developed factors
		S13: The model can be adjusted to specific users or needs
	Efficacy	S14: The model is focused on the supplier MDM in large and international companies
		S15: The model can be used to determine the maturity of companies in the supplier MDM.

Table 39: Performance measures

For the evaluation of the supplier MDM maturity model, two evaluative expert interviews took place in Philips, Eindhoven. The meetings last 60 minutes so that there is enough time for the feedback for improvement to be received and comprehended. The set-up of the meeting is presented in Appendix G, G1. Information about the interviewees is provided in Table 40. The table includes the number and date of the interview, the role of the interviewees in the organization and their experience in supplier data management and/or master data management in Philips or outside.

Interview number	Interview date	Interviewee role	Interviewee experience
1	11-10-2019	IT Project Manager	1 year
2	11-10-2019	Business Information Manager	2-3 years

Table 40: Information about the interviewees

5.3 Evaluation results

This part covers the results of the two evaluative expert interviews, based on the questionnaire provided in Appendix G. The scoring of the evaluation questionnaire is presented in Table 41.

Statement ID	Expert 1	Expert 2
S1	5	4
S2	4	5
S3	3	4
S4	5	4
S5	4	4
S6	3	3
S7	5	4
S8	5	3
S9	5	3

S10	4	4
S11	2	3
S12	5	4
S13	5	3
S14	3	4
S15	4	3

Table 41: Evaluation results

5.4 Feedback and suggested improvement actions

Some statements are scored less positively than others. Actions are taken for the model to be improved by incorporating the provided feedback. This part is intended to provide the feedback received during the evaluation interviews and the respected improvement actions.

5.4.1 Feedback received by the interviewees

This section provides the main comments received during the evaluative interviews. The interviewees discuss their concerns and recommend improvement actions.

Comment 1: "Some factors are relevant to the case company and might not be the same in other companies. Such as the alignment with the commodity strategy. This is how Philips does it. I believe few factors can be more generic to fit to a larger audience." I2

Comment 2: "I believe that you are missing one of the most important things nowadays. Data compliance should be considered, this is very important. Whether the data is compliant with GDPR for example. Maybe this is part of the Data rulebook." I1

Comment 3: "It is not clear how the maturity figures are used. How can a company understand its level of maturity?" I1

5.4.2 Improvement actions based on the received feedback

This section provides the suggested improvements in the supplier MDM maturity model, by incorporating the received feedback. Based on the comments of section 5.4.1, improvement actions are suggested. The implement changes are presented in Appendix G, G4 and the final supplier MDM maturity model can be found in Appendix I.

Improvement action for comment 1: The factor "Alignment of new supplier creation with the commodity management strategy", which resulted from the semi-structured exploratory interviews in the case company, is removed.

Improvement action for comment 2: A new factor is added, namely "Data compliance". According to Brous et al. (2016), an important aspect of the data governance is to define an authority which is responsible for the compliance with the data policies and procedures. The policies are decided from the business and IT teams, which develop under collaboration a common shared framework across the organization (Brous et al., 2016). This framework in this study, is comprised of a set of rules and responsibilities to ensure the protection of sensitive supplier information. In general, companies are socially and legally obliged to protect personal data and a challenge for organizations is to ensure accountability of the data users. Brous et al. (2016) suggest also the use of incentives to promote this

behavior. The study of Brous et al. (2016) proposes a data governance maturity model, in which compliance is a key concept and it includes the principles of accountability, policy enforcement, due diligence, privacy, openness, security and measurement of the data quality.

Improvement action for comment 3: At the time that the evaluative interviews were conducted, the maturity grid had been developed. Several figures were presented to the interviews to illustrate the priority and sequence of the supplier MDM factors. The interviewees suggested that this is not an easy way for a company to understand its degree of maturity and that an example could help understand the usability of the model. Thus, after the interviews, the supplier MDM questionnaire was added to serve as an assessment tool for determining maturity. The self-assessment questionnaire (Appendix J) can be used by companies to assess their capabilities in supplier MDM and determine their level of maturity in each dimension of supplier MDM. The section 4.4.6 was added, which are dedicated to the supplier MDM maturity assessment.

Chapter 6: Conclusion

6.1. Introduction

This chapter is dedicated to the presentation of the conclusions of this study. First, it provides answers to the research questions. Second, the reflection of the study, based on the approach followed, the choices made, and the research outcome, is presented. Third, the scientific contribution to the theoretical base of this study is explained. Moreover, the societal and managerial relevance of the study and the relevance with the MoT program are presented. Lastly, the limitations of the study are discussed, and recommendation are made 1. for managers to use the model and 2. for future work.

6.2 Conclusions

Throughout this study five research questions were formulated and answered to satisfy the design objective.

The design of a model to determine a company's maturity in supplier MDM.

This section is intended to present the answers to these research questions.

6.2.1 Answer to research question 1: What are the factors that can influence MDM?

The first research question is addressed in the third chapter of this thesis, aiming to develop the theoretical base for the study. This research question is based on the first design science phase, namely *"Identify problems and related factors"* (Johannesson and Perjons, 2014). A systematic literature review was conducted, using the input of methodologies as described by Kitchenham et al. (2009), Levy and Ellis (2006) and Webster and Watson (2002). Factors that can influence specifically supplier MDM could not be identified in existing literature. Therefore, in this research question, 10 articles were selected in the area of master data management, master data quality, master data architecture and master data governance. These articles provide useful for this study information, such as problems, factors, challenges and barriers of MDM. The articles were categorized using a concept-centric approach and the information provided in these articles was translated in MDM factors. Following this, the factors were categorized and synthesized. The outcome of this activity is a set of 80 factors that influence the MDM, as presented in Tables 10 – 17.

6.2.2 Answer to research question 2: What are the requirements for a company to manage the supplier master data problems?

The second research question of this study is also addressed in the third chapter. This question is related to the second design science phase, namely *"Define objectives of solution"*, as proposed by Johannesson

and Perjons (2014). The factors developed to answer the first research question, were used as a framework to identify requirements for the supplier MDM from an expert survey. The result of the survey is the selection of the 50% highest rated MDM literature factors (Appendix B), based on the specific challenged in the supplier domain and for the supplier master data problems, as described in chapter 1. The outcome of this activity represents the requirements for the maturity model design (Table 18), and it is used as a framework for the development of the supplier MDM factors in the following steps of the design.

6.2.3 Answer to research question 3: What are the elements of a model that can determine the maturity of companies in supplier MDM?

After the need for effective supplier MDM has explained and the objectives of the solution have been identified, this research question was formulated based on the third design science phase, namely *"Design model"* (Johannesson and Perjons, 2014). First, the requirements defined in the second research question (Table 18) are used as a framework to develop the factors that influence supplier MDM in companies within the scope of this study. Nine semi-structured exploratory expert interviews were conducted. The interviews consist of two parts: 1. discussion on the challenges of supplier MDM and the interviewees' experiences and 2. discussion on the literature factors derived from the previous research questions.

Inductive coding of the interview transcripts resulted in three types of codes: existing, adjusted and new (Table 27). The literature factors defined in the previous research questions are used for theory-driven coding of the interview data, resulting in a set of existing and adjusted codes. This is followed by data-driven coding aiming to identify new codes for the supplier MDM. Finally, the developed codes were processed to create the supplier MDM factors. This activity resulted in:

1. New factor development from the interview data
2. Adjustment of literature factors by
    a. Changing of name and/or meaning
    b. Merging
3. Confirmation of literature factors with two ways
    a. Extracted from raw data
    b. Evaluated by asking the interviewees if they agree
4. Deletion based on the suggestions of the interviewees

The outcome of the processing is presented in Tables 28 and 29. Explanation of the factors, based on literature and the interview information, is provided in Appendix E. The supplier MDM factors (Table 28) are categorized into groups (key concepts) and sub-groups (dimensions). The key concepts are explained in section 4.4.1 and the dimensions are presented in Tables 50-53. Figure 22 presents the outcome of this activity.

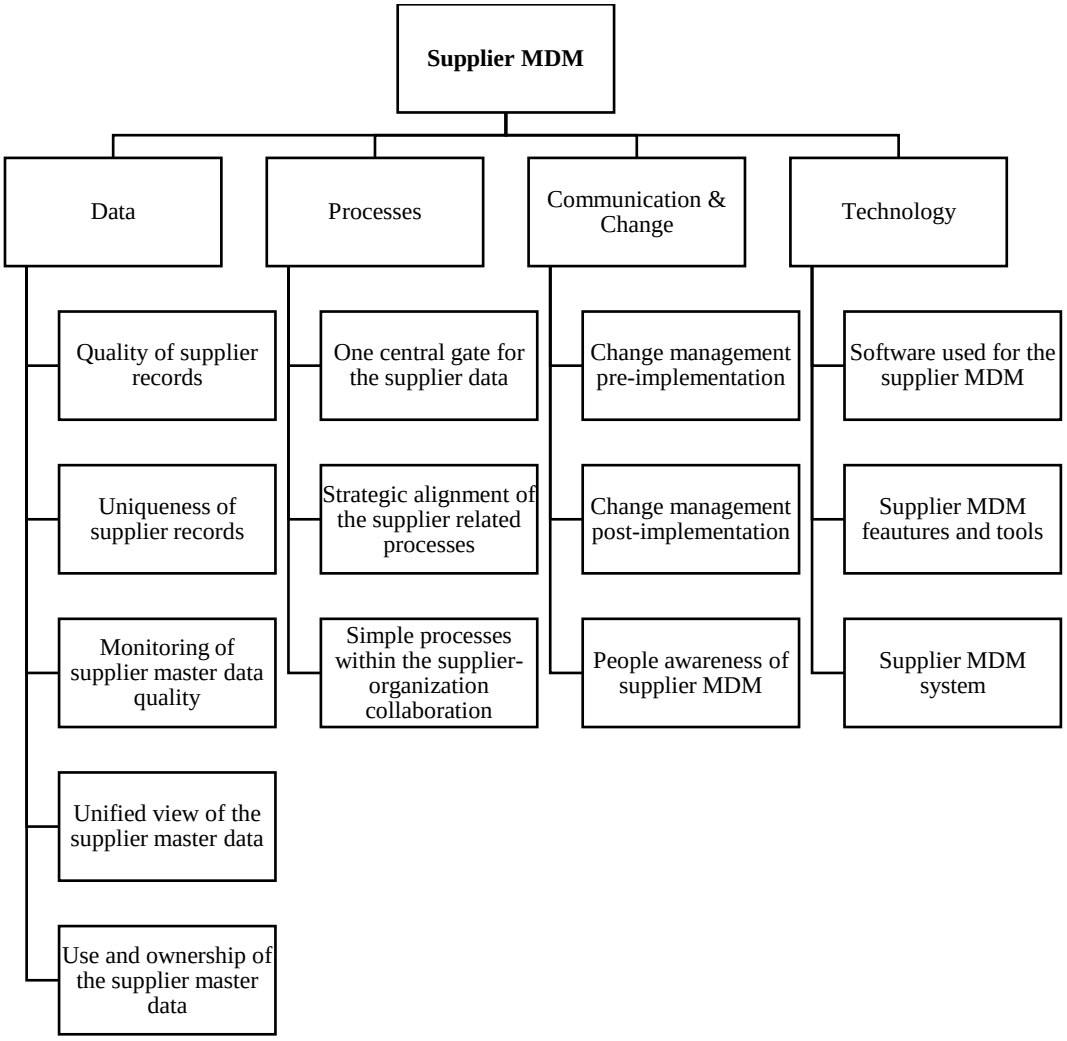

Figure 22: Supplier MDM key concepts and dimensions (conclusions)

Following this, each dimension is described by a set of five increasing supplier MDM capabilities (Table 54). The capabilities describe a company' performance in the dimensions of the model and based on them the maturity levels of this study are developed, as explained in section 4.4.4 and presented in Table 36. The maturity levels are: 1. Initial, 2. Reactive, 3. Defined, 4. Proactive, 5. Optimizing.

6.2.4 Answer to research question 4: What does a model that can determine the maturity of companies in supplier MDM look like?

The fourth research question is based on the fourth design science phase, namely *"Demonstrate model"* (Johannesson and Perjons, 2014). The elements of the maturity model which were developed in the third research question, are combined for the development of a maturity grid (Table 42). The final supplier MDM maturity model, including the description of the supplier MDM capabilities in each level of maturity, is presented in Table 55. The supplier MDM maturity model is complemented by an assessment tool. The self-assessment supplier MDM questionnaire is presented in Table 56, and it can be used by companies to determine their as-is situation and develop an action plan for growing maturity in supplier MDM. An example of the questionnaire is presented in Table 38 and Figures 20-21. Additionally, a suggestion of an improvement action toward higher supplier MDM is provided in Appendix F.

Dimensions \ Levels		Level 1 *Initial*	Level 2 *Reactive*	Level 3 *Defined*	Level 4 *Proactive*	Level 5 *Optimizing*
Data	Quality of supplier records	SRQ-A	SRQ-B	SRQ-C	SRQ-D	SRQ-E
	Uniqueness of supplier records	SRU-A	SRU-B	SRU-C	SRU-D	SRU-E
	Monitoring of supplier master data quality	SDM-A	SDM-B	SDM-C	SDM-D	SDM-E
	Unified view of the supplier master data	UDV-A	UDV-B	UDV-C	UDV-D	UDV-E
	Ownership of the supplier master data	SDO-A	SDO-B	SDO-C	SDO-D	SDO-E
Processes	One central gate for the supplier data	OCG-A	OCG-B	OCG-C	OCG-D	OCG-E
	Strategic alignment of the cross-functional supplier related processes	ACF-A	ACF-B	ACF-C	ACF-D	ACF-E
	Simple processes within the supplier-organization collaboration	SPR-A	SPR-B	SPR-C	SPR-D	SPR-E
Communication & Change	Change management pre-implementation	CPR-A	CPR-B	CPR-C	CPR-D	CPR-E
	Change management post-implementation	CPO-A	CPO-B	CPO-C	CPO-D	CPO-E
	People awareness of supplier MDM	PAW-A	PAW-B	PAW-C	PAW-D	PAW-E
Technology	Software used for the supplier MDM	MDS-A	MDS-B	MDS-C	MDS-D	MDS-E
	Supplier MDM system	SMS-A	SMS-B	SMS-C	SMS-D	SMS-E
	Supplier MDM features and tools	MFT-A	MFT-B	MFT-C	MFT-D	MFT-E

Table 42: Supplier MDM maturity grid (conclusions)

6.2.5 Answer to research question 5: How well can the developed model determine the maturity of companies in supplier MDM?

