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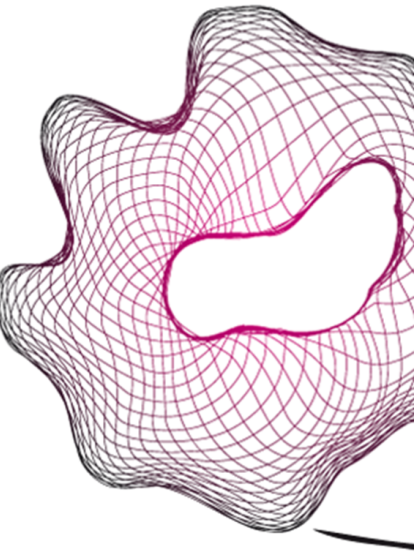

Migration to a data-driven organization

Building a framework to assist in digital transformation

Laurens R. S. Lafranca

Final Thesis

May 2023

Supervisors:
Dr.ir. J. M. Moonen
Dr. L. Ferreira Pires
S. Oude Aarninkhof MSc

University of Twente
P.O. Box 217
7500 AE Enschede
The Netherlands

Abstract

The Data-Driven Organization (DDO) is playing an increasingly prominent role in the world of digital organizational transformation, where organizations are trying to increase the internal use of data for decisions. However, many of these transforming organizations have difficulties transitioning to a DDO. While research has been done on the potential benefits and challenges of a DDO, there is a gap in research on how to connect these insights with a business case. This is why, in our research, it was tried to bridge this gap by reviewing several assessment methods discussing them to build a framework that can be used to determine the current state concerning data usage of an organization, and build recommendations based on this.

Our case study tests this framework by applying the assessment methods to an organization testing the data-driven state of one of its processes, namely the Purchase-to-Pay (P2P) process. Interviews with stakeholders from each individual P2P sub-phase, a maturity analysis, and an analysis of formalized documents identified problems holding back the organization. These problems were either technical, concerning data quality or a scattered IT infrastructure, or non-technical, concerning the skills of employees or the strategic documents of a business unit.

Using these results four main gaps were singled out, concerning culture, data governance, reference and master data, and lack of standardized processes. Our research continues with the focus on culture and data governance, after consolidation with the organization. Additional analyses concerning the roles and certain processes in the organization were done for extra information.

Combining these different sources of information, our research results in six recommendations for the organization. Next to this, an implementation plan is written showcasing the implementation order of the recommendations. These results were validated using expert review, where it became clear that the problems identified, and the recommendations were seen as accurate.

Our thesis presents the following four findings:

- Organizations are struggling to identify problems that obstruct them from shifting to data-driven decision-making.

- A combination of assessment methods can identify problems and suggest recommendations about the use of data in an organization.
- Purchase-to-Pay is an intricate process where data can play an important role in increasing efficiency and reducing errors, as well as increasing the ability to adapt.
- A data-driven organization is not only fueled by technology, but also by the attitude and knowledge of employees.

Our thesis makes several contributions. First, a framework was developed that can be used to assess a process of an organization on its data usage for decision-making that uses several techniques and models from literature sources. Second, our research bridged the gap between research and practice, by applying models from literature sources to a real-world case. Third, our research has shown that an existing company culture should be considered when trying to implement new cultural traits into it. Our research is limited by its scope, as only one process in one organization is currently used to test the framework, as well as biases in the interviews held and the interview structure may have influenced the results.

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List of acronyms

AI	Artificial Intelligence
BI	Business Intelligence
CAO	Chief Analytics Officer
CDO	Chief Data Officer
CRISP-DM	Cross Industry Standard Process for Data Mining
DAMA-DMBOK	Data Management - Data Management Book Of Knowledge
DDO	Data Driven Organization
DSMM	Data Science Maturity Model
DSRM	Design Science Research Methodology
ERP	Enterprise Resource Planning
ETL	Extraction, Transformation and Load
HiPPO	Highest Paid Person's Opinion
IT	Information Technology
IoT	Internet of Things
KPI	Key Performance Indicator
P2P	Purchase-to-Pay
RPA	Robotic Process Automation
RQ	Research Question

Chapter 1

Introduction

This chapter introduces this research, giving its motivation, research goal, research questions, methodology, and report organization.

1.1 Motivation

The importance of data has been growing in organizations over the last years. Data has become increasingly available to organizations since their products have become smarter, such as by implementing IoT products or digital twins [2]–[4]. The value of data has been shown many times in research. Several researchers have found that the inclusion of data in decisions has a number of positive effects on organizations [5], [6]. It is thus no surprise, that more and more organizations are trying to include data more in their decision-making process, trying to stay ahead of the competition and to reap the benefits of data inclusion [7], [8].

However, it can be seen that a lot of organizations fail to make the shift to including data more effectively in their decision-making process [5], [9], [10]. Many barriers exist in the process of shifting to more data inclusion, but most of the barriers exist due to the 5 V's of big data: Volume, Velocity, Variety, Value, and Veracity [11]. Research has shown that a range of aspects should be taken into account to successfully transform an organization for better data usage. These do not only include technology, but also culture, people, and processes [12]–[14]. Focusing on all of these aspects, organizations will have a better chance of successfully transforming into a Data-Driven Organization (DDO).

In this research, the shift to a DDO is central. The term DDO has been coined by the industry as an organization that effectively includes data in decisions and derives value from it [15]. As work has already been done on finding the optimal processes and practices for a DDO, [16]–[18] this can be used by researchers to assess whether the practices of organizations are in line with recent practices.

As the DDO concerns the entire organization, it was necessary for the scope

of this research to zoom in on more specific processes to make it manageable. This allows for a more detailed investigation of processes, problem identification, and solution building. For this research, we chose to focus on the Purchase-to-Pay (P2P) process of an organization. This process consists of the purchasing of goods/services [19] and is thus often a crucial process in terms of profitability in many organizations. Research has shown that benefits can be achieved when this process uses data more effectively, which shows the additional value of investigating this process [20]–[22].

This research builds on current research in the field of DDO and defines a framework that can be used to analyze organizations on their data capabilities. This framework includes the use of knowledge obtained in the research steps. First, literature has been used to review the state of the art in research about DDO. Second, literature has been leveraged to find appropriate assessment methods. Lastly, the assessment methods were used to assess the findings in literature to identify gaps and build solutions.

This framework was tested in order to show its relevance and its appropriateness to organizations. This has been done using a case study, during which the P2P process and the relevant data practices of an organization were analyzed using the techniques prescribed by the framework. This resulted in recommendations for the organization, concerning aspects in which the organization was underperforming compared to the optimal DDO. Of these recommendations, the focus was laid on culture and data governance to further build specific recommendations. The solutions included the people, strategies, and processes to tackle problems.

1.2 Research Goal

Our research goal has been specified using the design science methodology of Wieringa [1], who proposed the design problem template to describe four key elements in a research goal, namely problem context, artifact, requirements, and stakeholder goals. In order to tackle the problems that are currently experienced by an organization this template has been filled in. The template is structured as follows:

- Improve < *a problem context* >
- by < *(re)designing an artifact* >
- that satisfies < *several requirements* >
- in order to < *help stakeholders achieve some goals* >

When filling in this template for this research, the following design problem was defined:

- *Improve* the current practices of an organization concerning data usage for decision-making
- *by* designing a framework defines the steps needed to identify, assess, and implement data-driven practices in an organization
- *that satisfies* the improvement of in the decision-making process
- *in order to* improve the decision-making process in the areas that need improvement the most.

1.3 Research questions

In order to be able to answer the problems stated above and thus achieve the research goal, further specification of the research problem is needed. This has been done by answering the following research question:

How can the decision-making process of an organization be transformed to a data-driven process by shifting to a data-centric approach for certain key decisions?

For this research, the main research question has been decomposed into sub questions. These sub questions have helped guiding the research process and answering the main research question.

1. How is a data-driven organization defined in literature?
2. How can an organization's compliance with the Data-Driven Organization be assessed?
3. How can a gap analysis based on an assessment be used to find areas of improvement?
4. What steps need to be taken to prioritize the improvement areas found during the assessment process?
5. How can this assessment and the prioritization be used in a case study of an organization?
6. Do the results found during the case study remain valid after evaluation?

1.4 Methodology

Different methods have been used during this research to find answers to the research questions and are discussed below. First, the Design Science Methodology of Wieringa [1] is discussed. Then, the other methods that have been used for the individual research questions are reviewed.

For this research, the Design Science Methodology of Wieringa [1] was used. In his research, the design cycle shown in Figure 1.1 is used to design and validate a treatment. This cycle consists of three steps, namely problem investigation, treatment design, and treatment validation. By cycling through these three steps, it is possible to build and refine a design solution for a problem. The first step in this cycle is the problem investigation, in which the general problem is researched using literature review. In our work, the research focused on the Data-Driven Organization, and identified its benefits and challenges. Next, the treatment design focused on the design of a framework. This is where the research looked for methods that can be used for the assessment of the organization, and how to find and prioritize the solutions found. Lastly, the treatment validation focused on a case study in combination with a validation, where one organization was evaluated using the methods found in the previous steps. The results of this case study were validated to show whether the steps taken and its results are valid.

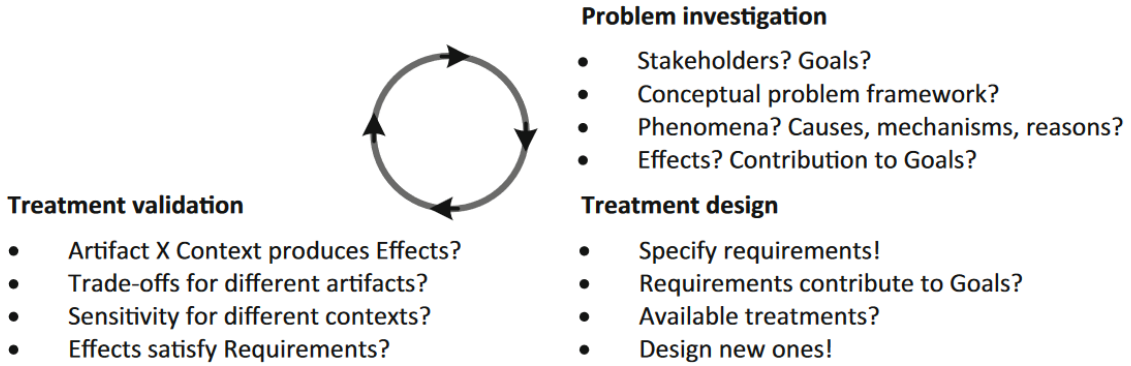

Figure 1.1: The Design Cycle of Wieringa [1]

In addition, the research questions have been answered using different methods (Table 1.1). These methods are elaborated on in the upcoming chapters of the research.

Research question	Method
1	Literature review
2	Literature review
3	Literature review, framework design
4	Discussion strategy
5	Case study
6	Case study, Validation

Table 1.1: Method overview for each Research Question

1.5 Report structure

In this section, we discuss how the research questions are connected to the design cycle, and where these research questions are answered.

Figure 1.2 shows that research question 5 takes up a large part of the research, as the case study was used to test the developed methods. Chapter 4, starts with applying the assessment methods on an organization that were defined in Chapter 3. Chapter 5, further elaborates on the results that came from the assessment, identifying the different gaps that were found during the assessment. Here, four main gaps are defined based on the results of the assessment. The chapter continues with a further focus on some of the identified gaps and doing further assessments that provide additional information necessary to bridge the gaps. Lastly, Chapter 6 ends the case study piece with six recommendations for the organization that followed from the assessment. Thereby, it shows how these recommendations can be implemented with an implementation plan.

The report ends with a validation and a conclusion in Chapter 7 & 8. The validation evaluates the methods and results of the research using expert opinion. The conclusion reflects on them and makes final remarks concerning the research.

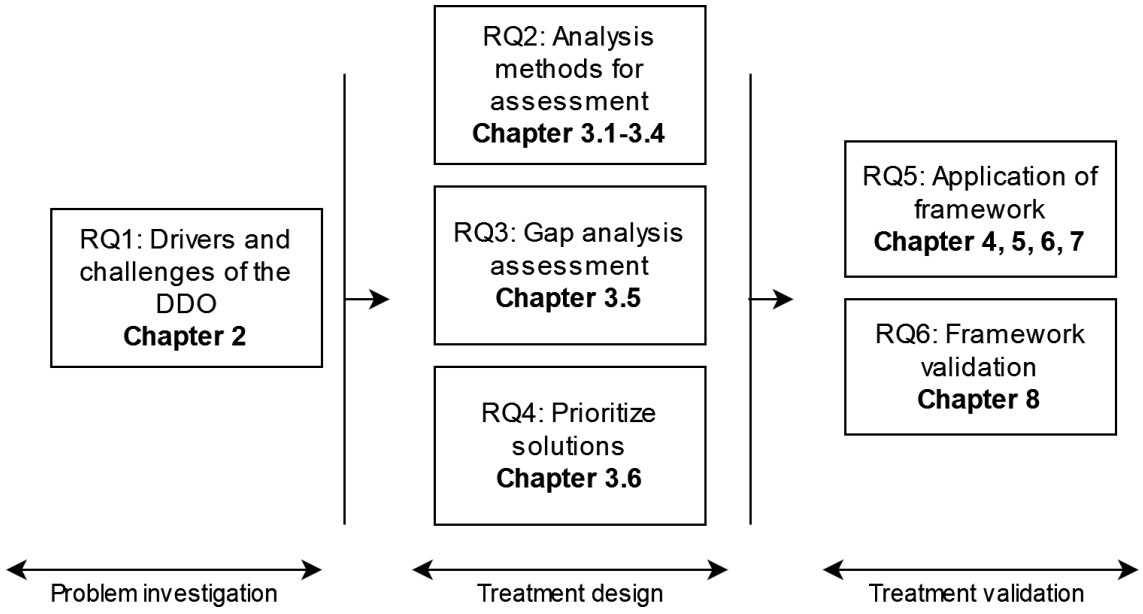

Figure 1.2: Schematic overview of the report structure

Chapter 2

The Data-Driven Organization

This chapter summarizes our findings to answer some research questions by means of a literature review. Scopus and Google Scholar were used to find literature that was applicable to the research topic. This was done by defining the Data-Driven Organization, and its culture, strategy, roles, processes and skills. Lastly, the benefits and challenges of the Data-Driven Organization are set out.

2.1 Definition

We aimed at identifying the essence of the concept Data-Driven Organization. Several papers define data-driven organizations, and what they must do to fulfill this definition. Several definitions have been analyzed and summarized in the paper of Hendrikse [15]. These definitions include definitions from influential research such as from Patil [14] and Fabijan [23]. Using these definitions as a reference, Hendrikse proposed the following definition for a Data-Driven Organization (DDO):

A data-driven organisation can be described as one that is successfully able to turn data into value, with the use of management alignment, organisational culture, infrastructure, skilled personnel, analytics solutions, effective data management & governance.

In this definition, it can be seen that the path of becoming a DDO includes more than only technical aspects. Five main aspects contribute to the DDO, namely Data Management & Governance, Management, Skilled Personnel, Analytics, Infrastructure, and Culture [15].

The cultural change that is necessary for an organization to transform to a DDO, is also mentioned in different research [13], [15]. In [13] it is mentioned that the culture has a big impact in assisting the organization in their ability to change. This cultural change should happen throughout the whole company.

The definition also states that the data should be turned into value. This means that having just data on its own does not qualify as data-driven. More concretely, this requires that raw data should be used and transformed into meaningful insights for business purposes. [24], [25] This value creation is supported by the five main aspects of the DDO, which all contribute to building valuable use cases that exploit data in order to support business goals. By aligning the value creation processes, the transformation of data into value can be achieved [15].

A DDO thus has a focus on data-driven decision-making as data is used in a DDO to generate insights for decisions. The definition of DDO also shows the difference between traditional and data-driven decision-making, namely that management is aligned with the use of data, just like corporate culture has a focus on using data for decisions. This focus is supported by the infrastructure of the organization, and the skills of the employees. For traditional decision-making the focus is not on data usage for decision making, but more on intuition and expert knowledge, while data may still be used for some decisions. The main difference is thus the focus and intensity of data usage that defines and characterizes the DDO, with data playing a central role in the organization.

2.2 Organizational culture

The culture of an organization is an important aspect of the shift to become data-driven. The culture, consisting of values, visions, and practices is essential for an organization to incorporate data in decisions. Many researchers see the positive effects of culture on this implementation [13], [14], [26]–[29]. These papers show that certain characteristics of the culture of an organization, elaborated on in the rest of this section, foster better data usage to affect businesses. However, this effect is sometimes disputed. Chetty [30] has done research in the moderating effects of the organizational culture on the adoption of data-driven decision-making and did not find any significant effect. This effect found in his research is however limited to the research population. Therefore, in our research, it has been assumed that a data-driven culture can have a positive effect, due to the overwhelming amount of literature that is attributed to this [13], [14], [26]–[29].

Our literature survey was used to build a list of general culture traits that should be in place in an organization to make the shift to a DDO. This information was used to compare to the current culture of the organization, to identify what is lacking. First, the main cultural traits are explained further. After this, the importance of strategy to the DDO culture is elaborated. Next, roles that are important in a DDO are explained. Then, certain key processes of a DDO that were found in literature are discussed. Finally, this section ends with the skills necessary in a DDO on an

individual and companywide level.