The last research question concerns the evaluation of the developed model, based on the fifth design science phase, namely “Evaluate model” (Johannesson and Perjons, 2014). For the development of the

evaluation approach, Verschuren and Hartog (2005), Venable et al. (2012) and Johannesson and Perjons (2014) were consulted. For the evaluation of the developed maturity model, two expert interviews were conducted. The model is evaluated based on its quality, efficacy and utility, according to the third guideline for design science (Hevner et al., 2004). The performance measures are presented in Table 39. These measures are used to develop the evaluation questionnaire, which is included in Appendix G, G2. The interviewees are invited to discuss these statements and by means of a Likert scale to express the extent to which they agree with them. The outcome of this activity is presented in Table 41.

Some statements are scored less positively than others. First, the interviewees expressed their concerns about the generalizability of the factors (some factors were more specific to the case company). They also discussed that some important aspects were not apparent, such as the factor of data compliance. Lastly, based on the feedback received, the use of the maturity model was not clear.

Actions were taken for the model to be improved by incorporating the provided feedback. Changes in the supplier MDM factors were made, as presented in Appendix G, G4. Moreover, a self-assessment questionnaire was developed to help companies determine their supplier MDM maturity (Table 56). The elements of the maturity model and the final supplier MDM maturity model, after the implementation of the changes, are presented in the Appendices H and I.

6.3 Reflection

This section provides a reflection of this thesis based on the approach followed, the choices made, and the outcome of this research.

6.3.1 Reflection on research approach

According toVerschuren and Hartog (2005), evaluation is the process "to compare separate parts of a designing process with selected touchstones or criteria (in the broadest sense of the word), and to draw a conclusion in the sense of satisfactory or unsatisfactory" (p. 738). Verschuren and Hartog (2005) suggest that a design study must be evaluated for its validity, reliability, researcher-independence and verifiability.

A. Validity

Conwell et al. (2000) refers to validation as the extent to which a maturity model represents accurately the real world based on the model's intended uses. The validity of the model design is evaluated based on criteria proposed by Yin (2017). To ensure construct validity this study follows Yin (2017), who proposes the use of multiple sources, by collecting data from the existing literature and the respected industry. Moreover, according to Dooley (2002), the appropriate methods for the concepts of the study need to be decided to ensure construct validity. A systematic literature review and thorough examination of internal documentation of the case company helped the author better understand the concepts and the need for this study. Evaluation loops were conducted, as suggested by Yin (2017), with the thesis supervisors. Lastly, discussions with employees in the case company provided this study with opportunities for ongoing evaluation of the draft study.

Dooley et al. (2002) relates the external validity of the study with the generalizability of the results. Yin (2017) advises, for single case studies, the use of the appropriate theory to establish external validity of the case study. Theory and existing maturity models were consulted in this study to develop a framework for the development of the factors for the supplier MDM. However, more interviews, with experts from other functions could improve the external validity of this study. Interviews with the

suppliers of the case company could be conducted as well, to incorporate also the supplier's perspective on the data governance during the supplier-organization collaboration.

B. Reliability

In order to ensure reliability of the study, the model design process is thoroughly documented, as it is advised by Dooley (2002). According to Yin (2017), clear documentation of procedures helps on the one hand to make the study replicable and on the other hand to avoid bias and errors. Replicability of the study implies that if other researchers use the same steps under the same conditions, they will derive to the same conclusions. However, the interpretation of the author in the processing of the factors, makes some steps of the design less easy to be repeated by other researchers.

The personal perspective and interpretation of the author in the decisions made during the research is an influencing factor of this study. For example, the study follows the design science approach, and there is not enough information provided to argue on whether another decision would provide a better outcome. Another barrier to the reliability of this study results from the decision to include some of the experts in more than one steps of the model design. This can increase bias and reduce the objectivity of the study.

C. Researcher-independence

Research independence refers to the dependency of the researcher with people having incentives for a specific research outcome (Verschuren and Hartog, 2005). The study is conducted only by one person. Advice was provided by the thesis committee to make some of the research choices. This research is part of the MoT master's program in Delft University of Technology and none of these people would benefit from a specific outcome. However, the author's extended activities with the case company and the choice for a single case study, can decrease the researcher-independence of this research.

Moreover, the experts that participated in the model design, either through the survey or interviews, are all from the same case company and the same development program. Although they were ensured that the information provided will remain confidential and will be shared only with the thesis team, there is a risk that the expert could have been reluctant to share some information and reveal the company's problems. Moreover, they might have incentives for the design of a maturity model that would allow them to score a high degree of maturity. A high maturity level could help the team communicate the program's success to other stakeholders.

D. Verifiability

Verschuren and Hartog (2005) refer to verifiability as the correctness and accuracy of the research. Conwell et al. (2000) define verification as the extent to which the model reflects accurately the conceptual description and the specifications of the developer. This study refers to the adherence to the criteria for the development of maturity models by Becker et al. (2009), as explained in section 2.3.1.2.1. They suggest the comparison with existing maturity models. First, literature research is conducted to identify the need for the supplier MDM maturity model. Second, previous maturity models were used to as sources in the literature review of this study. Lastly, the maturity levels of this study are developed by consulting previous MDM models. Moreover, Becker et al. (2009) suggest iterative development of the model. The study follows this approach for developing the factors and for designing the model. It is also important that the research is scientifically documented. A systematic literature review was conducted, following Levy and Ellis (2006) and Kitchenham et al. (2009).

Another factor for verifiable research, as proposed by Becker et al. (2009), is that the problem and its relevance are clearly defined, and the results of the outcome are targeted represented. The supplier data problems are thoroughly explained in the introduction of this study and examples are provided in the case study description and analysis. The relevance of the results from an academic and social

perspective are explained. Lastly, the design in this study is evaluated based on its quality, efficacy and utility according to the third guideline for design science (Hevner et al., 2004). The developed model was evaluated based on the structural and environmental factors, as defined by Johannesson and Perjons (2014). However, the model has not been deployed in a real-life setting, which makes it hard to establish high verifiability.

6.3.2 Reflection on research choices

According to Pierson (2000), the earlier choices made in a study can cause path dependency for the next decisions. This section is intended to discuss the choices made during this study.

A. The choice to follow a Design Science Research approach

The study follows the Design Science Research (DSR) approach to develop a new design artefact. The need for a model to help organizations create and maintain consistent and accurate supplier information was identified in the early steps of the design. Although a significant number of maturity models have previously been developed, there is currently no MDM maturity model that specifically address suppliers. The design phases proposed by Johannesson and Perjons (2014) were followed to answer the research questions and follow the objective of this study. The phases followed are 1. the identification and explication of the problem, 2. the definition of objectives and requirements for an artefact, 3. the design and development of the artefact using the requirements, 4. the demonstration of the artefact and, 5. the evaluation of the artefact. Factors that influence supplier MDM could not be identified in existing literature. The design science allowed for extended literature research and field research, in order to develop factors that influence supplier MDM.

The choice for a DSR approach was a deliberate decision of the author, based on the advice provided by the thesis supervisors. Other researchers choose the DSR approach for the design of MDM maturity models as well (e.g. Spruit and Pietzka, 2014; Zúñiga et al., 2018). However, there is not enough evidence to explore whether a different approach would be more beneficial for this study.

B. The choice to develop a stages-of-growth maturity model

A staged-of -growth maturity model was chosen for the purpose of this study. This is mainly due to the simplicity of this type of models. They are simply structured and easily understandable to others. Moreover, their application can be complemented by additional assessment tools, according to Becker et al. (2009), such as the self-assessment questionnaire provided in this study.

Stages-of-growth maturity model do not come of course without criticism. As discussed in section 3.3.1.3.2, the step-by-step approach of stages-of-growth models often oversimplifies reality. Moreover, they consider only one single path for maturity growth, neglecting possible equivalent maturity paths (Gomes et al., 2013; Fryt, 2019). Many authors support that these models do not consider internal and external factors which can possibly constrain the maturity model applicability in its standardized version (Meetler and Rohner, 2009). Also, they often neglect the possibility of evolution and change of the factors (King and Kraemer, 1984). A “high-level growth path” (p. 74) is indicated, while there should not be uniform approach. Case specific customization is suggested to achieve more reliable results (Maheshwari et al., 2011).

Maturity models often lack empirical evidence to support the suggested maturity measures or a theoretical basis (Gomes et al., 2013) or clear documentation of the design process (Pöppelbuß and Röglinger, 2011). This study considers the criticism on maturity models and uses a systematic literature review and a solid theoretical base to develop the supplier MDM maturity model. The design process is clearly documented and supported by existing literature in the area of maturity model development and in the DSR approach. Supplier MDM is a highly complex topic, as it involves many cross-functional

processes and it is influenced by many functions and departments within an organization. This do not allow for specific customization within the time frame of this study, as proposed by Maheshwari et al. (2011).

C. The development of the supplier MDM factors

There is currently no literature that specifically address the challenges and problems associated with the supplier domain in MDM. There is also not a universal view to define MDM, as it can be understood differently in different contexts. In this study, a systematic literature review was conducted to set the theoretical base for the development of the factors which can influence supplier MDM. The review included articles in the area of master data management, master data quality, master data governance and master data architecture. Following this, an expert survey was conducted to develop the requirements of a company to solve the supplier data problems, which were used as a framework for the development of the factors. Lastly, nine semi-structured exploratory interviews were conducted, and the transcripts were coded and analysed toward the development of the supplier MDM factors.

The iterative process followed allowed for academic and industry knowledge to contribute to the factor development. However, the survey and interviews were conducted in the same case company. This might have reduced the generality of the factors. Also, the processing of the information during the transition between the factor development stages, might have been influenced by the author's personal interpretation.

D. The choice to conduct a single-case study

The choice for a single-case study provided opportunities for in depth examination of the supplier data problems and challenges in a company within the scope of this study. Although the results from a carefully selected case study can be generalizable, it would be beneficial for this study to extend the industry knowledge used to develop the factors and explore problems that other experience with the supplier MDM. A company in the healthcare industry was chosen as the case company of this study. This decision is based on the assumption that wrong supplier master data could have significant impact in the operations of a company in this industry. Experts from companies in other industries could have been interviewed instead or could have been used as an additional resource for this study.

E. The evaluation approach

The model design is evaluated based on its quality, efficacy and utility based on the third guideline for design science (Hevner et al., 2004). For this purpose, structural and environmental factors, as defined by Johannesson and Perjons (2014), were used. Two evaluative interviews were conducted with experts from the case company. Although the evaluation approach followed is well documented, the number of interviews might not be adequate. Other ways could have been also used to evaluate the design, such as workshops. Moreover, evaluation loops could have been used to assess the changes made after the evaluative interviews.

6.3.3 Reflection on research outcome

The research approach which is followed and the choices that have been made during the research, resulted in the following research outcomes.

A. Different results can be derived if the model is used by employees/managers of different functions

Because of the decisions made, the competencies of the model are developed in a way which allows different interpretation by different users. The importance of the MDM varies according to the business department and the employees' functions. Moreover, success in this area can be perceived differently

from people with dissimilar experiences. Therefore, the developed assessment tool can be used from a number of people within the same company, without necessarily resulting in the same degree of maturity in supplier MDM.

B. The model is not evaluated in practice for its utility and efficacy

The evaluation of the developed model is realized only in a theoretical level. Therefore, the study cannot prove that the model helps organizations with their supplier MDM problems. The model needs to be deployed in the case company and other companies within the scope of the study, and their progress in supplier MDM needs to be monitored.

C. The model reflects the supplier data problems of the case company

During the exploratory interviews, employees of the case company were invited to discuss the problems they have experienced with supplier MDM. The problems that resulted from this questions are: local supplier IDs, intentional duplicates, inconsistent supplier data in different systems, too many silos, low supplier data quality, lack of global visibility, wrong supplier data, incomplete supplier data, duplicated supplier information. These problems and the proposed solutions are incorporated into the development of the competencies. This means that if a company uses the model and result in a high level of maturity, then the necessary actions are taken against these problems. Moreover, the evaluative interviews confirmed that the developed factors represent the organization's problems and that these can influence the supplier MDM in the case company.

D. The model can be interpreted wrong

The objective of the maturity model developed in this study is to help companies determine their maturity in supplier MDM. The maturity assessment can also help them identify which areas they need to improve to increase the maturity. However, the study does not provide a roadmap for improvement and does not suggest specific actions. The areas where improvement is needed are identified, and the activities are decided and planned by the company.

E. The study is lengthy

The iterative development of the maturity model in this study has resulted in an extended report. Existing literature was consulted in many phases of the research, such as the systematic literature review, interview protocol development, interview coding and evaluation of the design. Although this might have increased the reliability and verifiability of the design, it has increased the length of the study.

6.4 Scientific contribution

The DSR approach suggests the use of theories and methods, which are referred to as kernel theories, to provide theoretical grounding for the artifact (Walls et al. 2004). However, not everyone considers the use of kernel theories necessary to establish the rigor of artifact construction (Fischer et al., 2010). Hevner et al. (2004) suggest that the need of an IS knowledge base to construct design science artifacts, but not necessarily the use of a kernel theory. Goldkuhl (2004) supports "I do not conceive kernel theories (explanatory theories) to be indispensable parts of design theories" (p. 66). Lastly, March and Smith (1995) do not refer to the use kernel theories in the construction of the artifact.

The design of this study is based on a theoretical base, which is the first step for the factor identification. The theoretical base of the study is presented Table 43, using a concept-centric approach, as proposed by Webster and Watson (2002). This section is intended to explain the process followed for the study's outcome to contribute to the theoretical base.

Source ID	Source	Concept
1	Loshin (2010)	Master data management
2	Sivola (2011)	
3	Jonker et al. (2011)	
4	Van Unen et al. (2012)	
5	Spruit and Pietzka (2014)	
6	Haug and Arlbjørn (2013)	Master data quality
7	Silvola et al. (2016)	
8	Spruit and Van der Linden (2019)	
9	Alhassan and Sammon (2019)	Master data governance
10	Otto and Schmidt (2010)	Master data architecture

Table 43: Theoretical base of the study

The research outcome of this study is a maturity model for the supplier MDM. The model was developed iteratively, starting from a systematic literature review. The literature review was conducted to develop a theoretical base for the development of the model. There is extensive literature that can be used to identify factors, benefits, challenges and barriers of MDM. However, supplier MDM specific factors could not be identified in the existing body of knowledge. The ten articles which were chosen and used, as explained in section 3.3.1.4, provide knowledge in the area of master data management, master data quality, master data governance and master data architecture. Information was collected from these articles and it was translated into factors that can influence MDM. The theoretical base developed was used to conduct an expert survey, which resulted in the identification of the requirements for the design. Following this, exploratory semi-structured expert interviews were conducted. The analysis and coding of the interview transcripts provided a set of factors which influence the supplier MDM in organizations within the scope of the study.

Therefore, this study, contributes to the theoretical base of the model, by adding industry-driven factors that influence supplier MDM. The outcome of the factor identification activity did not result only in new factors, but also in prioritization and selection of the factors derived from the selected literature, based on the supplier data problems that companies experience. Some of the factors remained the same, as they were presented in previous literature. Some other were adjusted or merged to specifically address the supplier MDM challenges and problems. Moreover, new factors resulted from the coding of the interview data. While there are factors, such as data accuracy, that can be used also in other MDM domains, there are other factors which are supplier specific, such as the valid path for supplier offboarding.