2.2.1 Role of management

In all literature, the role management can play in the change process is made clear. Firstly, management should develop a clear vision or strategy that establishes the data-driven culture [13], [28], [31], [32]. This vision should consist of clear targets, consisting of clearly defined KPIs, which are communicated effectively throughout the organization. [13], [32]. By setting the KPIs up in advance, monitoring can be done objectively. Secondly, the vision can then be translated into specific processes, which should be documented, implemented, and communicated [31]. Management thereby plays a key role in managing the expectations and fears of the organization. [28] Thirdly, management has an important role in committing to data analytics and thus supporting the change to a DDO. [13], [32] Strom [32] prescribes that the management should have an exemplary role to the rest of the organization. However, to have this role, management should also have the analytical skills necessary to consider the data in their decisions [33].

2.2.2 Key Data Characteristics

The data itself is also an important driver for change. Broad data access is seen as a key factor to create a data-driven culture [13], [28]. Next to this, data should have high quality, to make the results from data analysis more valuable and trustworthy. Lastly, strong data governance should be enforced, which are processes that ensure and retain control over data [13], [28].

2.2.3 Skills

Research acknowledged that the change to a DDO is harder when the employees or the management lack data analytic skills [13], [28], [31], [32]. This includes the understanding of experimental design, statistical inference, and the dangers of extrapolation [13]. These skills should be obtained, as working with data analytics is the only way to make data effective. If possible, these skills can be taught by the analytics unit in the organization [28]. Otherwise they can be obtained using external organizations.

2.2.4 Change culture

The organization should be able to change to work better with data. The organization should provide its employees with the proper data, tools, and training to facilitate this change [13], [28]. However, for this to be effective, the leadership should

convince the rest of the organization that a data-driven approach, where data is included in the decision making process, is the beneficial way of working. This should be based on how data improves performance and that it improves the working situation of employees by changing the work they have to do on a daily basis [13], [28], [32]. In order to support this culture change, reviews and evaluations should be in place in order to monitor the improvement of the methods and results. For proper reviews and evaluations, everyone in the organization should be able to ask questions and comment on the current practices [13], [28], [31].

2.2.5 Trust

Trust is another main aspect that is essential for a DDO and should exist in multiple places. First, the employees should be able to trust the quality of the data and thus the results that follow from it [13], [28]. In addition, employees should be comfortable applying data-driven approaches to tackle their problems. When this is the case, responsibility and accountability can be determined in order to achieve trust in data-driven decisions [31].

2.2.6 Overview

These main topics can be combined into a general list of traits that should be found in a DDO culture. All the research mentioned in this section is used to build a complete list. Overall, the culture to achieve a DDO should thus be:

- Open, with broad data access for all the different employees [13], [28].
- Inquisitive, where everyone can ask questions about additional information and is able to challenge assumptions. Analyses should be rated on accuracy, not on who did the analysis [13], [28].
- Eager to learn, where results are reviewed, evaluated, and understood, to be used for improvement [13], [28], [31].
- Responsible, where data-driven approaches are widely applied, with responsibility and accountability for data [31]. This thus means that decisions should be made based on data, and not on intuition [13], [28].
- Innovative, enabling experimentation and innovation, where employees participate in transformation, and they can do their own analyses [28], [32]. Enabling should also be achieved by providing the necessary tools and data to the employees [13], [28].

- Trustworthy, where employees trust in the quality of data and the results that follow from it [13].
- Understanding, with a focus on broadening the data literacy of the complete organization. This thus includes all employees and managers [13], [28], [31], [32].

2.3 Transformation strategy

Strategy is an important driver in an organization when trying to transform to a DDO. A clearly defined strategy to become data-driven can help the entire organization to see the need for change and the reasons to move forward in data adoption and usage [32]. Data should become an essential element of this strategy for it to become successful [10], where data should be used to improve the strategy itself [13]. This strategy, or vision of the organization, should be monitored using KPIs, which should be able to determine whether the organization is going in the right direction [13]. The top-level management should be actively involved in developing a data-driven strategy, as there is otherwise a big chance that the strategy stays in silos [28]. Fitting data analytics with the overall strategy of an organization should help increase the companywide acceptance of the organizational culture [31]. This thus shows the importance of a fitting strategy for enabling the change to a DDO.

2.4 Roles

When analyzing an organization that can be considered a DDO, it can be made clear which roles should be implemented in an organization to fulfill the different tasks necessary in a DDO. These roles and their tasks will be described in this Section. To identify the roles that are deemed necessary, different literature sources have been used [13], [14], [34]–[38]. These sources identify distinct roles that we analyzed to identify their overlap and differences and determine which roles are relevant for a DDO.

2.4.1 Data analyst

Delke [34] and Anderson [13] describe this role as someone who uses technology to improve business performance. They can either use standard or specialized tools. An example of a standard tool is Excel, while more specialized tools can be R, SQL, or Python. The main tasks of these employees are in reporting and analysis. This is thus a broad description for a range of employees.

2.4.2 Data scientist

Data scientist is a role that is described in the research of Anderson [13] and Patil [14] while a similar role is described by Fletcher [35]. Overall, this role describes a person who can connect the data and the business requirements. For this, the employee needs to have statistical skills, computing skills, infrastructure design and communication skills, including the ability to code and use predictive modeling software. Using these skills, they should gather information from business users, data scientists, data engineers and their environment. This information should be extracted using the appropriate questions and be used to inform the decision-makers within the organization.

2.4.3 Data stewards

This role is described as someone who is responsible for executing the data governance strategy. This includes the application of defined principles from strategy, monitoring systems, and keeping track of data processes. Where the CDO/Data owner defines the policies to ensure high quality data, data stewards are responsible for implementing these. They are also responsible for defining rules for data creation and deletion and drawing up definitions of data. They should be in close contact with the CDO/Data owner to ensure everything is on track [36]–[38].

2.4.4 Master data manager

As described by Delke [34], the need to align the physical and digital world becomes more important, due to the fact that data is incorporated more in real life business processes. This means that the availability and accuracy of data should be managed. The master data manager should focus on aligning multiple systems and the data flow between them. This ensures high data quality. Especially when new suppliers and customers are linked to the system, this role becomes important as new data flows need to be aligned with the existing systems. Tasks of this role are data extraction, processing, and prepare data to be stored in databases.

2.4.5 Process automation manager

This role is also defined by Delke [34] as the person who works between the IT department and the purchase and supply chain management. Their main task is to implement and operate Robotic Process Automation (RPA) tasks. An example of such a task is the ordering and payment of deliveries. RPA allows employees to work faster and have more time for value-adding activities. The more technological developments are made, the more processes can be automated.

2.4.6 Data visualization specialists

Anderson [13] describes this role as employees who are specialized in creating different infographics, dashboards, or other designs to visualize the data. For this, different technologies and different visualization libraries can be used.

2.4.7 Data engineers

This role is described by Anderson [13] as people in the organization that are responsible for obtaining, cleaning and munging data. Afterwards, they should be able to get it into a form that analysts can access and analyze. These employees focus on problems such as throughput, scaling, peak loads and logging.

2.4.8 Financial analysts

This role is described as employees that focus on tasks such as internal financial statements, auditing, forecasting, analysis of business performance, and other similar tasks. For this they manage KPIs or develop models that can enhance future performance through monitoring [13].

Next to these roles Anderson [13] also sees distinct roles that should be implemented in the management layer. These roles have responsibilities and tasks to shape the data-driven culture within an organization, as this is seen as necessary to also do from a top-down perspective. These roles are the Chief Data Officer (CDO) and the Chief Analytics Officer (CAO).

2.4.9 CDO (Data Owner)

This role is focused on the strategic leveraging of data for business needs. In general, CDOs work in highly regulated sectors, such as the Banking and Healthcare sectors. The CDO is a leader who creates and executes data and analytics strategies to drive business value. As the role depends on the organization's situation, differences exist between CDOs. However, examples of tasks of a CDO are overseeing data management, overseeing data standards and policies, supporting and managing data projects, or identifying and exploiting new business opportunities. For overseeing data management, the focus is on tasks such as defining a vision, a strategy, and processes and methods to acquire, store and manage data and the data quality. When looking at overseeing data standards and policies, these can concern the quality of data, sharing or creation policies, or maintenance and visibility policies. Overall, the CDO has a focus on promoting data value and leading

change. In other research, the term Data Owner was often mentioned. [37], [39] After inspecting both the CDO and the Data Owner roles, we realized that these roles are very similar, which is why we assumed both names can be used for this role.

2.4.10 CAO

The CAO is a managerial role that is a lot closer to the analysts. The CAO has a focus on the strategic use of data and analytics. The tasks of a CAO are promoting the data-driven culture of the organization, enhancing data-driven practices and culture, monitoring the performance of the analytics of the organization, and delivering tangible results. For this, the CAO should be able to see potential in existing data, understand relations and be able to break silos in the organization. CAOs are most needed in organizations where there are analysts in different business units, a lack of standards, and unclear career paths for the analysts. The centralization of analytics in such organizations brings saving opportunities. Overall, a CAO should be able to get the management layer and the rest of the organization to see the value of contextual data. Thus, the CAO is mainly focused on changing culture, and getting business users to see the value in models and tools. Here, the CAO can also help train the organization to use these models and tools accordingly.
There is a certain overlap between the CDO and the CAO. However, the CDO has a focus on the backend, while the CAO focuses more on the strategic use of data and analytics. An organization can choose to combine these tasks of these roles into a single role.

2.5 Processes

The different roles that are defined in the literature already are related to a broad range of processes that should be implemented by the specific employees in these roles. Examples of these include analyzing data, visualizing data sets, or changing the culture within an organization. However, next to these role-specific processes, Patil [14] has specified some processes that should be implemented companywide if an organization wants to be data-driven. These processes are daily dashboard, metric meetings, standup meetings, and the democratization of data.

2.5.1 Daily dashboard

When an organization wants to be data-driven, it should become a habit of the employees to start the day by looking at their data. This can be done by looking at dashboards, which should contain key metrics. The dashboards should be in balance, thus there is not too much and not too little data in them. Next to this,

the time frame in which the dashboard should be updated should be considered. Dashboards should be reviewed regularly, removing or adding values to ensure their value adding property, and by using appropriate visuals the dashboard should be attractive. Lastly, the dashboard should have some alerts in them for value changes, but not too many alerts should be built in, as this can lead to people not paying attention to them.

2.5.2 Metrics meetings

Metrics meetings are meant to share an understanding of data. By using group meetings to explain the data, and allow for questions, a general understanding of the data is achieved, and a discussion can be held about the data itself. This prevents data from being used as a weapon, as the common understanding of the data helps make decisions based on it. Lastly, it should be considered that data should not always be followed blindly and can sometimes be questioned to make sure the broader landscape is taken into account.

2.5.3 Standup and domain-specific meetings

Standup meetings are a meeting structure that tries to limit meeting duration to a minimum, while making sure all the issues are discussed. By literally standing up, you make sure these meetings do not take too long, as people get uncomfortable. This can contribute to making meetings more efficient. Next to this, domain-specific meetings should be implemented to criticize work. This should of course be in a safe space, so attendees feel free to comment on other people's work.

2.5.4 Democratization of data

This is all about removing bureaucracy in the data access within your organization. When only a few people have access to the data resources, this limits the results that can come from data. Therefore, employees should be able to get data themselves, making data support the broadest possible set of users. The tools that the organization uses should thus also be focused on allowing as many employees as possible being able to work with data to build solutions. Naturally, overall security measures should still be taken into account, such as roles, permissions, and authentication to ensure only relevant data is available to employees.

2.6 Skills

2.6.1 Generic data skills

The different roles described in Section 2.4 require specific skills to effectively fulfill their tasks. Next to these specific skills, a general overview can be given of the skills that improve work performance of an employee in a DDO. This overview is taken from the research of Anderson [13], and focuses on the non-management roles. The skills can be summarized as:

- Numerate: they should have a general understanding of descriptive statistics.
- Detail oriented and methodical: reports and analyses must be trustworthy when they influence decisions.
- Appropriately skeptical: think first what would make sense, and then question the validity of the data and calculations when it differs from the expectation.
- Confident: have confidence in their work, especially if its results are unexpected.
- Curious: always develop hypotheses or question potentially interesting data aspects.
- Good communicators and storytellers: they should be able to properly convey their work to decision-makers. This thus includes good written, spoken and visualization skills.
- Patient: this is needed to handle problems in analyses, such as availability of data, or changing requirements.
- Data lovers: they should love data as a resource and dig into it to make sense of the world.
- Life-learners: try to always develop new skills and knowledge.
- Pragmatic: focus on the right questions and keep the bigger picture in mind to prevent time wasting.

2.6.2 Future skills

Next to Anderson [13], Delke [40] has investigated the different skills that will be necessary in the future of an organization that is going to be more data-driven. His research is however more focused on the advancements in procurement, which is

also interesting for this research as the Purchase-to-Pay process is central in our case study. The skills found by Delke fall in one or more of the following categories: Technology, Relationship, or Strategic. These skills focus both on operational, but also on the management in an organization:

- Data analytics skills: focused on handling, analyzing and interpreting large amounts of data. This can be done by using data mining, visualization, or AI. This helps with finding and solving problems, and show the impact of decisions
- E-procurement technology skills: working with e-procurement systems and defining requirements for future systems.
- Digital leadership skills: focus on the ability to organize and manage employees in a digital environment. This should be targeted to the activities of the digital systems and becomes more important due to the quick development of digital tools.
- Robotic Process Automation skills: focus on the implementation of RPA in (repetitive) purchasing tasks. Employees should be able to configure bots to capture, analyze and interpret data, and act accordingly on it.
- Supply network management skills: the understanding of the horizontal and vertical supply chain of goods and/or services. This is necessary to manage the supply chain based on economic, social or environmental concerns.
- Digital negotiation skills: concerns the ability to negotiate in a digital environment. For example with e-sourcing technologies. This also includes the skills to decide when to negotiate face-to-face, and when to use machines for this.
- Digital contract management and legal skills: concerns the ability to integrate legal requirements into the automated purchasing process. Legal environments change, and this should be monitored. Technologies such as blockchain or smart contracts could be used for this.
- Strategic management skills: concerns on the synchronisation with global trends and assessing their addition to the organization's competitive advantage. This can be done by examining them in strategy development and the organization's strategy.
- Digital partnership management skills: the personal communication skills to solve issues beyond the electronic system communication. For example, the growing intersection between buyers and suppliers.

Delke [34] thus focuses next to the analytical skills of the employees, also on the role of management to be able to work with a more digital environment. These skills should also be considered, as an organization that works more with digital tools also needs proper management of these tools. So, the skills focus both on hard skills, for implementing and configuring software and bots, and on soft skills, for managing employees and relationships.

2.6.3 Comparison

Comparing the two lists, a few interesting insights can be found. There are some similarities between the lists, as they both show the necessity to be able to work with the digital tools that are becoming increasingly important. Both lists also showed some soft skills that are important for working in an environment that depends on these tools. Delke [40] also discussed typical skills that managers of organizations that increasingly use these tools should possess. A combination of technological skills, relational skills, and strategic skills is thus necessary for the digital transformation to a DDO. Both lists are important to get a complete picture of the skills needed in a DDO, because they focus on different aspects of the DDO. The list of Anderson [13] focuses more on the skills of the individual employee, especially data analysts, while Delke [40] has a broader focus on skills that should be present throughout the organization. Thus, these lists complement each other.

2.7 Benefits

A lot of research has been done in order to find out the challenges and the benefits of becoming a DDO. Examples are Berntsson [5] and Brynjofsson [6]. Using interviews, Berntsson was able to identify six main potential benefits of becoming a DDO. Namely, better decision making, understanding customers better, increased creativity, increased productivity, better market position, and increased growth opportunities. Increased productivity was also identified by Brynjofsson, as they found out in their research that organizations that become data-driven had an increase of 5 to 6% in their productivity.

Next to these benefits, one can also look at the decisions themselves. The better decision-making, as found by Berntsson, is often measured by decision reliability. This effect is attributed to the use of data, but why data has this effect is not clear in this research. When looking deeper into literature about decision-making, one can notice that experience-based decision-making has a history of being deeply flawed. Effects such as bias in decisions have been researched in vast amounts

in literature, with examples such as cognitive bias [41], confirmation bias [42], or status quo bias [43]. These biases limit the accurateness of the conclusions and judgements that are made when making a decision, and its effects should thus be reduced and mitigated.

However, next to inducing bias in decisions, data can also help reduce the decision noise. This is basically by making sure that the identical cases get the same judgement when looked at by two different people. This concept was studied intensely by Kahneman [44]. It was found that there are 2 forms of noise that are important: Pattern noise and Level noise. Pattern noise is the variability of a judges' response to particular cases, which can be due to irrelevant factors. Level noise is variation in the average level of judgements by different judges. Both these forms of noise have been found in many different areas of research [45]–[49].

Through the use of proper data collection and analysis, more consistent conclusions can be reached, which reduces the noise and the bias in the decisions made by the company. This is also confirmed through research, as better decision-making is also identified as a potential benefit of the DDO [5].

2.8 Challenges

Challenges to transition to a DDO fall in four categories: data [5], [50], [51], management [5], [50], organization [5], [51], and decision-making [5].