The factors were processed to develop the elements of the maturity model. The supplier MDM maturity model consists of a set of key concepts, dimensions and capabilities. Additionally, five cumulative maturity levels have been developed based on the capabilities of the model. These elements comprise a new maturity model, which it is intended to determine a company's MDM maturity with regards to today's supplier master data problems. The maturity model that is developed in this study contributes to the current body of knowledge on scientific based tools that can guide organizations when implementing MDM development programs. Concluding, the thesis adds to the theoretical base, as presented in Table 44.

Aspect	Existing literature	Source	Contribution of this study
Factors that influence MDM	Yes	[1], [2], [3], [4], [5], [6], [7], [8], [9], [10]	Adjustment of existing factors to reflect the supplier master data problems, as resulted from the coding of the interview data

Factors that influence supplier MDM	No	-	New factors that influence supplier MDM, as resulted from the coding of the interview data
MDM maturity models	Yes	[1], [3], [5]	Maturity model which address specifically supplier MDM, as resulted by combination and processing of the factors

Table 44: Contributions to the theoretical base

6.5 Societal and managerial relevance

In this study, the dual nature of DSR is considered, aiming at both advancing the scientific knowledge base and providing results that are useful in practice. The study provides an approach for the assessment of the maturity of large and international companies in supplier MDM. The model considers the supplier MDM as a way to increase the value of the supplier master data within the supplier-buyer collaboration. Distributed organizations experience problems with managing effectively the supplier information in all the stages of the collaboration and from an enterprise-wide perspective. During the different stages of the collaboration, multiple departments and functions within the same organization collect thousands of data elements to create or edit supplier records, in many disconnected processes and tools. The study provides factors that influence the supplier MDM and addresses these challenges by incorporating industry knowledge.

Previous research already gave an indication of the benefits that MDM can provide to organizations. This study pays attention to the benefits of MDM in the supplier management. According to this study, by integrating and combining data from different sources companies can create more meaningful supplier information. This can provide companies with opportunities to maintain long-term stable relationships with the supplier, which can result in "effective communication, enhanced information sharing and trust, reduced cost and cycle time, and improved customer satisfaction". (Yang, 2013; p.1984). Thus, the study provides insights on how the supplier collaboration can become more transparent, based on effective supplier MDM.

The managerial relevance lies in the fact that the study provides companies with a model they can use to determine their supplier MDM maturity and to identify potential improvement areas. Once organizations know where they are, they can develop a systematic approach for growing supplier MDM maturity. According to Otto (2015), modern businesses treat their master data as a strategic resource and therefore this study aims to help them manage it accordingly.

In section 4.2.6.1 the problems that the case company experiences with the supplier data during the supplier onboarding, management and offboarding are presented, based on the expert interviews. The supplier MDM maturity model is developed in a way that a high degree of maturity means that the company takes the necessary actions to resolve these problems. In particular:

1. *Create supplier (supplier onboarding)*: A company with a high level of supplier MDM maturity takes actions to ensure the entry of accurate and concise supplier information into the system. There is one gate for entering the supplier data and a unique identification number is assigned to the new supplier. Supplier can-self register, ensuring the believability and correctness of the information. Additionally, the system settings do not allow for the creation of a supplier which already exists, which prevent users from creating supplier duplicates. Lastly, people are aware of how to correctly use the company's systems and how to treat the supplier data.
2. *Update supplier (supplier management)*: In a company with high maturity level, the changes in the supplier master data are reflected everywhere across the organization. All the changes are

performed in one central system, which distributes the information in all the other systems, and they are approved by the company and the suppliers. The data rules and policies are strictly followed, and the people of the organization knows how to manage and maintain the supplier information.

3. *Deactivate supplier (supplier offboarding)*: A company with a high degree of maturity, ensures that the supplier offboarding is performed in all the systems across the organization. When a supplier is offboarded, its information is treated according to the company's regulations, so there is no redundant supplier information. The supplier then is blocked appropriately in the relevant ERP systems.

If the company does not have a high maturity level, then the model can be used to indicate the areas which can be improved to increase the organization's maturity.

6.6 Relevance to the MoT program

The Management of Technology (MoT) programme aims at providing knowledge on how engineers can manage technology and promote innovation. Its main objective is to train responsible future decision-makers and teach them ways to deploy the appropriate strategies to support social, technological and economic changes. To that end, the Delft University of Technology has set three main axes for an MoT thesis to comply with the program's requirements:

"The work reports on a scientific study in a technological context"

The nature of this thesis is inherently based on the context of technology and strategy. The aim of this study was to explore how technology can be successfully implemented in large and global organization to achieve successful MDM practices with regard to the management of supplier information. Insights from the areas of Data Science and ICT Management and Design have contributed to the development of Master Data Management as a solution toward the enterprise-wide management of the businesses' key data objects. This thesis provides information for companies to develop a data-driven strategy to gain competitive advantage, by ensuring effective data management and exchange and maintaining a long-term supplier relationship.

"The work shows an understanding of technology as a corporate resource or is done from a corporate perspective"

In accordance with the objectives of the MoT program, this study aims to apply the knowledge and skills gained during the two-year curriculum, in a complex realworld setting and to support a high-tech business initiative. During the study, the author was a graduate intern at Koninklijke Philips N.V. in the procurement department, which provided great insight into the needs and challenges of the industry.

"Students use scientific methods and techniques to analyze a problem as put forward in the MoT curriculum"

Insights from the following courses were used to facilitate the research process of the thesis:

- MOT2312 Research Methods: Guidelines for conducting scientific research, Interview structure, Transcript analysis, Research ethics
- MOT1435 Technology, Strategy & Entrepreneurship: Technology strategy, Strategic Intent development, Sustainable competitive advantage
- MOT1524 Leadership and Technology Management: Challenges of technology firms in leading and managing people, Contribution of leaders to organizational performance, Alignment between management practices and business strategy

- MOT 1531 Digital Business Process Strategy: Business and knowledge rules, Business process automation and technology, Business process maturity, Compliance by design

6.7 Limitations

This study aims to develop a maturity model that is theoretically sound, rigorously tested and widely accepted. However, there are some limitations in this study. The conclusions of this study result from the in-depth examination of one case company. This was a deliberate decision in order to comprehend the complexity of a supplier MDM program in an organization within the scope of the study. However, the decision for a single-case study could limit the reliability of the results. A greater number of case studies within the same scope would provide a broader view of the needs of the industry and could advance the results of this study. Moreover, deployment of the developed maturity model is missing from this study. Testing and maintenance of the model could provide opportunities for further development and continuous improvement. Application of the model could also further explore the extent to which the model is accurate and easy to use.

It is also important to be mentioned that the factors developed and the domains they are assigned to, can be perceived differently from different perspectives. Interviewees with expertise in different areas, for example in the business, IT or data management, suggested dissimilar categorization and prioritization of the factors. This does not mean that the results are inaccurate rather than that the domains are broad. The results of the study reflect an overview of the experience and understanding of all the people involved in the research.

Moreover, the assumption that all the factors have the same weight is made in this study. However, this can be inaccurate in specific settings and different weights could have been assigned to the factors. Lastly, environmental factors that could possibly impact the results of the study are not explored in this thesis and the relationships and dependencies among the developed factors are not analyzed. Concluding, the study encompasses a first step toward the exploration of the supplier MDM and suggests further research for greater insights into the field.

The limitations of this study are:

- The phases of deployment and maintenance of the model are missing. These phases could advance the study by providing means to 1. better understand the utility of model, 2. identify ways to improve the model.
- A single case study is used for the development of the model, which can limit the generality of the research outcome.
- The choice of developing a stages-of-growth maturity model oversimplifies reality and considers one single path for the supplier MDM maturity improvement.
- This study presents an objective-centered design research, where the development of the model is initiated by a specific industry need. This can narrow down the extent that the developed model can be used.
- All the capabilities in the developed model are assigned with the same weight. The importance of the supplier MDM dimensions and capabilities in different settings could be explored, and different weights could be assigned.
- The dependency of the factors is missing and environmental factors that could possibly influence the capabilities of companies are neglected.
- The time frame of the study was limited by the university's regulations for the master thesis completion. The study can be further improved.

6.8 Recommendations

This section provides recommendations for managers to use the model and for researchers to improve the model.

6.8.1 Recommendation for managers to use the supplier MDM maturity model

The maturity model of this study is designed to help companies determine their maturity in supplier MDM. The model also serves as comparative basis for improvement. It provides an approach for increasing the supplier MDM maturity of the organization, by indicating the areas that need to be improved. The model can also be used to provide an accessible approach to present the need for actions toward growing maturity in supplier MDM with stakeholders outside the team. In this section, a suggestion of how the results of the maturity assessment can be used by the organization, is explained.

After the level of maturity has been estimated, the company can set its goals and targets for a higher maturity level. When companies know where they are and where they want to be, they can plan the necessary activities to get there. The decision to grow the company's maturity in supplier MDM needs to be communicated with the stakeholders involved in the development program. The supplier MDM maturity model can be used in this phase to align new partners or to engage decision makers. A shared view of the level of maturity can be established across the team or the steering committee. This helps managers manage the expectations of the organization of what the growing supplier MDM requires and justify the resources and time needed.

Following this, the model can be used to guide the actions towards a higher supplier MDM maturity level. The model represents the capabilities needed to achieve a specific degree of maturity in each focus area. In this way, steps can be formulated to close the gaps, which result from the maturity assessment using the designed model. Thus, in this phase, the model is useful to sequence the steps to be followed in order to develop a systematic approach to change. First, the areas where development is needed are defined. Following this, the tasks and roles for growing the maturity level need to be created and assigned. By prioritizing the required activities, a roadmap to achieve higher maturity is developed, which can be communicated with the company to discuss the investments and potential trade-offs.

6.8.2 Recommendations for future work

The supplier MDM maturity model developed in this study can be further improved. A single- case study is chosen in this thesis to develop the model. According to Yin (2003), case studies have limited generalizability by nature. It is possible that specific for the case company requirements have influenced the design of the model. The supplier MDM related problems, challenges and objectives are discussed in this study from the perspective of the case company. The elements of the design, which include the key concepts, dimensions and capabilities, can be further improved to incorporate the perspective of other organizations which experience supplier master data problems. Thus, a first step towards an improved version of the model, is to conduct more case studies. Case studies in different companies within the scope of this study (i.e. international and global) can eliminate any specific requirements and factors.

Moreover, the maturity model development in this study, does not include the phases of deployment and maintenance. These steps are important to evaluate how applicable the developed model is in different environments. Therefore, a second step to improve the current model, is to use the model in real-life settings. The deployment or testing of the model is an important step in most of the methodologies proposed for the maturity model development (e.g. De Bruin et al., 2015; Mettler and

Rohner, 2009; Van Stenbergen et al., 2010). First, the model needs to be used in the case company, to evaluate its usability and to ensure that it reflects the challenges that the organization experience. Second, the model can be deployed in other companies within the scope of this study. Lastly, a further step is to explore he usability of the model in other contexts, as for example smaller companies. However, this will highly increase the complexity of the study, as some factors do not apply to companies outside of the defined scope. If a significant number of companies is used to deploy the model, this will help understand its utility and identify its weaknesses. Finally, the developed model can be improved with maintenance. The maintenance stage is a step proposed in some of the existing maturity model development procedures (e.g. De Bruin et al., 2015; Maier et al., 2005). In this phase, if the model is approved, changes are managed and, if necessary, the model is updated. Collecting and analyzing data from the use of the model, could provide information on the dependencies between the key concepts and the dimensions. Lastly, the environmental factors that can influence the capabilities of a company could be explored.

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Appendices

A: Factors influencing MDM derived from the literature (a concept-centric approach)

Concept	Source	Categories	Factors
Master Data Management	Loshin (2010)	Business process management	Business process integration
			Business rules
			MDM business component layer
		Integration	Application integration and synchronization service layer
			MDM component service layer
		Identification	Identity search and resolution
			Record linkage
			Merging and consolidation
		Management	Migration plan
			Hierarchy management
			Identity management
			Administration/Configuration
		Governance	Data standards
			Metadata management
			Data quality
			Data stewardship
		Architecture	MDM service layer architecture
			Master data model
			MDM system architecture
	Sivola (2011)		Data model
			Data ownership
			Data quality
			Culture
			Roles and responsibilities
			Organizational structure
			Processes
			Managerial support
			Information systems
	Jonker et al. (2011)	Governance	Ownership
			Guiding principles
			Governance
			MDM policy and strategy
		Process	Common process descriptions
			Common role descriptions
			Organization embedding
			Common tools
		Content	Data rulebooks

			Conversion plan
			Data object sheets
			Data quality routines
			Data validation checks
			Migration rules
		Systems	System and data landscape
			Master data mapping across system
			Synchronization rules
			Interface automation
			Data cleansing
	Van Unen et al. (2012)	Data definition	Master data dictionary
			Data model
		Data quality rules	Technical rules
			Business rules
		Monitoring	Preventive measures
			Detectives measures
			Corrective measures
		MDM tooling	Data quality tooling
			Data integration tooling
			Data governance tooling
	Spruit and Pietzka (2014)	Data model	Definition of Master Data
			Master Data Model
			Data Landscape
		Data quality	Assessment of Data Quality
			Impact on Business
			Awareness of Quality Gaps
			Improvement
		Usage and ownership	Data Usage
			Data Ownership
			Data Access
		Data protection	Data security
		Maintenance	Storage
			Data Lifecycle
Master Data Quality	Haug and Arlbjørn (2013)		Delegation of responsibilities for maintenance of master data
			Rewards for ensuring valid master data
			Master data control routines
			Employee competencies
			User-friendliness of the software that are used to manage master data
	Silvola et al. (2016)	Item, company and supply chain management data	Data believability
			Data security
			Data value-added
			Data accessibility
			Data accuracy
			Data relevance
			Data timeliness
			Data completeness
			Data reputation

			Data consistency
			Data representation
	Spruit and Van der Linden (2019)	Intrinsic	Data accuracy
			Data timeliness
		Accessible	Data accessibility
			Data security
		Contextual	Data relevancy
			Data completeness
			Data objectivity
		Representational	Data understandability
			Data conciseness
			Data consistency
Master Data Governance	Alhassan and Sammon (2019)		Employee data competencies
			Clear data processes and procedures
			Flexible data tools and technologies
			Standardized easy-to-follow data policies
			Established data roles and responsibilities
			Clear inclusive data requirements
			Focused and tangible data strategies
Master Data Architecture	Otto and Schmidt (2010)		Master data ownership
			Master data validity
			Master data lifecycle
			Master data operations
			Conceptual master data model
			Master data object definition
			Master data processing
			Metadata management
			Master data application topology
			Master data distribution