Data involves data quality, as the data has to be relevant and trustworthy. On top of this, the volume of the data can become a problem, either when there is too little or too much data [13]. Research has shown that when there is too much data, an analytics team cannot derive the maximum value out of it, inhibiting innovation performance and sales growth [52]. Other challenges concerning the data are the data governance with topics like availability, access, and a lack of standards. This can also hinder the process of using data for decisions [5], [50]. The usability and generalizability of the data could also be a problem, as it is hard to test models that are used within the organization [53]. Lastly, the company should have appropriate tools for collecting and analyzing the data [5].

Concerning management, topics of interest are inexperience with working with data, lack of communication within the organization, and challenges in process and strategy. Concerning processes, management should ensure that it has certain processes in place for ensuring data quality, and data validation. Strategy includes the awareness of data and the sharing of insights between teams [5]. Furthermore, the lack of management bandwidth and the lack of executive support for using data are also problematic [50].

The challenges concerning the organization are similar to the ones concerning

management, since not only management should be capable of and aware of the use of data for decisions, but this should also happen companywide. This thus requires a change in company culture, with a more focus on a companywide adoption of a data-driven culture. Included here is the mindset of employees, removing their skepticism about data [5]. This thus constitutes a change for different parts of the organization, such as Project management [54], but also for strategies within the HR department [55]. So, this shows that employees should have enough skills and understanding the process of how to use data analytics [50].

Lastly, the decision-making process itself can be a challenge when becoming data-driven. When an organization has all the capabilities and skills to effectively and efficiently analyze data, the conclusions still need to be used in the decision-making process, thus moving from opinions-based decision-making to data-driven decision-making. In literature, the practice of not using data for opinions is also called listening to the Highest Paid Person's Opinion, or HiPPO for short. In case data is properly managed, analyzed and reported on, the decision-makers within an organization (the HiPPO's), may still use their own intuition and experience to make decisions, instead of looking at the data. This may result in the positive effects to be missed [56].

Trust is also an important factor, as decision-makers should trust the insights that data gives them their own intuitions more. The insights can be made clear using visualizations, but these should be concise in order to make sure the information is not overwhelming. Lastly, the data sources that are used for decision-making are also challenging, as it can be unclear which data sources to use [5].

This shows that it is not easy to become a DDO, and an organization should overcome a lot of challenges in different areas before the transition is successful.

2.9 Summary

In this chapter, literature sources have been used to answer some research questions concerning the background of data-driven organizations. First, a definition of the DDO was adopted. Then, we determined the culture, strategy, roles, and processes of a DDO, as well as the skills that are needed in a DDO on an individual and a companywide level. Literature sources were used to find potential benefits of the DDO. Benefits found concerned the improvement of decision-making, due to a reduction in noise and bias in decisions. This increased decision reliability possibly led to an increase in productivity and competitiveness. However, also challenges of becoming a DDO were investigated. Challenges were found concerning data, management, organization, and decision-making. For data itself, problems are related to data quality, data volume, and data governance. Management problems fixate

on inexperience, lack of communication, and processes and strategy that are problematic for supporting the change. For the organization part, similar problems are faced, such as inexperience, incapability of working with data, and lack of trust. For decision-making itself, problems arise when the capabilities are in place to do the analyses, but the results are not used, which also lies in a mistrust of data. The chapter can also be summarized using Figure 2.1, where it can be seen how the different elements of a DDO moderate the data usage of people. Thereby it shows that the data usage brings several challenges and benefits with it.

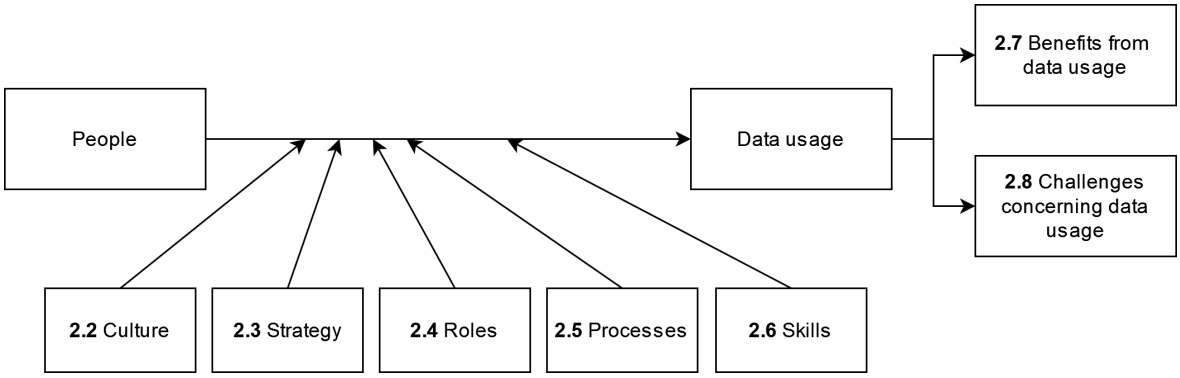

Figure 2.1: Graphic overview of Chapter 2

Chapter 3

Assessment methods

This chapter introduces the different assessment methods that are central in the framework built during this research. It can be assumed that information can be found either by looking into documents or talking to employees of the organization. Therefore, this chapter explains five methods that are used to assess an organization, namely interviews, maturity models, formalized documents, gap analysis, and solution building. This chapter gives more insights into why the different techniques were chosen, what they entail, and how they were used to gather information.

3.1 Interviews

For this research, interviews were needed to find information about several research questions. Interviews allowed us to find the unique information that the employees of the organization have. When doing interviews, several techniques can be used to gather information. There are different levels of structure on which interviews can be done, namely Structured, Unstructured, or Semi-structured. For this research, Semi-structured interviews were chosen as their structure allows for some flexibility in the questioning, like adjusting the questions to accommodate to the interviewee [57]. This thus makes sure information is obtained in a structured way, but it also gives room for discussion.

We used the research of Kallio [58] to develop our semi-structured interview. In his research, stages are described to build an interview guide, which is a script that can be used during the interviews. Each stage is elaborated on below.

1. Identifying the prerequisites for using semi-structured interviews
Literature sources gave us initial knowledge about the topic of Data-Driven Organizations. A semi-structured interview would be applicable for this situation, as it could be argued that the topic of a Data-Driven Organization is something that could be interpreted in many ways, thus having some freedom during the interview is prefer-

able.

2. Retrieving and using previous knowledge
The literature review helped assess the state of the art of the DDO and basic prerequisite knowledge. We found information that enabled us to answer some of our research questions. This gave more insight into the definition of DDO, the advantages, and obstacles for becoming a DDO, and maturity models. This knowledge has been used to build the initial interview guide.

3. Formulating the preliminary semi-structured interview guide
The interview guide should make sure that the proper interview questions are asked. Thus, information gathered from these interview questions should help answering research questions related to the case study. These are Research Questions 5 and 6. During some interviews, additional questions may be asked in order to make use of the expertise of the interviewee.

4. Pilot testing of the interview guide
The interview guide was tested through evaluation by certain individuals within the organization. As these individuals have experience with the different business units and their problems, they could help structure the interview guide to extract as much relevant information as possible. The interview guide should allow the assessment of the current situation of the employees of the organization and to find interesting topics to investigate. Next to this, general questions about the problems the interviewees encountered with the use of data evoked more topics that were interesting to discuss in detail. Due to the broad setup of the questions, we found topics of importance for the specific interviewees, before going into detail. During the pilot testing of the interview guide, it became clear that some questions were more relevant than others, resulting in small adjustments in the guide.

5. Presenting the complete semi-structured interview guide
The complete interview guide can be found in Appendix A. This interview guide was followed during the semi-structured interviews. It does not include any additional in-depth questions that were asked to follow up on the answers given by the interviewees.

3.2 Maturity Models

A maturity model is a framework which can be used by an organization to determine how ‘mature’ it is concerning the topic of interest of the maturity model. A matu-

rity model is also described as a structured collection of elements that describe the characteristics of effective processes at different stages of development. [59] This assessment is based on different parameters, which are used to assess the maturity level of an organization. In order to reach a maturity level, the different processes of that level should be supported within the organization. Conversely, with a maturity model, an organization can get an overview of which processes are not done correctly. Maturity models differ in terms of complexity and extensiveness, depending on the results that should be achieved using the model. It is possible that the organization only wants a broad company-wide overview of its maturity, or that it wants a more detailed account of where to improve. Maturity models are often updated due to the changing business environment. For this research, we found that the Data Science Maturity Model (DSMM) [60] was the best model to evaluate the organization. This choice was made based on three inclusion and exclusion requirements. Firstly, the model had to be elaborate in its review, excluding smaller, less detailed, models. Secondly, the model had to be developed recently, as the field of data science is quickly developing, making models quickly outdated. Lastly, the model had to be in the field of the organization of this study, which is the manufacturing domain. The DSMM consists of 26 processes, which can be assessed based on their best practices. Based on this, the capability level for each level can be determined, and the complete maturity of the organization can be assessed.