Table 45: A concept-centric approach on factors influencing MDM

B: Rating of the factors

B1: Results of the expert survey

Factors	**Rating**			
	Expert A	Expert B	Expert C	Average
Standardized easy-to-follow data policies	10	7	10	9
MDM policy and strategy	9	8	9	8.666667
Common process descriptions	8	7	8	7.5

Data rulebooks	9	8	9	8.5
Guiding principles	7	6	8	6.5
Focused and tangible data strategies	9	6	9	7.5
Business rules	8	6	8	7
Clear data processes and procedures	9	9	9	9
Common role descriptions	6	7	7	6.5
Established data roles and responsibilities	8	8	9	8
Managerial support	7	7	6	7
Hierarchy management	8	7	8	7.5
Identity management	7	7	7	7
Administration/Configuration	8	6	8	7
Data Usage	9	6	9	7.5
Data Ownership	10	10	10	10
Data stewardship	8	6	8	7
Identity search and resolution	8	5	8	6.5
Record linkage	9	7	9	8
(Conceptual) master data model	10	8	10	9
Master data mapping across system	10	9	10	9.5
System and data landscape	8	9	8	8.5
Master data oblect definition	9	7	9	8
Master data operations	9	6	9	7.5
Data object sheets	7	5	7	6
Clear inclusive data requirements and standards	9	7	9	8
Migration rules	7	6	8	6.5
Migration plan	7	6	8	6.5
Conversion plan	7	6	8	6.5
Synchronization rules	10	6	10	8
Data cleansing	10	8	10	9
Merging and consolidation	9	8	10	8.5
Real time master data processing	6	7	6	6.5
Application integration and synchronization service layer	9	6	9	7.5
MDM component service layer	8	6	8	7
Master data application topology	8	6	8	7
Master data distribution	10	7	10	8.5
Interface automation	9	6	9	7.5
Business process integration	9	8	9	8.5
MDM business component layer	8	6	8	7
MDM system architecture	10	7	10	8.5
Master data lifecycle	9	7	9	8
Delegation of responsibilities for maintenance of master data	10	5	10	7.5
Data storage	8	5	8	6.5
Data believability	9	9	9	9
Data security	6	8	10	7
Data value-added	8	8	10	8
Data accessibility	10	8	10	9
Data accuracy	9	10	10	9.5
Data relevancy	8	7	10	7.5

Data timeliness	7	6	8	6.5
Data completeness	9	10	9	9.5
Data reputation	6	6	6	6
Data consistency	9	10	10	9.5
Data representation	9	6	8	7.5
Data objectivity	7	7	7	7
Data understandability	6	9	9	7.5
Data conciseness	8	9	8	8.5
Data quality technical rules	9	9	9	9
Data quality business rules	8	8	8	8
Data quality routines	9	7	9	8
Data validation checks	10	10	10	10
Master data control routines	8	8	9	8
Assessment of Data Quality	9	9	9	9
Awareness of Quality Gaps	9	9	9	9
Rewards for ensuring valid master data	10	6	10	8
Preventive measures	8	9	8	8.5
Detective measures	9	9	9	9
Corrective measures	10	10	10	10
Employee competencies	8	6	8	7
Organizational structure	8	6	9	7
Organization embedding	9	6	9	7.5
Information systems	9	7	9	8
Culture	6	6	6	6
Common tools	9	7	10	8
Flexible data tools and technologies	8	7	8	7.5
Data quality tooling	9	9	9	9
Data integration tooling	10	9	10	9.5
Data governance tooling	10	9	10	9.5
User-friendliness of the software that are used to manage master data	9	8	9	8.5

Table 46: Results of the expert survey

B2: Selection of the highest rated factors

Factors	**Rating**			
	Expert A	Expert B	Expert C	Average
Standardized easy-to-follow data policies	10	7	10	9
MDM policy and strategy	9	8	9	8.666667
Data rulebooks	9	8	9	8.5
Clear data processes and procedures	9	9	9	9
Established data roles and responsibilities	8	8	9	8
Data Ownership	10	10	10	10
Record linkage	9	7	9	8
(Conceptual) master data model	10	8	10	9

Master data mapping across system	10	9	10	9.5
System and data landscape	8	9	8	8.5
Master data oblect definition	9	7	9	8
Clear inclusive data requirements and standards	9	7	9	8
Synchronization rules	10	6	10	8
Data cleansing	10	8	10	9
Merging and consolidation	9	8	10	8.5
Master data distribution	10	7	10	8.5
Business process integration	9	8	9	8.5
MDM system architecture	10	7	10	8.5
Master data lifecycle	9	7	9	8
Data believability	9	9	9	9
Data value-added	8	8	10	8
Data accessibility	10	8	10	9
Data accuracy	9	10	10	9.5
Data completeness	9	10	9	9.5
Data consistency	9	10	10	9.5
Data conciseness	8	9	8	8.5
Data quality technical rules	9	9	9	9
Data quality business rules	8	8	8	8
Data quality routines	9	7	9	8
Data validation checks	10	10	10	10
Master data control routines	8	8	9	8
Assessment of Data Quality	9	9	9	9
Awareness of Quality Gaps	9	9	9	9
Rewards for ensuring valid master data	10	6	10	8
Preventive measures	8	9	8	8.5
Detective measures	9	9	9	9
Corrective measures	10	10	10	10
Information systems	9	7	9	8
Common tools	9	7	10	8
Data quality tooling	9	9	9	9
Data integration tooling	10	9	10	9.5
Data governance tooling	10	9	10	9.5
User-friendliness of the software that are used to manage master data	9	8	9	8.5

Table 47: Highest rated factors of the expert survey

C: Interview protocol

C1: Interview invitation via e-mail

Subject: Invitation to interview for research on the supplier master data management

Dear -name-,

My name is Ifigeneia Athanasiadou and I am conducting this research for my graduation project as part of my master's degree in Management of Technology at Delft University of Technology. My research is focused on the development of a maturity model for the master data management in the supplier lifecycle management. In the coming phase of my research I will be conducting interviews with members of the Philips SLM team to obtain a deep understanding on the needs of the organization.

You are invited to this interview because of your expertise in the supplier lifecycle management/ business information management. Your contribution to my research is invaluable. I would like to plan a meeting with you based on the scheduling on your agenda, preferably between July 17 and July 30. The interview will last 45-60 minutes, and it can be a face to face meeting or a skype-call.

Thank you in advance. I look forward to hearing from you.

Kind regards,
Ifigeneia Athanasiadou

ifigeneia.athanasiadou@philips.nl
I.Athanasiadou@student.tudelft.nl

C2: Consent form

You are invited for an interview for the supplier master data management. This interview is part of a graduation project for Delft University of Technology. Before you decide to participate, it is important that you understand why this research is conducted and what it entails. Please read this form carefully.

What is the purpose of this research? I am interested in exploring how a holistic and unified view on the supplier data can be achieved during the supplier-organization collaboration. The objective of this study is to develop a maturity model for the evaluation of the supplier master data management during the supplier lifecycle, by large organizations which aim to manage supplier information in a centralized manner.

Who is the interviewer? This research is being conducted by Ifigeneia Athanasiadou as a graduation assignment for the master's degree in Management of Technology at Delft University of Technology.

Who are the interviewees? Employees of Philips with expertise in the supplier master data management or business information management.

How the provided information will be used? The interviews will be recorded and transcripts will be created to be used in the data analysis phase. The transcripts will be anonymized, but reference will be made to the position and years of experience of the interviewee in the organization. The transcripts and audio recording will not be shared beyond the study team, and the information will be stored securely. Lastly, the anonymized results of this study will be published in TU Delft Repository for future research and learning. No personal information that can identify you will be published or shared.

Are there any risks associated with this study? There are no risks.

Can I withdraw from the interview? The participation to this interview is voluntary and you can withdraw at any time.

When and where does the interview take place? The interview can take place at the any building of the High-Tech Campus in Eindhoven, according to your convenience, or through Skype.

How long will it take? The interview will last 45-60 minutes.

Checklist

Please tick the appropriate boxes

- ☐ I have read and understood the study information.
- ☐ The purpose of this study is explained.
- ☐ I consent voluntarily to be a participant in this study.
- ☐ I understand that I can refuse to answer questions and I can withdraw at any time, without having to give a reason.
- ☐ I give permission for audio recording.
- ☐ I understand that the recording of this interview will be stored securely.
- ☐ I give permission for the study results that I provide to be archived in TU Delft Repository, so it can be used for future research and learning.
- ☐ I would like to receive the results of this study.
- ☐ I give permission for saving my e-mail address with the purpose of sending me the results of this study.
- ☐ I understand that reference will be made to my position and years of experience in the research findings section of the thesis.
- ☐ I understand that the anonymized transcript of the interview will not be shared beyond the study team.
- ☐ I understand that information I provide will be used for the thesis (in anonymized transcripts and research findings section) of Ifigeneia Athanasiadou
- ☐ I understand that personal information collected about me that can identify me, such as (e.g. my name or e-mail address), will not be shared.

By signing this form, you indicate that you have read carefully the participation form and that you agree to participate in this study.

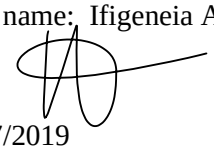
Your name:

Your signature:

Date:

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name: Ifigeneia Athanasiadou

Signature: 

Date: 16/07/2019

If you have any further questions, please contact me via e-mail at I.Athanasiadou@student.tudelft.nl.

C3: Information provided to the interviewees before the interview

Key concepts of this study

Master data management is used by organizations to manage critical data and provide a single point of reference. The need for master data management derives from the request of modern businesses to manage information from different sources in a centralized manner. The supplier master data management, in this study, refers to a unified and holistic view of the supplier data through the whole supplier-organization collaboration cycle and from an enterprise-wide perspective.

Supplier lifecycle management is defined as the entire relationship of a supplier with the organization, including all the stages from choosing and contracting with a supplier, to tracking its performance and eventually phasing the supplier out. This study identifies three main phases in the supplier lifecycle; the supplier relationship initiation phase (from identification to ready to use), the supplier relationship development phase (supplier relationship management) and the supplier relationship ending phase (phase-out).

Maturity refers to well-understood and well-defined processes, supported by documentation and training.

Maturity models are used to assess the as-is situation of a company and to assign it a specific degree of maturity.

Research objective

My motivation for this study is to explore factors that influence the supplier master data management. I aim to understand how master data management is applied in practice during the supplier lifecycle and how holistic supplier data management can be achieved in today's organizations.

The objective of this study is to develop a maturity model for the evaluation of the supplier master data management during the supplier lifecycle, by large and international organizations which aim to manage supplier information in a centralized manner.

C4: Set up of the interview

Part 1: Introduction

In the beginning, general information about the interviewer is provided such as field of studies and interest in this study. Second, general information about the interview is provided, such as the duration and set up. Key concepts are explained and after this the objective for this study and the purpose of the interview are discussed.

Part 2A: Presentation of the selected factors

In this part, the selected factors influencing the supplier master data management are being presented and explained. The interviewee is given as much time as he needs to understand them.

Part 2B: Questions about the selected factors

The interviewee will be asked to answer some questions with regards to the selected factors that have been presented to him. This part aims at identifying weaknesses and evaluating the importance of these factors

Part 3: Questions for development of the critical success factors

This part includes some exploratory questions, which can be categorized as follows:

1) Background information about the interviewee
2) Background information about the experience of the interviewee with the supplier master data
3) Supplier master data management and the holistic approach
4) Supplier master data management and the supplier-buyer collaboration cycle
5) Supplier master data management and the digital transformation

The interviewees are encouraged to explain their contribution to the supplier lifecycle management at Philips and discuss their opinion and experiences. This discussion aims at the identification of the competency drivers for the supplier master data management.

C5: Interview script

General information (to be completed by the interviewer)
Interview number: _____
Interview date: _____July 2019
Interviewer: Ifigeneia Athanasiadou
Interviewee (Title and Name): _____ /_____
Interviewee gender: ◯ Male ◯ Female
Organization:
Country:

Part 1: Introduction

My name is Ifigeneia Athanasiadou and I am carrying out my master's graduation project in Management of Technology at TU Delft. I have been a member of Philips Supplier Lifecycle Management since February 2019, participating in data modelling and data migration activities. My graduation project is about the supplier master data management. I have kindly asked you to speak with me today because of your expertise in the supplier lifecycle management / business information management. I very much appreciate your availability for this interview.

Introduction to the interview

I am going to ask you a few questions about the supplier master data management. Please feel free to share any ideas or experiences related to the questions. Do not hesitate to interrupt me to ask for further clarification when needed. Although there are no wrong answers, try to provide honest and concise answers to my questions. The interview will last approximately 45 minutes. If time begins to run short, it may be necessary to interrupt you in order to push ahead and to cover all the interview questions in time.

Confidentiality and interview recording

All provided information will be treated confidentially, as it has been explained in the consent form that I sent you. I would like to remind you that your participation is voluntary, and you may stop at any time if you feel uncomfortable or refuse to answer a question. I would like to ask your permission to record our conversation today. Would you agree with recording this interview?

◯ Yes → thank you, I will now start recording

◯ No → No problem, I will take notes of our conversation.

Part2: Background information

Part 2A: Background information about the interviewee

Question 1: What is your role in Philips?

Question 2: How long have/had you been involved in activities related to the supplier master data management or similar?

Part 2B: Background information about supplier lifecycle management in Philips

Question 3: Could you provide me an overview of the objectives of Philips SLM?

Part 2C: Experience of the interviewee in supplier master data management

Question 4: Did you experience any problems with the supplier data?

Part 3: Questions for the supplier master data management

Part 3A: Supplier master data management and the holistic approach

Question 5: How do you believe that an organization with complex information system, such as Philips, can achieve a holistic and unified view of its supplier data?

Question 6: What do you believe that can be a barrier to a holistic and unified view of an organization's supplier data?

Part 3B: Supplier master data management and the supplier-buyer collaboration cycle

Question 7: What do you believe should be considered, with regard to the management of the supplier data, in the supplier relationship initiation phase? (e.g. identification, intended use, registration, contracting)

Question 8: What do you believe should be considered, with regard to the management of the supplier data, in the supplier relationship development phase? (e.g. supplier relationship management)

Question 9: What do you believe should be considered, with regard to the management of supplier data, in the supplier relationship ending phase? (e.g. phase out, end of collaboration)

Part 3C: Supplier master data management and the digital transformation

Question 10: What do you believe is important when a new technology/tool is used for the supplier data management?

Question 11: After supplier data has been cleansed, what do you believe is important for the supplier data to remain clean?

Part 4B: Questions about the selected factors

Question 12: To which extent do you believe these factors are understandable?

Question 13: To which extent do you believe these factors are comprehensive?

Question 14: Do you believe that some of these factors are not related to the supplier master data management?

Question 15: Are there other important factors for supplier master data management that need to be considered?

Part 5: Follow up questions or additional comments

I would like to thank you for participating in my study. Your help is very much appreciated.

Please let me know if you want to share further related information with me or if you have any questions for me.

D: Main findings of the exploratory interviews

The interviews resulted in some interesting findings for this study. Some people focus primarily on the technology aspect for success, while some other pay great attention to the communication of the importance of the program to the internal and external stakeholders. There seem to be a consensus that a single-entry gate for everyone entering or managing data is a key factor for successful master data management.

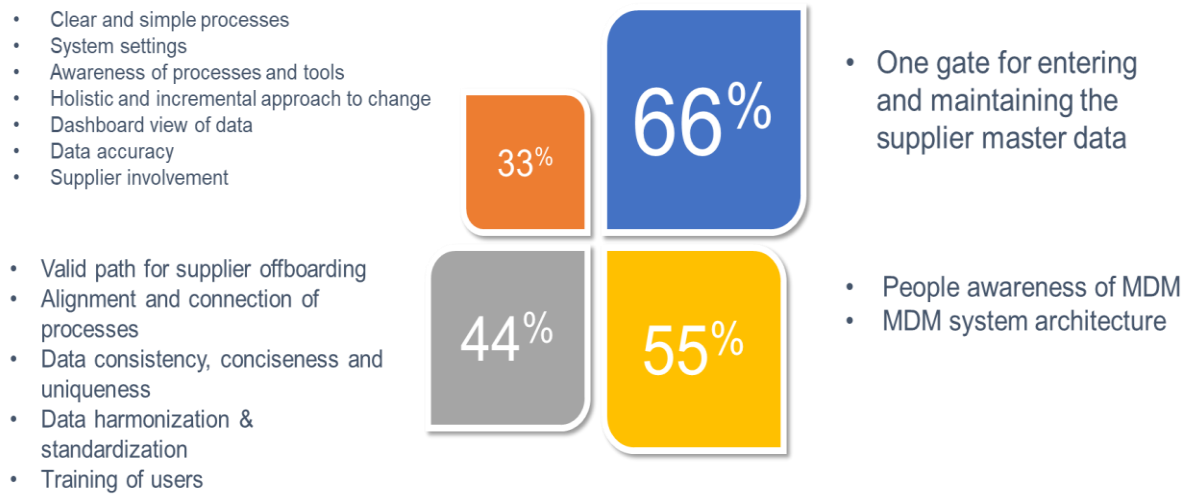


Figure 23: Main findings of the exploratory interviews

E: Explanation of the supplier MDM factors

1. Unique identification of the supplier data

Duplicate supplier data is one of the biggest problems of large organizations. According to the interviews in the case company, “we have a big number of duplicates. Not only between systems, but also within each and every separate system”, “sometimes we have the supplier more than once as a record and sometimes we have it in different flavors with different spelling, different writing”. As a solution to this problem, deduplication activities are proposed, so that all the supplier data are unique. Instead of assigning local IDs to the suppliers in every system, a unique identifier is proposed to be assigned to every supplier that can be used across the organization and through all the processes of the supplier-buyer collaboration. This, according to the interviews, can highly reduce complexity and prevent data duplication issues.

2. One gate for entering and maintaining all supplier information

The majority of the interviewees highlighted the importance of one single entry gate for all the supplier master data and its maintenance. They refer to one core system, one entry for all the phases of the supplier-buyer collaboration cycle, from the onboarding to the phase-out, “Because we need to have one core, where the truth of supplier master data is stored and maintained and this one has to be connected to all other tools which are using supplier master data for their local processes.". Following the decision to introduce one single gate, it is important that all the other gates are successfully closed. According to the interviews, "That means you need to identify all the open doors in every system, in every landscape in order to make sure that nobody is able to pollute the data again"

3. Alignment and connection of the supplier related processes

According to the interviewees it is important to connect all the supplier related processes by breaking off the silo-thinking. In order to make this happen, “the in between layer are the handshakes and the talks that you have to do with your cross-functional processes.”. What has also been mentioned is that the centralization of processes requires “to fit in one template the entire landscape”. The transition from a non-centralized to a centralized architecture can be highly challenging and time consuming. You need to have all local configurations, local requirements and local processes to be aligned with a centralized way of working.

4. Alignment of new supplier creation with the commodity strategy

This factor relates to the reduction in the number of suppliers. Before a new supplier record is created, and the collaboration of the company with a supplier starts, it is important that the new supplier creation is aligned with the commodity strategy. It might be the case that the company is in a program of reducing the supplier amount. This important not only for the alignment with the defined strategy but also for the reduction of complexity.

5. Clear and simple processes

It is often that unnecessarily complex processes impede the success of master data management activities. The interviewees support that the employees need to know what to do and it should be clear and easy for them. If not, it should at least be easy to know who to interact with in case of a problem. The introduction of one entry gate for the supplier data is a first step towards simplification of the processes. The concerns of the interviewees include also the complexity of processes related to the suppliers. The suppliers are asked to provide information more than once during the supplier-buyer collaboration, which often results in inaccurate supplier data.

6. Support teams

After any change in the management of the supplier master data, the employees need to adjust to the new way of working. The existence of teams that support them in this process and people who are available to explain the new procedures, can highly contribute to the success of supplier master data management programs.

7. Training of users

People in the case company refer to the program as a complete transformation process. In this case, and within the context of change management, training of the users is a vital element of success. Training sessions, webinars, webcasts and various other ways can be used to inform the employees on the new proposed way of working and the use of the new tools. What has been mentioned is that "The tools have to be set up so that it is only possible to enter correct data with minimum requirements and on the other hand, in parallel to that, we have to train all people using these tools to do it correctly." An interesting way that has been proposed for the training of the users is the development of an interactive tool. “So a

self-knowledge base, an interactive tool that would show the users that they actually need this onboarding, that actually need some processes just play with the tool how to navigate in it, but everything would be self-operated so basically what you do is you don't need support team as big as before, and you still can inform the user.”.

8. Holistic model for change management

It is significant to have a clear overview of the different aspects of change of an MDM program and the objectives from the perspective of different stakeholders. This study proposes a systemic approach to change, where managers need to have from the beginnings a holistic view of the company and the enablers and constraints of the cross-functional communication. According to the interviews, “You always paint your picture from a need perspective, what would you like to have. The picture you translate it...you make it visible. You describe your needs, you are making it visible for cross-functional benefits.”

9. Incremental change

Although it is important to have a holistic view in the beginning, the implementation need to be performed step by step. The introduction of a new way of working is something that requires time, and it cannot be done at once. As it has been reported in the interviews, “You have to do it step by step, department by department, cross-function by cross-function, IT tool by IT tool”. Moreover, communication with the user community need to take place through the whole implementation process and also during the after-implementation phase.

10. Alignment of the interests of internal stakeholders

In large organizations, many different stakeholders are involved in the management of the processes. A team for the implementation of a supplier master data management program can include experts from different business areas and therefore it can be challenging to integrate all the opinions and interests. The interviewees support that it is important to make sure that all the people involved in the decision-making process, from the senior stakeholders to the all the employees, are on the same page. Communication within the members of the development team is also considered important. According to the interviews “In order to make your program successful you what you need is to have it together in one group, in one place, in one-time frame, in one time zone.”

11. People awareness of processes and tools

It is highly significant that all people of the organization are aware of the processes and tools used for the supplier master data management. The users of the system need to be aware of its functions and the proper way of use. For example, “people need to know if the system tells you there is a duplicate don’t ignore it and follow the process”. You need to understand the messages that you get from the system and this is a matter of training where “people are trained on the procedures and tools that that they can take the right decisions”. It is common that companies instead of replacing the previous systems, they add new tools that are supporting the existing systems. Thus, it is significant to clarify the relationships and interactions between the existing and new systems.

The interviewees mentioned that employees often have learned to work in their own way and the biggest challenge is to change their mindset. According to the interviews, “People will have a very closely working to an SAP system and if they need an update on a piece of master data, for example customer, they want to achieve it as soon as possible and they want to put it in that system right away.” and “The people who knows the suppliers, who work with suppliers directly, they technically know it but very often they just know it by heart. They have it written somewhere on the computer like the supplier’s address and that's I think the only why way it can work because the people who directly works with the supplier, they know the information so they don't have to go to the systems.”.

12. People awareness of MDM

This factor refers to how people feel responsible about the data they use in their daily work. It is important to understand the broader perspective of the supplier master data and the impact their decisions might have to the whole organization. According to the interviews, "in the past they were only looking at their kingdom at their own realm and I think also here Philips employees they have to understand that they are part of a big global company and also the supplier master data is shared in the whole company ". Moreover, employees need to understand the benefit that such a program will bring to them. As one of the interviewees supported the processes, they are responsible for will be leaner, better and optimized, with more efficient supplier master data management. The employees need to understand the benefit that a supplier master data management program will bring to them.

13. Software compatibility

Employees of the case company highlighted the need for compatibility of the new system with the existing ones. The new system needs to be able to cooperate successfully with the existing on the same environment. The selection of the software provider is often in accordance with existing collaboration of the company. An example has been given during the interviews, "Why Software A? The main reason for that is as I already mentioned that we have three maybe four modules in this platform and that it is probably the reason we selected Software A. Because we already use it and we have one contract and it is easier to maintain the relationship with the supplier."

14. System settings

A great advantage of any proposed system to the company, is the offering of customized settings according to the needs of the organizations. These can be for example, a duplicate check which does not allow the user to create a new record of a supplier which already exists. The validity of some information can also be checked by the system, such as the location of the supplier. The system could also not allow the creation of incomplete supplier master data, by defining mandatory fields. Lastly, another interesting feature that was proposed during the interviews, is the notifications by the system for the expiration dates of certificates. Therefore, the system settings is an important factor because it could possibly limit the problems in the data, especially the ones caused by human errors.

15. System scalability

Scalability of the system is mentioned as an important factor during the interviews and based on the interviewees it "would be the first thing that needs to be considered before getting a new system or introducing a new system". Bondi (2000) refer to scalability as "the ability of a system to accommodate an increasing number of elements or objects, to process growing volumes of work gracefully, and/or to be susceptible to enlargement." (Bondi, 2000; p.1)

16. System flexibility

According to the interviews, companies need to "make sure how flexible it is because you have many systems, multiple ERPs and flexibility is one of the major concerns that makes you go slower it in terms of your digital maturity." The system needs to be able to cope with future processes and adapt to future needs of the organization.

17. Relational master data model

During the interviews, the need for a relational master data model was highlighted. It was specifically mentioned that "I would say that it is very important to have relational master data models. So for example we know that the ID number 123 is linked to the other ID which is 856 within the same or different tools. So the data model should be relational basically." Therefore, the previously used conceptual model from the literature is replaced with the relational, as consulted by the interviewees.

According to Otto and Schmidt (2010), conceptual master data models are used to describe conceptually the master data and their relationships. Van Unen et al. (2012) also identify the need for clear view of the master data and their relations “to ensure uniform usage and application” (Van Unen et al., 2012; p.4).

18. Dashboard view of the supplier data in all kernels

Van Unen et al. (2012) identify the need for detective measures, such as defect reports and dashboards. According to Van Unen et al. (2012), the identification of KPIs is important for master data monitoring as well as the continual adaptation of these metrics according to the needs of the company. According to Spruit and Pietzka (2014), data quality must be known so that actions can be taken towards improvement. The interviewees emphasized on the use of dashboard for monitoring data quality. According to the interviews, "with the dashboard you can see exactly the data between the tools…so you can easily check in which tool data is fault.”. Monitoring can also help organizations to detect any misuse of new tools and settings so that they can better inform and train the employees.

19. Supplier involvement in the supplier data creation and maintenance

The role of suppliers in ensuring high quality data is one of the most interesting findings of this study. By providing access to the suppliers to the system, they can self-register and they can be involved in activities of data confirmation and maintenance. The supplier data entered in the system (“It should be kind of verification point by the supplier if the provided data are accurate and the correct one.”) and any changes in this data (“Also if there is any change in the supplier data, it should be delivered by the supplier as well as confirmed as the real one), shall be confirmed by the supplier. According to the interviews, "It is better to ask the suppliers themselves to give the data rather than making an assumption or have any misinterpretations based on the data given.”, “If the supplier has access to his own master data, he makes sure that he update it regularly. Because that can reduce the lead time between getting that information and updating it”, “We have the address information, and who knows the address of the supplier better than the supplier. I think he would know the best from everyone.”, and “Maybe we can give the job working on the data quality on the supplier side”.

The suppliers can understand the benefit of maintaining correct data, as this can directly affect their relationship with the company. Thus, they are motivated to ensure high quality data. In this way, the data ownership is extended to the suppliers as well. This highly affects the believability of the data, which Sivola et al. (2016) define as “the extent to which data is credible, correct and trusted by others” (Silvola et al., 2016; p.10). However, the extent to which the suppliers are involved in the company’s processes can be challenging sometimes. What has been discussed during the interviews is that “you clearly need to make sure whatever you're asking towards the suppliers is actually affecting your business processes in a way and also that some of the information that supplier is providing you're also validating from your end in order to avoid complications or regulatory issues.”. Also, the type and level of data can play significant role in this decision, because “depending on the data type, for A level data I think we have the tools where the supplier can maintain its own data…but when we it comes to like more internal information…these are the things that the supplier probably wouldn't know. He wouldn't know the structure, how it works in Philips.”

20. Global visibility and accessibility of the supplier data

Spruit and Van der Linden define data accessibility as the “extent to which data are available, or easily and quickly retrievable” (Spruit and Van der Linden, 2019; p.9). Data protection can be challenging when managing supplier data. On the one hand, data need to be distributed carefully and be available only to people that have access to this information (Spruit and Pietzka, 2014). This however can restrict the availability of the data. The interviewees discussed their concern that apart from the problem that information is often missing or is incorrect, the access to some data is restricted because it is treated as

confidential. If someone cannot have access to some information, he might create it again. This his can result in the creation of duplicated data.

In large and international organizations, it is also important that data are visible globally and within the whole company. According to the interviews, “Within every department that we have within Philips, everybody worked with supplier master data in their own way. But in the end, it all needs to go together in “system A” in our kernels for transactional purposes. Whilst most employees do not have access level of making extractions out of “system A” for their own purposes, the visibility for a global level was missing. So everybody looked in their own domain but never upon a global scale.” Therefore, in order to ensure that all employees around the world talk about the same supplier, global visibility and accessibility is important.

21. Master data validation checks

During the interviews there was confusion between the quality checks included in the previously developed set of factors. Based on the advice given by the interviewees the data quality routines, data validation checks and master data control routines, as they are reported in the literature, are merged into this factor. Sivola et al. (2016) refer to these activities as checking the outdated or not recently used factors. Haug and Arlbjørn (2013) support that control routines are important and even simple routines can have significant impact based on the motivation provided by the awareness that quality is controlled.