3.2.1 Construction of maturity model

Unfortunately, it was impossible for us to obtain the full DSMM, as the researcher could not make it available to us. Therefore, we created our own maturity model based on the DSMM to be able to use it for this research. To keep the maturity analysis within the scope of this research, only processes of the lowest maturity levels of the DSMM have been used as an inspiration to build our own maturity model. We chose to focus on these processes as they are essential to forming a DDO, and the organization should first have these in place before continuing with higher maturity levels. The processes came from five domains, namely data analytics, data management, people management, organizational governance, and project management. Processes we included in our constructed model get their definitions and their requirements from several other models. Data analytics processes are included as defined in the CRISP-DM model [61], data management as defined in the DAMA-DMBOK [62], people management as defined by Fletcher [35], organizational governance as defined by Gökalp [60], and project management as defined by Frame [63]. Figure 3.1 shows how our model was constructed and gives some more detail about the processes included for each domain. The complete overview

of the maturity model used in the analysis can be found in Appendix B, where the base practices of each of the processes and their explanations are found.

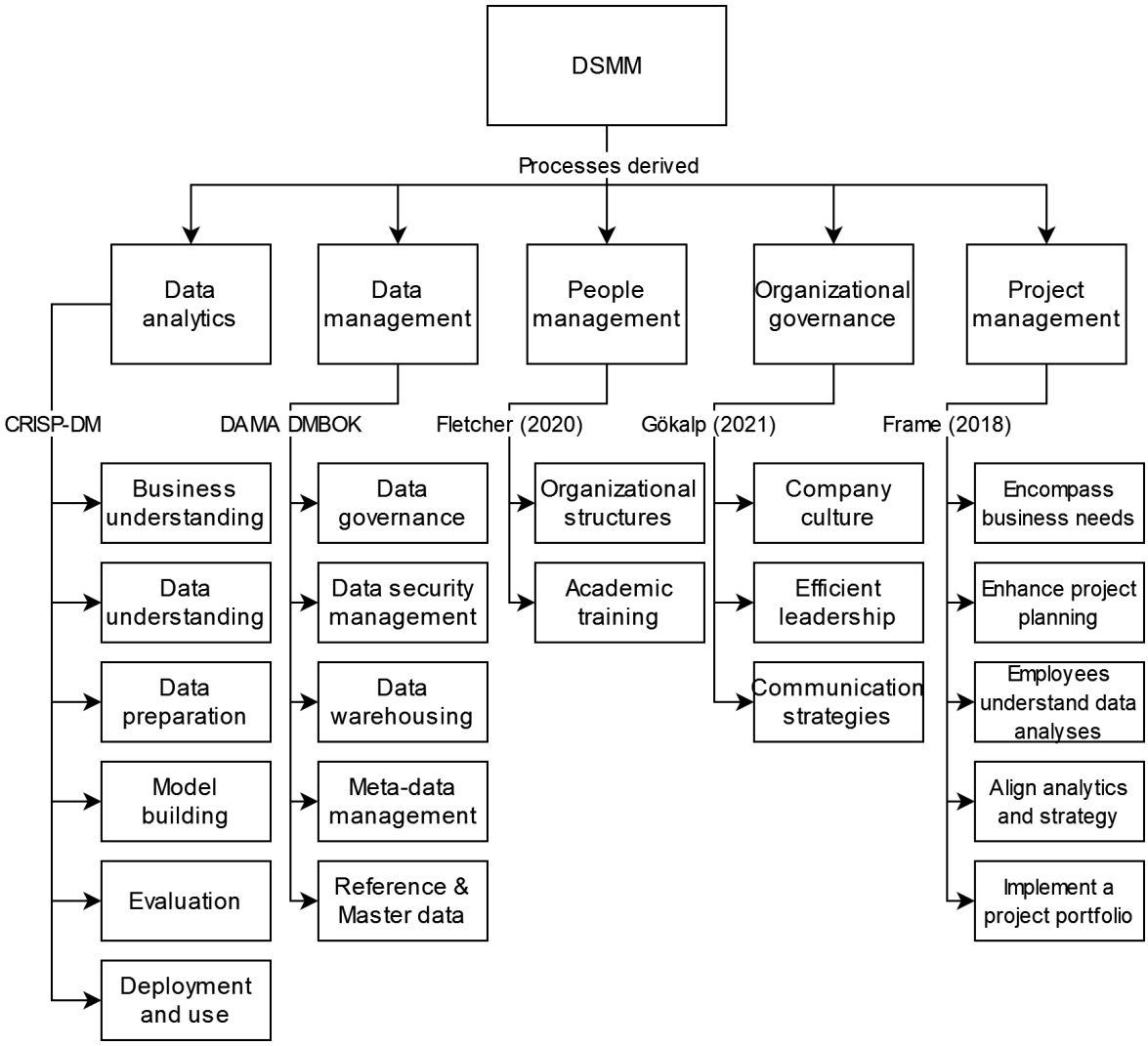

Figure 3.1: Construction of the maturity model

3.3 Formalized documents

A formalized document analysis are a convenient way to find more information on the organization [64]. These formalized documents may report on current strategies, current goals, and the values that are central to the organization. These documents are often limited in terms of accessibility, which means that the researcher should assess which documents can be made available, and what information should be found using other methods. Next to this, it should also be assessed whether the documents are up to date, since documentation can easily become outdated within a fast-changing organization. Interviews can then be used to assess the differences

between the formalized, explicit documents, and the actual situation in the organization. Formalized documents should be considered, as they are often used within an organization to fall back on when questions are asked about specifics. Since they are explicit, formalized documents promote a sense of trust in the organization and help share information into the memory of an organization. [65] Therefore, they serve an important role in an organization and can give basic interesting insights without the need to have time-intensive interviews. This can help researchers prepare their interviews and anticipate what to expect from employees during interviews.

3.4 Gap analysis

When the information is gathered and structured, it is possible to start with the gap analysis. During this analysis, it is tried to compare the information gathered during the literature review with the information gathered during the organization's assessment [66]. This comparison can lead to a clear overview of the differences between the current organization and the optimal DDO. This is in line with the problem investigation phase of Wieringa [1].

The information about DDO reported in Chapter 2 has been used to compare the as-is situation of an organization, which results from the assessment, with the optimal situation of a DDO from literature. The differences between the two show the gaps in the current situation of the organization.

3.5 Solution building

The last step in this process is to build solutions for the gaps that are encountered. This is in line with the second step in the DSRM of Wieringa [1], treatment design. This should be done based on the gap analysis, which shows the different areas where there is room for improvement. Based on the identified gaps, solutions should be developed [67]. In order to determine which of the gaps should have a high priority, it is recommended to have a discussion with the organization. During this discussion, the researcher can present his findings to relevant stakeholders in the organization, who can then discuss and evaluate the results. Based on this discussion, the gaps can be ranked according to their priority. It should be made very clear why certain gaps have a higher priority than others. This can be done with argumentation about potential value, risk, or any other means that allow for a comparison between the different areas.

After it is clear which of the gaps has the highest priority, solutions can be built. These solutions can be of a wide variety, depending on the subject that it improves.

In this research, the solutions will focus on certain aspects concerning the DDO that are not correctly implemented yet. This can involve data-related processes, but also responsibilities of employees. It is important that the proposed solutions are well-built, and that they fit the problem they solve. Also, the solutions should be complete, thus they include the implementation steps, the reason why such a solution would fit, and the expected goals after the solution is implemented. Solutions in our research thus demonstrate their need first, after it is stated how the solutions will contribute to combat the problem. Also, all solutions will be combined in an implementation plan that can be used as a template for the implementation order of the proposed solutions.

Chapter 4

Case study: Assessment

The basis for a case study has been laid out in the previous chapters of this report. This chapter reports on a case study that has been done using the assessment techniques described in Chapter 3, and discusses our results.

4.1 The organization

In this case study we consider an organization that is active in building technology solutions for several industry areas. Their focus is on software solutions, hardware solutions, or a combination thereof. While the organization has departments worldwide, the Dutch department of the organization has about 900 employees. The organization has seven distinct business units, all working on different areas of technology improvement. The organization has grown a lot over the last decades in terms of employees and production, but it has tried to maintain a flat organizational structure. This means that the different business units within the organization have much freedom, and thus responsibility for their own part of the business.

Although the flat organizational structure has given the organization a lot of benefits, several problems concerning data have come into existence over the years. Therefore, the organization is currently in the process of trying to move to a situation where data is better incorporated into its decision-making process. Especially during this process to move to a DDO, problems have become apparent. This is because the organization's departments must cooperate better to effectively and efficiently gather, analyze and distribute the correct information to the correct people. When trying to improve cooperation, several challenges are currently being faced by the organization, which is why it was deemed necessary to evaluate its current state. This assessment can be helpful to identify the best areas for improvement concerning data-related practices. The scope of this research had to be limited to a single process to be analyzed, which is the Purchase-to-Pay (P2P) process.