22. Data harmonization and standardization

This factor incorporates the previously mentioned data quality technical rules, a term which Van Unen et al. (2012) use when they refer to data attributes such as the length and format. The interviewees discussed their concerns regarding the IT constraints when combining information from different sources, “Name can be max 35 characters for example in other cases can be 100 characters”, “how long can a field be, what kind of characters are allowed, only alphanumeric characters or if should be bold character or whatever.”. Standardization and harmonization of data is proposed as an answer to these challenges. According to the interviews, we need “standardization of an approach where you can reuse the same data across multiple systems without having pre-processing or post-processing of it”.

23. Data consolidation and centralization

The challenges of consolidating the supplier master data were widely reported during the interviews. People can directly enter supplier information in all the SAP systems used by the company resulting in variations in data. Creating a single version of truth can be a highly complex endeavor in large organizations with a great amount of supplier data. According to the interviews, it is important to have a full picture on all the supplier data in one place, by following a centralization procedure.

This factor represents a broader concept, according to the description of the interviews, including the synchronization rules, record linkage, master data distribution and merging rules that were introduced in the previous steps based on literature findings. Otto and Schmidt (2010) refer to the distribution of the master data as the activities regarding the data flow between the different application systems. According to Loshin (2010), merging and consolidation of the master data includes a number of different processes, such as review of the data with identity resolution, record linkage to identify relations and similarities and representation of the values included in each examined attribute. Lastly, the master data needs to be synchronized, which Jonker (2011) supports that it is better to be performed automatically by the selected tool.

24. Data conciseness

Data conciseness is the “Extent to which data are compactly represented without being overwhelming” (Spruit and Van der Linden, 2019; p.9). According to the interviews, suppliers are sometimes asked to provide more information than what the organization actually needs. Noisy data can only increase

complexity. It is also possible that they are asked to provide some information multiple times in different steps and processes. As it has been reported in an interview, “The holistic view needs to be what are the bare minimum that I need to have on the supplier master data from a high-level perspective.” The concept of data conciseness, as it has been explained by the interviewees, is closely related to the data value-added, which Sivola et al. (2016) refer to as “the extent to which data is beneficial and provides advantages from its use” (Sivola et al., 2016; p.10). Therefore, data value-added has been merged with conciseness, resulting in an adjusted factor for this model.

25. Data accuracy

Data accuracy reflects whether the “values are correct and reliable” (Silvola et al., 2016; p.10, Spruit and Van der Linden, 2019; p.9). Silvola et al. (2016) understand accuracy as the extent of “how well data values are in line with the source of correct data” (Silvola et al., 2016; p.10). A single source of truth for the supplier data is important for the information to be accurate though the process of data maintenance within the ongoing collaboration of a supplier with the company. According to the interviews “The supplier master data always starts with the data accuracy. Always. That's one because without that you cannot do your next steps.”, “We do not have for all suppliers the correct address or the correct country information or sometimes we have it in different tools and there are not in sync and yes we have we have issues daily issues with wrong supplier master data.”.

Data cleansing is important for ensuring accurate supplier records. This activity is vital during the first steps of a master data management program. What has been stated during the interviews, is that people in companies are often pushing toward a deadline for the rollout of a new tool, instead of properly cleansing the data. Even if the introduction of the tool is proposed as a solution to accurate master data, the wrong way of approaching this solution can result in a worse situation.

26. Data roles and responsibilities

Whilst the data ownership and the roles and responsibilities of master data were two different factors after the survey was conducted, they are merged into this adjusted factor based on the advice given during the interviews. In particular, what has been discussed is that “the data governance can also be merged with the policies. Sometimes you have a policy where the content is described but also the governance is described. Who owns which data and then also the rules and responsibilities. I think one role and responsibility is the ownership, so I think this is also a category of this one.”.

Moreover, the interviewees mentioned the extension of the data ownership for some of the data to the suppliers as well, as an important parameter for the self-maintenance of data. The competency of the data ownership is also important according to the interviews, which is covered when the suppliers themselves are the data owners and responsible for the maintenance of their data.

27. Data rulebook

The interviews in the case company identified the need for a clear and defined ruleset, when deciding to have one entry point for the supplier master data. The data rulebook was also identified in the previous step as an important parameter, but in this model the meaning of the factor is extended, so that the clear data processes, clear data requirements and standards and data quality business rules are incorporated. The merging has been decided based on the comments of the interviewees, such as “What is the difference between data quality technical rules and data rulebook?”, “I had some troubles to differentiate. And then we are talking about processes and procedures, which should be part of a data rulebook. I think this is one chapter of a data rulebook” and “Clear data requirements and standards…These are data rules. Right? And data rules are defined in the data rulebook. And in the data rulebook you also have the procedure and processes to have clear data so therefore for me these three are connected very much.”

Alhassan and Sammon (2019) refer to clear data processes and procedures as the activities with regards to the integration of data, the data authorization etc. They also refer to the need for data requirements and standards to define the ways for data implementation. Lastly, Van Unen et al. (2012) discuss the business rules that influence the quality of the master data, which they define as "rules which arise directly from business processes and scenarios" (Van Unen et al., 2012; p.4)

28. Valid path for supplier phase-out

It is important that the suppliers are phased-out properly through a defined process. When a supplier ends collaboration with the company, this should be reflected in every system. If this does not happen, there is risk that unusable information for inactive suppliers is remain stored in the systems. According to the interviews, having such supplier records reduces the system's speed and leads to additional complications of having duplicates. All open documents need to close so that the supplier can be offboarded. This concept relates to the previous "Master data lifecycle" factor, which Otto and Schmidt (2010) refer to as the description of the use of the data through the business processes.

29. Corrective measures

Van Unen et al. (2012) support that in order to make the quality tangible, a company needs to define a number of quality regulations. The compliance with these regulations needs to be measured and monitored regularly. When problems with the supplier data are identified, it is important that the company takes corrective measures, such as rectification procedures.

30. Awareness of quality gaps

Spruit and Pietzka (2014) support that the awareness of poor data quality is important for the necessary measures can be taken by the organizations. Pietzka (2012) in her master's thesis, discusses further this need, explaining that a way to identify the reasons for low quality data is to understand the extent of quality gaps. High quality master data is important, as it strongly influences the productivity and performance of the company.

31. System and data landscape

The data landscape has been reported as an important factor from Spruit and Pietzka (2014) and Jonker et al. (2011). This factor refers to an organization's data and the systems using this data (Pietzka, 2012). Data is spread over various applications and systems. They often are often not connected properly, and thus it is hard for companies to provide useful information.

32. Master data object definition

According to Spruit and Pietzka (2014), it is important to establish shared understanding of the data in order to align the interest of different stakeholders. The use and understanding of supplier data often differ according to the purpose of use, the department or the stage of the supplier-organization collaboration. The complexity of processes can result in multiple perspectives for the same supplier data element. It is useful for large organizations, to collect all the supplier related data fields in one place, and to provide uniform definitions (Otto and Schmidt, 2010)

33. Rewards for ensuring valid master data

Haug and Arlbjørn (2011) define the lack of rewards for ensuring valid master data, as one of the main barriers for data quality. It is often hard for people being used in a certain way managing the supplier data, to change their way of working. They need to understand how their decisions on their everyday work, impact the organization and the work of other people. According to the interviews, this is an interesting factor to provide incentives to employees to keep up with the changes in the company.

34. Data quality tooling

According to Van Unen et al. (2012), specific MDM tooling is needed to ensure high quality master data. Data quality tooling in this study, is focused on the management and monitoring of the supplier data.

35. Data integration tooling

Following the suggestion of Van Unen et al. (2012), this study refers to data integration tooling as the tools used to extract and transform the supplier data according to the target system.

36. Data governance tooling

The data governance tooling, as proposed by Van Unen et al. (2012), mostly concern the maintenance of the master data and the master data ownership. The supplier master data stored in the company's systems need to be managed carefully and these tools can simplify the necessary processes.

37. Information systems

Sivola et al. (2011) refers to several challenges related to the information systems. Companies often use different applications to manage their supplier data, including ERP or CRM systems. The supplier data is transferred within these applications, which can cause multiple changes in the original supplier master data. This results in different formats and lower data quality.

38. Data consistency

Spruit and Van der Linden refer to data consistency as the "extent to which data are presented in the same format and compatible with previous data." (Spruit and Van der Linden, 2019; p.9). Silvola et al. (2016) classify data consistency as one of the dimensions for data quality, citing Kahn et al. (2002). They further categorize consistency as an important factor for data quality with regards to company data. The company data in this study represents a set of information referring to customers, suppliers and vendors, such as the name, address and the Data Universal Numbering System (DUNS) number. Main challenges identified in this area are duplicate or irrelevant data (Silvola et al., 2016).

During the interviews this factor has been reported as a significant requirement for the improvement of data quality in the organizations. The interviewees referred to the problem of the extended number of systems used for the management of supplier data and to how this situation challenges the consistency of supplier data. During the interviews it has been reported that "There are too many procurement tools in which one of those tools you have the supplier record and very often these records are not equal, are not the same in every tool". They describe situations where although information about a supplier can exist in a system, the same supplier can be registered in another system with different address or name. Even the slightest variation in this information can result in the creation of multiple identification numbers (IDs) for the same in supplier within the same or different systems. It is moreover possible that inactive supplier records can exist in some systems when the phasing out of suppliers is not performed properly. Although this might be harmless in situations where the supplier has been phased out because of the replacement with another supplier, it can be highly risky when the collaboration has ended because this supplier didn't follow the sustainability agreement for example.

39. Data completeness

Spruit and Van der Linden (2019) explore the concept of data completeness citing previous authors. They refer to Shanks and Corbitt (1999) which categorize completeness in the semantic information quality characteristics and Naumann and Rolker (2000) which classify it as an objective criterion for high quality data. They conclude to the definition of data completeness as the "extent to which data are not missing and are of sufficient breadth and depth for the task at hand" (Spruit and Van der Linden, 2019; p.9). According to the interviews, a complete set of supplier information is necessary to identify a supplier, starting from the accurate name and a full address. Hundreds of supplier records in the case

company are blank or they are comprised only by a name or an incomplete address including for example only the country. This is challenging while the same supplier can be located in multiple places. Data enrichment activities are important in such situations during the phase of data cleansing.

Missing information can result in the creation of new unnecessary supplier records and therefore to data duplication. While different information is asked by the supplier in different systems, it is important that the data is categorized as level A or level B according to the importance of the information. The registration system shall also prevent the creation of incomplete supplier records by categorizing some fields as mandatory. Another risk is the absence of location data, which is key information for regulatory activities. As it has been reported in an interview with a business process expert at the case company, if you are for example located in Africa you need to comply with the rules and legislation of women rights, and in this case the city and country information is highly important.

40. Preventive measures

A significant factor that indirectly influence the quality of supplier data is the monitoring. The interviewees expressed their concerns about the extensive focus of companies on data cleansing activities, suggesting that they should primary focus on preventing low quality data. Therefore, preventive measures, such as clear working instructions and policies are highly important.

41. Business process integration

During the interviews the need for the integration of processes is identified. According to Loshin (2010), individual activities are linked through a business process model which "is a logical presentation that incorporates the descriptions of a business process in a way that communicates the right details to the right people at the right time" (Loshin, 2010; p.10). Business process integration enables also the automation of business processes, which has been reported during the interviews as an addition to the developed factors, "I would add here automatization of well how to call it…So that it is easy to upload the data, all robotics and stuff that technology can provide us now". This concept is closely related to the concept of digital transformation of businesses and their need to adapt their practices in accordance to the recent technological advancements. The IT Gartner glossary (2019) describe business process automation as "the automation of complex business processes and functions beyond conventional data manipulation and record-keeping activities.".

42. User-friendliness of the software

What has been discussed from the interviewees is the need for a software that it will be easy for the employees to use. This can be supported, if the software is aesthetically appealing with interfaces which are easy to use and with clear instructions. Haug and Arlbjørn (2013) classify also user-friendliness of the software that is used for the master data management as a significant factor for data quality.

43. MDM system architecture

It was broadly discussed in the interviews that the target systems need to be aligned. The central point of supplier master data, accessed by one single entry gate, need to be connected with all the functions of the company, such as the finance, legal or risk management department. As it was stated, "So for me the most important thing for supplier master data is that the tools are connected and that they are fed from one central source, where it is maintained where it is created…We need to have this connection through the whole IT landscape for the tools.". Loshin (2010) also supports the importance of this factor in his MDM maturity model.

The employees expressed also their concerns about the intentional duplicates that are created in the multiple kernels. According to the interviews, "Sometimes the one supplier needs to have records created in all of the kernels. Maybe not all the time, but it can happen and because of that it's very hard to track it. We have something that we call here intentional duplicate. We have one supplier, but because

of our master data architecture, because of the multiple kernels it needs to be created in multiple places and that's an issue. Because sometimes it's very hard to tell whether this is duplicate that was created because of the mistake or whether it was intentionally duplicated." and "The other is that we have a lot of vacant systems. We do not have one kernel, but we have a lot of them, and some duplicates are intentional. So, it's also a matter of fixing the architecture of vacant systems".

44. Data compliance

According to Brous et al. (2016) an important aspect of the data governance is to define an authority which is responsible for the compliance with the data policies and procedures. The policies are decided from the business and IT teams, which develop under collaboration a common shared framework across the organization (Brous et al., 2016). This framework in this study, is comprised of a set of rules and responsibilities to ensure the protection of sensitive supplier information. In general, companies are socially and legally obliged to protect personal data and a challenge for organizations is to ensure accountability of the data users. Brous et al. (2016) also suggest incentives to promote this behavior.

F: Suggestion for the case company to grow maturity in the dimension "uniqueness of supplier records"

The case company collects over 700 data elements for every supplier, which can be created and stored in different systems and ERP kernels. It is common that multiple IDs can refer to the same supplier. During the duration of this thesis, to reduce the complexity of the supplier information and assign it to a unique ID, the information was classified into categories. Each category has its own ID, and all the categories are connected to the supplier's identification information, which is reflected with a unique Golden Record Identification (GRID number). The categories are presented below, and examples are given for the information included in each category. It is important to be mentioned that the categories which are specific to the case company are not included in the below diagram and the complete relational model cannot be shared for confidentiality issues. The below information is intended to give an idea to the reader of how the supplier data elements can be connected to a single ID.