In this chapter, we explain the processes and results of the different assessments

that were done. First, we describe the overall P2P process and show its relevance to an organization. Second, the interviews performed to get information on the process are elaborated on, and their results are shown. The interviews mainly focused on extracting more information about the organization's P2P process, the problems that are currently faced, and the possible solutions. All interviewees played a role in the P2P process, which revealed the need to use more data in the process. Third, a section is devoted to a maturity analysis to find the gaps between the optimal processes within a DDO and the current processes within the organization of the case study. Finally, the formalized documentation analysis of the organization was used to find out more about the values, visions, and strategies within the organization.

4.2 The Purchase-to-Pay process

The Purchase-to-Pay (P2P) process describes the different steps that are taken in an organization to purchase products or services from external suppliers. The process is unique to each organization, but it often contains similar processes. As defined by Murphy [19], the P2P process often involves the creation of a purchase order, the authorization of a purchase order, sourcing, the selection of the goods and/or services, the provision of the purchase order to the chosen supplier, the receipt of the goods and/or services, the authorization of the invoice of the supplier, and finally the payment to the supplier. All big organizations implement these processes in their way of doing business. These processes are of different importance to the organization, depending on their reliance on the goods received, and the number of products that are ordered. Research has also shown that the P2P process is one of the most labor-heavy and time-consuming processes in an organization, resulting in major benefits when processes are more automated. [20] Therefore, organizations have implemented new technologies to help employees involved in this process to do their work activities and automate some tasks. [68]

However, the more important a process becomes, the more challenges can be seen. Several challenges are found in the current processes [69], such as dealing with errors and compliance. This is why many organizations can still improve their P2P processes a lot. Especially looking at data-driven practices, Rozados and Tjahjono [70] argue that the P2P process is an area where there is a lot of data available, but it may not be used properly yet. Research of Moretto et. al. [71] showed that the use of data has a critical role in supporting the P2P process, and that data usage impacts strategic and sourcing activities, as well as risk management, supplier performance monitoring, negotiation and selection, and sourcing planning and forecasting. Thereby, other research shows that the use of data can improve the competitiveness of an organization [21], [22] demonstrating the benefits of data an-

alytics within the processes that are relevant to procurement.

4.3 Interviews

During the course of the research, we conducted several interviews with different stakeholders within the organization. This allowed us to create a complete picture of the different viewpoints on how to become a DDO. The complete guide of these interviews is available in Appendix A.

Due to the flat organizational structure and the individual operation of the different business units, collaboration was not necessary. This meant that over the years, the different business units have crafted their own ways of conducting business and doing the necessary operational tasks. This thus resulted in a business environment where a lot of differences exist between different parts of the organization. For the P2P process, this means that each of the different business units has its own employees responsible for the purchasing of products and the registration of sales.

For this research, we chose to interview employees at the different business units that are responsible for different phases within the P2P process, to get a complete picture of the current situation for the organization. An overview of the stakeholders that were interviewed can be found in Table 4.1.

Due to practical reasons, the interviews were conducted in Dutch, which resulted in the findings being translated. These interviews were done either physically or online, depending on the availability of the interviewee. During the interviews, notes were taken of the relevant information. After consent, interviews were recorded to be able to reference them at a later stage.

4.3.1 Interview Results

Currently, the IT department is responsible for hosting the various applications that are used within the organization. Next to the hosting, the IT department also has a BI/Data team that is responsible for building dashboards and reports based on the data. The ambition of the IT department is that they are able to efficiently and effectively provide the rest of the company with relevant data. However, this is not possible yet and we will discuss the reasons for that.

4.3.2 P2P process of the organization

Within the organization, the P2P process has been specified and it was indicated during initial interviews that the P2P process was still not using data properly in some phases. In addition, data about the complete P2P process is highly available, which increases the potential benefits that could be achieved from data usage. However,

Interviewee	Professional role	Responisibilities
I1	IT architect	Infrastructure team lead, experience with digital structure of organization
I2	Purchase manager	Overseeing procurement of different business units
I3	Lead purchaser	Replenishment of items for two business units
I4	Project manager supply chain	Monitor the purchasing process of different components for a business unit
I5	Strategic purchase coordinator	Investigate markets for purchases for possible future products. Also oversees the procurement process
I6	Supply chain planner	Uses data and dashboards to generate insights in the supply chain, and advice based on this
I7	Sales and operations employee	Works on inventory management for multiple business units
I8	Operations Lead	Oversees operations teams of sales and purchasing for four business units

Table 4.1: Overview of the interviewees

due to the size of the organization, we still had to limit the focus of the case study. Here we chose to focus on the direct spending of the organization, which concerns all products or goods that are used to directly support production. Figure 4.1 shows schematically the P2P process of the organization in terms of its phases. Each phase is discussed in the sequel.

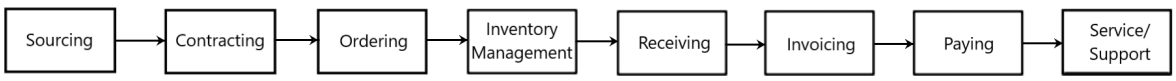

Figure 4.1: Phases of the P2P process

Sourcing

In the sourcing phase, different suppliers of either goods or services are analyzed and reviewed. Contact is established between the organization and the suppliers, giving them the ability to discuss the possibility of a contract. This step is currently done mostly by the central procurement of the organization. Relevant data that could be gathered in this step is the interesting leads that can be given to the department handling the contracting phase. Currently, data usage for decisions is minimal in this step. There are some projects which are currently being worked on to improve this, namely the building of a spending analysis and a supplier reliability dashboard, which can be used to improve this step by incorporating more data. While these initiatives are promising, their implementation will determine if it is sufficient.

Contracting

In the contracting phase, both parties try to come to an agreement for the delivery of the goods and/or services. Terms and conditions of the contract are negotiated, and if both parties agree to the stated terms, a final contract is drawn up. Just like the sourcing phase, this activity is done by central procurement. When looking at data usage in this step, this is not effectively used yet as contracting data is not made digitally available. This limits the value that can be derived from this data. Currently, a project is running to assess contracts and suppliers based on contracting data and make this available.

Ordering

The ordering phase is where the actual goods/services are ordered. In this phase, the organization sends an order to the supplier, indicating that they want certain goods. The ordering phase is done by the business units individually, as they determine how much of each product is needed. Since this phase is done by each individual business unit, the incorporation of data in this phase differs among them. Some have clear structures in place which help them determine when to order which products, while others have difficulties connecting sales and ordering data to assist them in the ordering process. There is thus a difference in data maturity between the business units in this phase.

Inventory management

During the inventory management phase, the organization needs to keep track of the number of goods and/or services that are still in their inventory. Inventory management allows the organization to make sure that there are always enough of the

necessary goods in the inventory. This should be closely monitored to make sure that the organization does not run out of materials. This thus may include some analysis of the resilience of the supply chain in order to monitor and cope with disruptions. Inventory management is done by the operational manager, who oversees one or more business units. Data is used in some way during this process, by giving operational managers insights into the current inventory, and the projected sales. With these insights, they can make data-driven decisions. However, during interviews it became clear that there are still significant problems concerning data quality, data availability, and forecasting, so that data is not always optimally used in inventory management.

Receiving

Receiving is the phase of the P2P process where the ordered goods are received by the organization. During the receiving phase, it should be checked whether what is received is in accordance with what was ordered and that all the received goods are up to standard. Goods are received by the warehouse, which can either be at the organization, or an external warehouse. In this phase, clear procedures are set up that describe the steps that should be taken when receiving goods. The use of data is accurately incorporated into this, as the processes ensure data availability, quality, and validity. Also, when problems arise, clear policies are available to determine what to do to ensure the quality of the data.

Invoicing

After the goods are received, the organization receives an invoice from the supplier that has delivered the goods and/or services. The invoicing should be checked on whether it agrees with the contract, and whether the invoiced amount is in accordance with the received goods and/or services. Invoicing is done by the finance department of the organization. During interviews, it became clear that contract data is used extensively in order to check invoices. Contract data is stored in the ERP system, to help create an overview of the contracts in the system at any time. When the organization receives invoices, these are mapped onto the different orders in the system. When an invoice cannot be mapped onto an order, either because the quantity or price does not match, the invoice is mapped onto an order individually evaluated.

Paying

In the paying phase the invoiced amount is transferred to the supplier. Just like invoicing, the paying phase is done by the financial department. The organization has a system in place that is used to approve all of the payments. When payments are above a certain amount of money, the system needs some extra checks in order to finalize the payment. Anyway, for each payment made the 4-eyes system is used, making sure that all payments made are checked by at least two people.