- Identification: Golden Record Identification (GRID), Name
- Contact: URL, Email address
- Business data: Type of industry, Type of business
- Capabilities: Technical capabilities, Supply chain management capabilities
- Spend data: Estimated annual spend
- Savings: Savings last 12 months
- Location: Country, Postal code
- Business systems: Business partner type
- PO Box: PO Box region
- Banking: IBAN, Bank account
- Finance & Accounting: Payment method, Minority indicator
- Tax: Tax type, Tax number
- De-Duplication: De-Duplication status
- Legal family tree: Hierarchy code, Type of ownership
- Request data: Reason for choice, Supplier registration approval status
- Sourcing & Contracting: Supplier managed inventory, Supplier quality agreement
- Supply chain: Shipping conditions
- Block: Contract block, Qualification block
- Deletion: Deletion flag

- Certificates & Agreements: ISO 14001, ISO 9001
- Qualification: Business partner qualification status
- Medical device: ISO 14644, ISO 14155
- Sustainability: Supplier sustainability performance status, Conflict minerals status
- Phase-out: Supplier phase-out timing
- Segmentation: Sourcing dependency classification
- Customer: Customer indicator
- Risk: Safety incident history, Business continuity risk
- Audit reports: Business review meeting
- Procurement: Purchasing units, Ordering method

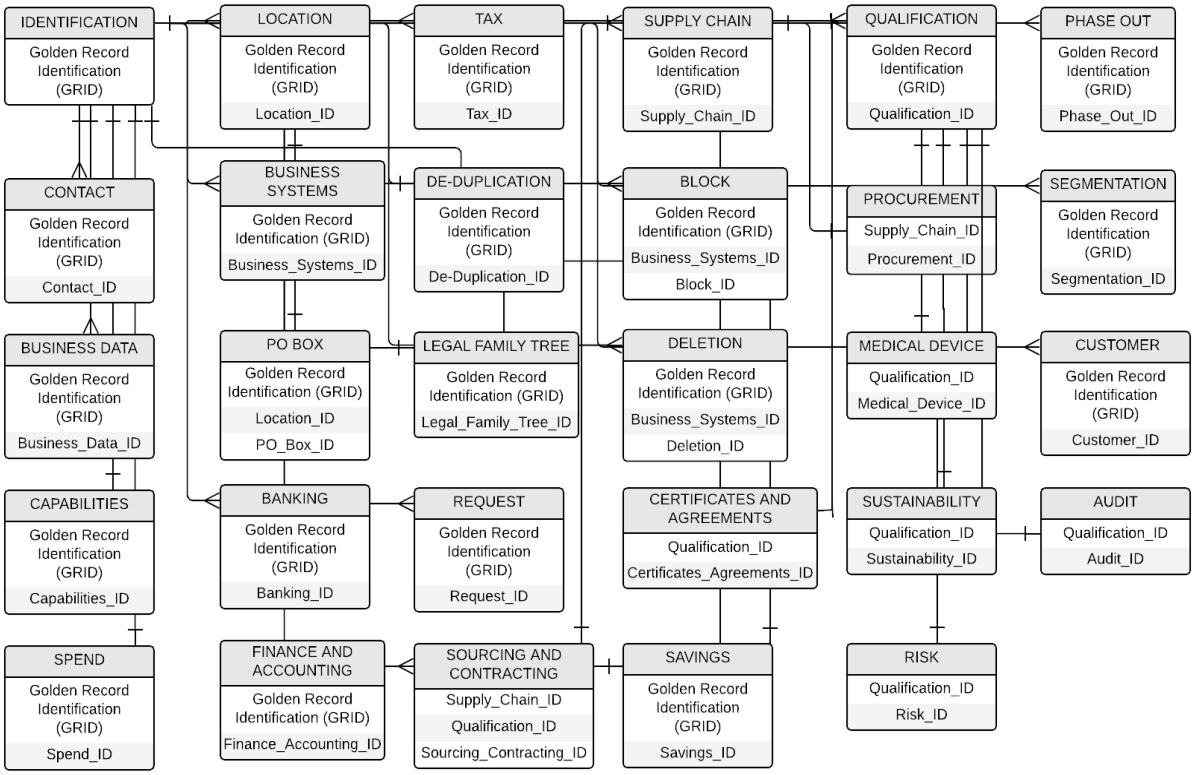


Figure 24: ERD for the supplier master data in the case company

G: Evaluative expert interviews

G1: Set-up of the evaluation meetings

Activity	**Time**	**Goal**
Introduction	10 minutes	Explain the purpose and set-up of the meeting.
Presentation	25 minutes	Present the main findings of the study. Explain the design process and product.
Open discussion	15 minutes	Discuss with the participants their opinion on the study and answer their questions.
Break	5 minutes	
Questionnaire	10 minutes	Ask participants to fill in the questionnaire.

Feedback on the questionnaire	10 minutes	Ask participants for feedback on the statements they rated low (below score=3).
Closing	5 minutes	

Table 48: Set-up of the evaluation meetings

G2: Evaluation questionnaire

Statements	**Score (1-5)**	**Comments**
The objective of the model is clear.		
The scope of the model is clear.		
The development of the model does not lack any important phases.		
The phases of the development are structured in a logical way.		
The factors used in the model are clear and understandable.		
The set of the developed factors is complete.		
The factors used in the model influence the maturity of the supplier MDM in large and international companies.		
The parts of the model are logically related.		
There are no redundant components in the model.		
The model is easy to understand		
The model is easy to use		
The model represents the developed factors		
The model can be adjusted to specific users or needs		
The model is focused on the supplier MDM in large and international companies		
The model can be used to determine the maturity of companies in the supplier MDM.		

Table 49: Evaluation questionnaire

G3: Evaluation Likert scale

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Figure 25: Evaluation Likert scale

G4: Changes implemented after the evaluative expert interviews

1. **Change in Table 30**

Use and ownership of the supplier master data	Data roles and responsibilities	The data owners are aware of all the data rules and the use of the supplier master data is clear and well-documented.
	Global data visibility and accessibility	The supplier data is visible and accessible globally across the organization.

	Supplier involvement in the supplier data creation and maintenance	The suppliers can self-register and maintain their data.
	Data compliance	The company complies with all the data privacy relagulations for the supplier master data.

Figure 26: Changes in Table 30 after the evaluation

2. Change in Table 31

Strategic alignment of the cross-functional supplier related processes	Alignment and connection of processes	All the cross-functional processes regarding the management of supplier master data are connected.
	Business process integration	The systems are integrated, and the supplier data is shared across the applications easily and with security.
	~~Alignment of new supplier creation with the commodity strategy~~	~~The supplier data need to be created when it aligns with the commodity strategy of the organization.~~

Figure 27: Changes in Table 31 after the evaluation

H: The supplier MDM maturity model dimensions and capabilities (after the evaluation)

H1: Dimensions of data

Dimension	Factor	Description
Quality of supplier records	Data accuracy	The supplier data is correct and reliable.
	Data consistency	Data is the same and with same format across the all organization and for all the stages of the supplier-buyer collaboration cycle.
	Data completeness	There are no blank or incomplete supplier records.
	Data conciseness	The supplier records contain only the required information.
Uniqueness of supplier records	Unique identification of the supplier data	Every supplier is defined through a unique set of information, assigned to a unique identifier.
	Relational master data model	The company has a model describing all the supplier related data objects and their relationships.
	Master data object definition	Shared understanding on the supplier data is established across the organization.
Monitoring of supplier master data quality	Corrective measures	The company takes initiatives to solve the supplier data issues that are detected through data monitoring activities.
	Awareness of quality gaps	The company knows where the data quality problems are and the reasons why these problems arose.

	Master data validation checks	The supplier data is checked frequently for complying with the defined data quality regulations.
	Preventive measures	The company takes actions to prevent problems with the supplier data.
	Dashboard view	The company uses dashboards to monitor the quality of the supplier data in different tools and systems.
Unified view of the supplier master data	Data harmonization and standardization	The supplier data is in same format and under the same technical rules they can be consolidated without pre- or post-processing.
	Data consolidation and centralization	The supplier data is collected through all silos to a centralized database.
	Data rulebook	The data standards and the data rules for creating and maintaining the data are clear and well-defined.
	System and data landscape	The data landscape of the company allows for single representation of the supplier data elements.
Use and ownership of the supplier master data	Data roles and responsibilities	There is a solid role-based foundation that defines the accountability for how employees produce and use supplier master data.
	Global data visibility and accessibility	The supplier data is visible and accessible globally across the organization.
	Supplier involvement in the supplier data creation and maintenance	The suppliers can self-register and maintain their data.
	Data compliance	The company complies with all the data privacy relagulations for the supplier master data.

Table 50: Dimensions of data (final)

H2: Dimensions of processes

Dimension	Factor	Description
One central gate for the supplier data	One gate for entering and maintaining all supplier information	All the supplier data can be created and maintained in one place.
	Valid path for the supplier phase-out	The supplier phase-out is performed in all the systems and tools across the organization.
Strategic alignment of the cross-functional supplier related processes	Alignment and connection of processes	All the cross-functional processes regarding the management of supplier master data are connected.
	Business process integration	The systems are integrated, and the supplier data is shared across the applications easily and with security.
Simple processes within the supplier-organization collaboration	Clear and simple processes	Easy to understand and simple processes for the supplier data creation and maintenance.

Table 51: Dimensions of processes (final)

H3: Dimensions of communication and change

Dimension	Factor	Description
Change management pre-implementation	Holistic model for change management	There is clear view of the objectives and the needs of all the stakeholders involved and of all the actions that need to be taken in order for the development program to be successful.
	Incremental change	The change is implemented step by step, department by department, IT tool by IT tool etc.
	Alignment of the interests of different stakeholders	All the stakeholders involved in the development program need are on the same page and their interests are aligned.
Change management post-implementation	Support teams	There are supporting groups to help the users with the changes in the supplier MDM processes and systems.
	Rewards for ensuring valid master data	The company provides incentives to the employees for managing the supplier data according to the defined rules.
	Training of users	There is training offered to the users to help them become familiar with the new processes and systems.
People awareness of supplier MDM	People awareness of processes and tools	The employees of the company fully understand the supplier MDM processes and systems suggested by the organization.
	People awareness of master data management	The employees understand the benefits of master data management and they are aware of ways to maintain the supplier master data.

Table 52: Dimensions of communication & change (final)

H4: Dimensions of technology

Dimension	Factor	Description
Software used for the supplier MDM	Software compatibility	The software used for the supplier MDM can operate with the existing systems in the same environment.
	Software scalability	The software can handle a scalable business model.
	Software flexibility	The software can cope with the changes and potential additional processes.
	User-friendliness of the software	The software has easy-to-use interfaces and clear instructions.
Supplier MDM system	MDM system architecture	The target systems are linked to provide a common point of reference for the supplier master data.
	Information systems	The applications used to collect and distribute supplier data are aligned in a way to ensure that the supplier data remains unchanged during the supplier-organization collaboration.
Supplier MDM features and tools	Data quality tooling	Tools for the management and monitoring of the supplier data.
	Data integration tooling	Tools to extract and transform the supplier data.
	Data governance tooling	Tools for the maintenance of the master data and the master data ownership.

Customized features	There are customized features, such as certification update and duplication check for the supplier master data.

Table 53: Dimensions of technology (final)

H5: Supplier MDM capabilities

Dimension	Capability	Description
		Data
Quality of supplier records	SRQ-A	The company is aware of the supplier data problems.
	SRQ-B	Problems with duplicated or wrong supplier data are managed locally when they are detected.
	SRQ-C	A systematic approach has been developed to ensure high quality master data in each system.
	SRQ-D	The suppliers are defined through a complete, accurate and concise set of information.
	SRQ-E	An accurate and unified view of the supplier master data is reflected globally across the organization. The supplier master data quality is a KPI for all the process and data owners.
Uniqueness of supplier records	SRU-A	There is no standardized way to identify the suppliers in the company's systems.
	SRU-B	Each supplier is identified per system or use.
	SRU-C	There is some knowledge about how the supplier master data objects of different business functions relate.
	SRU-D	The supplier master data objects are connected, and common definitions are shared across the organization.
	SRU-E	Every supplier is defined through a unique set of information, which is assigned to a unique identification number.
Monitoring of the supplier master data quality	SDM-A	The company does not monitor the supplier master data quality. The data users are in charge of monitoring the quality of the supplier data they work with.
	SDM-B	The company does not regularly monitor the supplier master data quality. Actions are taken when data inaccuracy or duplicated records are detected in a database.
	SDM-C	Dashboard view of the supplier data allows monitoring of the supplier data across all systems and applications.
	SDM-D	The supplier data is checked regularly, and actions are taken to prevent the data problems.
	SDM-E	The reason why the supplier data problems occur is known and the company takes initiatives to manage this situation.
Unified view of the supplier master data	UDV-A	There are no defined data rules and standards.
	UDV-B	Data rules and standards are defined for each system and application.
	UDV-C	The supplier data is in same format and under the same technical rules across the organization.

	UDV-D	There are uniform data rules and standards. The supplier data is harmonized and standardized across all the systems and applications.
	UDV-E	The supplier data is consolidated into a centralized database and there is single representation of the supplier data elements.
Use and ownership of the supplier master data	SDO-A	The are no defined roles and responsibilities for using and maintaining the supplier data. There are gaps in the supplier master data rights.
	SDO-B	The supplier master data are logically owned by the related roles and department. Privacy and security policies and standards are published.
	SDO-C	The people that are responsible for the supplier master data are clearly defined and they have documented responsibilities. IT security provides basic controls across all systems in scope.
	SDO-D	There is a solid role-base foundation that defines the accountability for how employees produce and use the supplier data. Employees can reactively and proactively obtain information about the supplier master data privacy issues.
	SDO-E	The supplier data roles and responsibilities are clearly defined. The supplier data is visible and accessible globally across the organization. The suppliers can self-register and maintain their data. The company fully complies with the supplier master data security regulation.
		Processes
One central gate for the supplier data	OCG-A	There are multiples entries for the supplier data creation and processing.
	OCG-B	There is one entrance for the supplier data for each department, but processing is allowed also from other systems and applications.
	OCG-C	The supplier data is created and managed centrally for each department.
	OCG-D	There is one gate for all the supplier related processes, from the supplier onboarding to the supplier phase-out.
	OCG-E	There is one entry gate for all the supplier related processes, and all the other gates have been successfully closed.
Strategic alignment of the cross-functional supplier related processes	ACF-A	The supplier data related processes are not connected to each other.
	ACF-B	The supplier data related processes are only partially connected to each other.
	ACF-C	The supplier cross-functional processes are aligned.
	ACF-D	All systems are integrated, and the supplier data is shared across the different applications easily and with security.
	ACF-E	All the supplier related business and technical processes are connected and automated.
Simple processes within the supplier-organization collaboration	SPR-A	The supplier related processes are unnecessarily complex.
	SPR-B	The supplier related processes are complex but well-documented and explained.

	SPR-C	The supplier related processes are clear and well-documented.
	SPR-D	Most of the supplier related processes are clear, simple and easy to understand.
	SPR-E	All the processes for the supplier data creation and maintenance are clear, simple and easy to understand.
	Communication & Change	
Change management pre-implementation	CPR-A	Change of the systems and processes has been proposed as a solution to the supplier master data problems.
	CPR-B	The company takes action to communicate the need for supplier MDM to the stakeholders.
	CPR-C	A strategic approach to change management has been developed, which incorporates the interests of different business functions.
	CPR-D	All the stakeholders involved in the change are on the same page and their objectives are aligned.
	CPR-E	A systematic plan and improvement roadmap toward gradual implementation of change has been developed.
Change management post-implementation	CPO-A	New systems and processes have been introduced to the organization.
	CPO-B	The company provides informative material and technical help for people who experience troubles adjusting to the changes.
	CPO-C	An adjustment period of trainings, seminars and workshops is defined.
	CPO-D	All the people in the organization are trained to the new system and processes, and support groups are assigned to provide continuous help and monitoring.
	CPO-E	People are used to the new systems and processes. Incentives are provided for managing the supplier data according to the new defined rules.
People awareness of supplier MDM	PAW-A	People rely on their knowledge and way of working to manage the supplier data.
	PAW-B	The benefits of the supplier MDM are communicated across the organization.
	PAW-C	People are aware of the MDM processes and tools an know how to use and maintain the supplier data.
	PAW-D	People understand the importance of the supplier MDM and try to maintain clean supplier data.
	PAW-E	People understand the impact of wrong supplier data in their work and the organization and try to prevent misuse of the supplier data in their working environment.
	Technology	
Software used for the supplier MDM	MDS-A	The need for a supplier MDM software is identified and communicated with the organization.
	MDS-B	A supplier MDM software is introduced to the organization to solve specific supplier data problems, but it is not fully compatible with the existing applications.
	MDS-C	The supplier MDM software is compatible with the existing software applications.

	MDS-D	The supplier MDM is compatible with the existing applications and it is user-friendly.
	MDS-E	A compatible with the existing applications and user-friendly supplier MDM software is used. The software is scalable, and it can cope with changes and additional processes.
Supplier MDM systems	SMS-A	There is an overview of the systems that are used to create or manage supplier master data.
	SMS-B	The first steps towards alignment of the target systems and applications have been implemented.
	SMS-C	The applications used to collect and distribute supplier data are aligned.
	SMS-D	The target systems are aligned with a centralized MDM architecture to provide a common point of reference for the supplier master data.
	SMS-E	All supplier master data has been cleansed, transformed and loaded into the hub. The target systems and applications are aligned in a way to ensure that the supplier data remains unchanged during the supplier-organization collaboration.
Supplier MDM features and tools	MFT-A	Although there are data management tools, the company has no specific tools for the supplier MDM.
	MFT-B	Some tools for the supplier MDM are introduced, but their use has not yet been established in the organization.
	MFT-C	MDM tools are introduced and used by the employees. However, there is still need for more tools to support them with the supplier MDM practices.
	MFT-D	There are all the necessary tools for the supplier master data quality, integration and governance to support the employees with the supplier MDM practices.
	MFT-E	There are all the necessary tools for the supplier master data quality, integration and governance. There are also customized features according to the needs of the company, such as certification update and duplication check for the supplier master data.

Table 54: Supplier MDM capabilities (final)

I: Supplier MDM maturity model

Levels / Key concepts	**LEVEL1** *INITIAL*	**LEVEL2** *REACTIVE*	**LEVEL3** *DEFINED*	**LEVEL 4** *PROACTIVE*	**LEVEL 5** *OPTIMIZING*
DATA	The company is aware of the supplier data problems.	Problems with duplicated or wrong supplier data are managed locally when they are detected.	A systematic approach has been developed to ensure high quality master data in each system.	The suppliers are defined through a complete, accurate and concise set of information.	An accurate and unified view of the supplier master data is reflected globally across the organization. The supplier master data quality is a KPI for all the process and data owners.
	There is no standardized way to identify the suppliers in the company's systems.	Each supplier is identified per system or use.	There is some knowledge about how the supplier master data objects of different business functions relate.	The supplier master data objects are connected, and common definitions are shared across the organization.	Every supplier is defined through a unique set of information, which is assigned to a unique identification number.
	The company does not monitor the supplier master data quality. The data users are in charge of monitoring the quality of the supplier data they work with.	The company does not regularly monitor the supplier master data quality. Actions are taken when data inaccuracy or duplicated records are detected in a database.	Dashboard view of the supplier data allows monitoring of the supplier data across all systems and applications.	The supplier data is checked regularly, and actions are taken to prevent the data problems.	The reason why the supplier data problems occur is known and the company takes initiatives to manage this situation.
	There are no defined data rules and standards.	Data rules and standards are defined for each system and application.	The supplier data is in same format and under the same technical rules across the organization.	There are uniform data rules and standards. The supplier data is harmonized and standardized across all	The supplier data is consolidated into a centralized database and there is single

				the systems and applications.	representation of the supplier data elements.
	The are no defined roles and responsibilities for using and maintaining the supplier data. There are gaps in the supplier master data rights.	The supplier master data are logically owned by the related roles and department. Privacy and security policies and standards are published.	The people that are responsible for the supplier master data are clearly defined and they have documented responsibilities. IT security provides basic controls across all systems in scope.	There is a solid role-base foundation that defines the accountability for how employees produce and use the supplier data. Employees can reactively and proactively obtain information about the supplier master data privacy issues.	The supplier data roles and responsibilities are clearly defined. The supplier data is visible and accessible globally across the organization. The suppliers can self-register and maintain their data. The company fully complies with the supplier master data security regulation.
PROCESSES	There are multiples entries for the supplier data creation and processing.	There is one entrance for the supplier data for each department, but processing is allowed also from other systems and applications.	The supplier data is created and managed centrally for each department.	There is one gate for all the supplier related processes, from the supplier onboarding to the supplier phase-out.	There is one entry gate for all the supplier related processes, and all the other gates have been successfully closed.
	The supplier data related processes are not connected to each other.	The supplier data related processes are only partially connected to each other.	The supplier cross-functional processes are aligned.	All systems are integrated, and the supplier data is shared across the different applications easily and with security.	All the supplier related business and technical processes are connected and automated.
	The supplier related processes are unnecessarily complex.	The supplier related processes are complex but well-documented and explained.	The supplier related processes are clear and well-documented.	Most of the supplier related processes are clear, simple and easy to understand.	All the processes for the supplier data creation and maintenance are clear, simple and easy to understand.

CHANGE AND COMMUNICATION	Change of the systems and processes has been proposed as a solution to the supplier master data problems.	The company takes action to communicate the need for supplier MDM to the stakeholders.	A strategic approach to change management has been developed, which incorporates the interests of different business functions.	All the stakeholders involved in the change are on the same page and their objectives are aligned.	A systematic plan and improvement roadmap toward gradual implementation of change has been developed.
	New systems and processes have been introduced to the organization.	The company provides informative material and technical help for people who experience troubles adjusting to the changes.	An adjustment period of trainings, seminars and workshops is defined.	All the people in the organization are trained to the new system and processes, and support groups are assigned to provide continuous help and monitoring.	People are used to the new systems and processes. Incentives are provided for managing the supplier data according to the new defined rules.
	People rely on their knowledge and way of working to manage the supplier data.	The benefits of the supplier MDM are communicated across the organization.	People are aware of the MDM processes and tools an know how to use and maintain the supplier data.	People understand the importance of the supplier MDM and try to maintain clean supplier data.	People understand the impact of wrong supplier data in their work and the organization and try to prevent misuse of the supplier data in their working environment.
TECHNOLOGY	The need for a supplier MDM software is identified and communicated with the organization.	A supplier MDM software is introduced to the organization to solve specific supplier data problems, but it is not fully compatible with the existing applications.	The supplier MDM software is compatible with the existing software applications.	The supplier MDM is compatible with the existing applications and it is user-friendly.	A compatible with the existing applications and user-friendly supplier MDM software is used. The software is scalable, and it can cope with changes and additional processes.
	There is an overview of the systems that are used to create or manage supplier master data.	The first steps towards alignment of the target systems and applications have been implemented.	The applications used to collect and distribute supplier data are aligned.	The target systems are aligned with a centralized MDM architecture to provide a common point of	All supplier master data has been cleansed, transformed and loaded into the hub. The target systems and applications are aligned in a way to

				reference for the supplier master data.	ensure that the supplier data remains unchanged during the supplier-organization collaboration.
	Although there are data management tools, the company has no specific tools for the supplier MDM.	Some tools for the supplier MDM are introduced, but their use has not yet been established in the organization.	MDM tools are introduced and used by the employees. However, there is still need for more tools to support them with the supplier MDM practices.	There are all the necessary tools for the supplier master data quality, integration and governance to support the employees with the supplier MDM practices.	There are all the necessary tools for the supplier master data quality, integration and governance. There are also customized features according to the needs of the company, such as certification update and duplication check for the supplier master data.

Table 55: Supplier MDM maturity model (final)

J: Supplier MDM self-assessment questionnaire

Dimension	Capability	Statement	Answer
Quality of supplier records	A	The company is aware of the supplier data problems.	
	B	Problems with duplicated or wrong supplier data are managed locally when they are detected.	
	C	A systematic approach has been developed to ensure high quality master data in each system.	
	D	The suppliers are defined through a complete, accurate and concise set of information.	
	E	An accurate and unified view of the supplier master data is reflected globally across the organization. The supplier master data quality is a KPI for all the process and data owners.	
Uniqueness of supplier records	A	There is no standardized way to identify the suppliers in the company's systems.	
	B	Each supplier is identified per system or use.	
	C	There is some knowledge about how the supplier master data objects of different business functions relate.	
	D	The supplier master data objects are connected, and common definitions are shared across the organization.	
	E	Every supplier is defined through a unique set of information, which is assigned to a unique identification number.	
Monitoring of the supplier master data quality	A	The company does not monitor the supplier master data quality. The data users are in charge of monitoring the quality of the supplier data they work with.	
	B	The company does not regularly monitor the supplier master data quality. Actions are taken when data inaccuracy or duplicated records are detected in a database.	
	C	Dashboard view of the supplier data allows monitoring of the supplier data across all systems and applications.	
	D	The supplier data is checked regularly, and actions are taken to prevent the data problems.	
	E	The reason why the supplier data problems occur is known and the company takes initiatives to manage this situation.	
Unified view of the supplier master data	A	There are no defined data rules and standards.	
	B	Data rules and standards are defined for each system and application.	
	C	The supplier data is in same format and under the same technical rules across the organization.	
	D	There are uniform data rules and standards. The supplier data is harmonized and standardized across all the systems and applications.	
	E	The supplier data is consolidated into a centralized database and there is single representation of the supplier data elements.	
Use and ownership of	A	The are no defined roles and responsibilities for using and maintaining the supplier data. There are gaps in the supplier master data rights.	

the supplier master data	B	The supplier master data are logically owned by the related roles and department. Privacy and security policies and standards are published.
	C	The people that are responsible for the supplier master data are clearly defined and they have documented responsibilities. IT security provides basic controls across all systems in scope.
	D	There is a solid role-base foundation that defines the accountability for how employees produce and use the supplier data. Employees can reactively and proactively obtain information about the supplier master data privacy issues.
	E	The supplier data roles and responsibilities are clearly defined. The supplier data is visible and accessible globally across the organization. The suppliers can self-register and maintain their data. The company fully complies with the supplier master data security regulation.
One central gate for the supplier data	A	There are multiples entries for the supplier data creation and processing.
	B	There is one entrance for the supplier data for each department, but processing is allowed also from other systems and applications.
	C	The supplier data is created and managed centrally for each department.
	D	There is one gate for all the supplier related processes, from the supplier onboarding to the supplier phase-out.
	E	There is one entry gate for all the supplier related processes, and all the other gates have been successfully closed.
Strategic alignment of the cross-functional supplier related processes	A	The supplier data related processes are not connected to each other.
	B	The supplier data related processes are only partially connected to each other.
	C	The supplier cross-functional processes are aligned.
	D	All systems are integrated, and the supplier data is shared across the different applications easily and with security.
	E	All the supplier related business and technical processes are connected and automated.
Simple processes within the supplier-organization collaboration	A	The supplier related processes are unnecessarily complex.
	B	The supplier related processes are complex but well-documented and explained.
	C	The supplier related processes are clear and well-documented.
	D	Most of the supplier related processes are clear, simple and easy to understand.
	E	All the processes for the supplier data creation and maintenance are clear, simple and easy to understand.
Change management pre-implementation	A	Change of the systems and processes has been proposed as a solution to the supplier master data problems.
	B	The company takes action to communicate the need for supplier MDM to the stakeholders.

	C	A strategic approach to change management has been developed, which incorporates the interests of different business functions.
	D	All the stakeholders involved in the change are on the same page and their objectives are aligned.
	E	A systematic plan and improvement roadmap toward gradual implementation of change has been developed.
Change management post-implementation	A	New systems and processes have been introduced to the organization.
	B	The company provides informative material and technical help for people who experience troubles adjusting to the changes.
	C	An adjustment period of trainings, seminars and workshops is defined.
	D	All the people in the organization are trained to the new system and processes, and support groups are assigned to provide continuous help and monitoring.
	E	People are used to the new systems and processes. Incentives are provided for managing the supplier data according to the new defined rules.
People awareness of supplier MDM	A	People rely on their knowledge and way of working to manage the supplier data.
	B	The benefits of the supplier MDM are communicated across the organization.
	C	People are aware of the MDM processes and tools an know how to use and maintain the supplier data.
	D	People understand the importance of the supplier MDM and try to maintain clean supplier data.
	E	People understand the impact of wrong supplier data in their work and the organization and try to prevent misuse of the supplier data in their working environment.
Software used for the supplier MDM	A	The need for a supplier MDM software is identified and communicated with the organization.
	B	A supplier MDM software is introduced to the organization to solve specific supplier data problems, but it is not fully compatible with the existing applications.
	C	The supplier MDM software is compatible with the existing software applications.
	D	The supplier MDM is compatible with the existing applications and it is user-friendly.
	E	A compatible with the existing applications and user-friendly supplier MDM software is used. The software is scalable, and it can cope with changes and additional processes.
Supplier MDM systems	A	There is an overview of the systems that are used to create or manage supplier master data.
	B	The first steps towards alignment of the target systems and applications have been implemented.
	C	The applications used to collect and distribute supplier data are aligned.

	D	The target systems are aligned with a centralized MDM architecture to provide a common point of reference for the supplier master data.
	E	All supplier master data has been cleansed, transformed and loaded into the hub. The target systems and applications are aligned in a way to ensure that the supplier data remains unchanged during the supplier-organization collaboration.
Supplier MDM features and tools	A	Although there are data management tools, the company has no specific tools for the supplier MDM.
	B	Some tools for the supplier MDM are introduced, but their use has not yet been established in the organization.
	C	MDM tools are introduced and used by the employees. However, there is still need for more tools to support them with the supplier MDM practices.
	D	There are all the necessary tools for the supplier master data quality, integration and governance to support the employees with the supplier MDM practices.
	E	There are all the necessary tools for the supplier master data quality, integration and governance. There are also customized features according to the needs of the company, such as certification update and duplication check for the supplier master data.

Table 56: Supplier MDM self-assessment questionnaire

K: List of acronyms

DSR Design Science Research

ERD Entity Relationship Diagram

ERP Enterprise Resource Planning

MD Master Data

MDM Master Data Management

SRM Supplier Relationship Management