Service and Support

After the goods or services are received by the organization, some further services may be applicable to the goods. If the delivered product is a service, some support may be included to ensure proper functioning. Additional services such as warranties can be included here for when the received products are goods. Data is not optimally incorporated in this process. Interviews made clear that the SLAs were initially defined for some of the products, but that these are not kept up to date. On top of that, this data is not centrally stored, and there is no procedure in place for how to follow up when things go wrong. This is not always a problem, as, for example, warranties are not always relevant due to the extensive testing the organization does with the products that it builds. When something goes wrong during this phase, it is difficult to hold suppliers accountable due to legal reasons. Anyway, data quality, accessibility, and validity practices are thus not in place in this phase.

4.3.3 Problems

During the interviews, the interviewees were asked what problems they were currently experiencing with data related topics. When assessing the problems expressed by the different interviewees, there are a few topics that stand out. These problems have been discussed further, showing their relation to the interviews.

Data availability

The first topic that became apparent during the interviews was the availability of data to the interviewees. The interviewees mentioned that they did not have proper access to the relevant data, or that it was difficult to find the data that was needed to answer their questions. This became apparent with I1, who mentioned that the data is currently stored on premise, which creates problems making it available to everyone. Also, he mentioned that not all systems communicate with each other, leading to data silos. I2 also mentioned the problems with data availability. Due to

the lack of a central place for reporting and analysis, he found it difficult to find answers to certain questions about the data. Furthermore, specific suggestions about non-available data were made by I3 and I6. They mentioned that data concerning the comparison between the forecast and the realization of sales was not available for analysis right now. I5 mentioned that he experienced a gap in the availability of data both internally and externally. Internally, there were problems with providing the correct employees with the correct data to do analyses. Externally, data was not always provided by the suppliers, leading to problems when trying to analyze the supplier's performance. This external data problem was also mentioned by I8, when talking about supplier assessment. Several data fields are not available yet in the system to analyze suppliers, for example, their reliability on delivery dates. Overall, data seems not to be accessible to the correct persons at the right time due to several technical and organizational reasons.

Data quality

When data was made available to the employees, there were still problems concerning the quality of the data provided, i.e., whether the data that is in the systems is accurate and reliable. Concerning data not being up to standard, I1 mentioned the possibility of a client having multiple instances in the different systems of the organization, while this was not satisfactory. These instances existed due to ineffective communication between systems. I5 also mentioned the poor quality of data, especially concerning the data that was received from external suppliers. This data was often full of mistakes because it was not an automatic report, but a manually made report. I6 also mentioned data quality, when elaborating on his work at one of the business units. Here, the quality of data was not always guaranteed since the people entering the data in the system did not always do this properly. I7 mentioned that essential data for some of the processes was not always up to date, namely data concerning the article cards, which were used for determining stock, determining delivery times, and controlling suppliers.

Data validity

Data validity concerns whether the data that is used for evaluation, is evaluated and thus checked for errors and consistency. I1 showed that in the current IT infrastructure they tried to only allow analyses from data that was verified and stored in a data warehouse. However, he also indicated that there are still links that allow for unverified data to be pulled from the system and be used for analysis. The validity of the data also led to problems for I4, as the data that was used for forecasting was not valid and led to problems. I5 mentioned that the validity of the data was

not always guaranteed. This was the case, for example, with the external data that was received, as this data was often invalid. I7 also mentioned problems concerning data validity, as there is no real control system implemented that can alert when invalid data enters the system and is used for analysis.

Data value awareness

Before employees are willing to use data as an aid for their decisions, the employees must see and understand the added value of the data, which characterizes the value awareness of data within an organization. When employees clearly see the value the data can add to their decision-making process, its use is more easily accepted. Some interviewees mentioned that this was not always the case. I2 commented that employees of the organization did not always trust the data. This lack of trust also came from a wrong interpretation of data, leading to wrong conclusions, which supported their low trust in the data. I6 showed another aspect of the status of data that was lacking in the organization. He mentioned that during his work, it was not always clear to some employees why it was important to fill in the data correctly and completely in the system. These two perspectives show that data is not trusted, and due to this the importance of the possible additional value of data usage is not clear to everyone within the organization.

Forecasting

In the P2P process, forecasting is necessary in the purchase of stock in order to determine the expected sales in the next period. The purchasing of stock should be in line with the sales, as this prevents the organization from having either too few or too many products in stock. For the forecasting process, a software system (Futurmaster) was acquired by the organization in order to help the different business units with making and adapting their forecasts. Futurmaster was implemented throughout the organization, but this led to many problems at different business units. The first problem was expressed by I3 and I4, who both mentioned that the software was not living up to its standard after a period of inconsistency. The software was not able to deal with inconsistent deliveries and thus made forecasts unreliable. Eventually, both interviewees indicated that they stopped using Futurmaster, as this did not enhance their forecasts. I5 indicated that he missed a proper link between sales and demand, which is necessary for making a proper forecast. I6 explained that he did have a proper connection between sales and demand, and that a proper link was not the only problem. As Futurmaster used statistics to build its forecasts, the program needs more input data to produce better predictions. However, most of the

products of the different business units are ordered by one big client, which means that a statistical program like Futurmaster is not able to give any interesting insights.

Next to this, I3 and I6 also mentioned that it was difficult for them to improve the forecasts, as comparing the forecast with realization was hard to do. It was currently not possible to easily compare the actual products sold with the initial forecast at the beginning of the year, which limited the possibilities for improvement.

Architecture systems

The architecture of the IT systems of an organization is often important for its effectiveness. During the interviews, it became clear that the IT architecture of the organization of the research is suboptimal. I1 mentioned that there are still some inconsistencies in the architecture, such as incomplete system interconnectivity, leading to problems. The architecture became scattered due to legacy, but this scattered architecture now allows for invalid and inaccurate data to exist. Thus, the system should be adapted to increase the possibilities for data analytics. The scattered architecture also became clear during the interview as I4 mentioned that he had to use 2 different ERP systems for his analysis. As these two systems were not integrated data had to be combined manually, making data analytics more difficult.

Data literacy

Effective use of data analytics requires a certain level of knowledge from employees. This analytical competence is novel for some jobs, we can conclude that traditional roles have changed, while the people that fulfill these roles have not changed. Employees should possess the competence to shift to this different viewpoint. However, I6 mentioned that he is not sure this is currently the case with all the positions in the organization. The competence of some employees to correctly handle data is not always in place. This can be at several levels within the decision-making process, such as data entry, data analysis, but also at the level of data-driven decision-making.

Standardization of Processes

The interviewees also mentioned a lack of standardization of processes, which means that for some of the data analyses, the data was already in the system, and available for the correct people, but there was no standard way of analyzing this data. Thus, the data that came in was analyzed manually in order to act upon it. This was most evident with I6 and I8, who had a lot of the necessary data already available, but their analysis was still manual. For example, they had to manually check which products were almost out of stock and set out appropriate actions based on

this. The manual work took a lot of their time, which was mentioned as a problem. By shifting from an ad hoc measuring situation to a more standardized situation, a lot of time can be saved.

4.3.4 Solutions

Some of the interviewees were able to indicate some solutions for the problems that are currently in the organization. The solutions were widespread due to the different problems that were encountered, which is why they are divided into different sections, namely technical solutions and non-technical solutions.

Technical solutions

Several interviewees proposed technical solutions to the identified problems. It stood out, but it was not surprising, that the technical solutions were proposed by the people with the most technologically advanced skills on data techniques. For example, I1 mentions that data storage should be centralized and put in the cloud for better accessibility. I2 also indicated the problem of not having a centralized database, which gave him problems when trying to analyze data. Similarly, I4 indicated that this might help concerning his problem of having to deal with two different ERP systems. An extra data link is also mentioned by I8, which indicates that it is necessary to find the differences and similarities between the Make-to-Order and Make-to-Stock production processes, to improve the monitoring of stock.

I1 also mentioned that the security of the data should be improved by improving the authorization policies and roles of the organization.

The interviewees mentioned quite often that a dashboard could be used to solve the problems. I2, I3, I6, I7, and I8 identified dashboards as a possible solution for the problems they experienced. For I2, dashboards could help give a better overview of the different parts of the organization when trying to analyze data from different processes. Examples include the comparison of different suppliers or inventory. I3 sees dashboards as a possible solution to visualize the difference between the original forecast and the realized purchase and sales of products. This is now difficult to do due to the correct dashboards not being available, which leaves them with questions that should be answered to improve the forecast for the next year. This problem is also experienced by I6, who also sees the need for a tool that can help visualize this difference. I7 also mentioned dashboarding as a solution, to give more insights into supplier reliability. This could be either operational or analytical dashboards, depending on the use of the dashboard in the organization. Lastly, I8 also mentioned dashboarding as a solution, or at least the extension of the current dashboards, since the current dashboards lack some of the relevant information for

analyses. These dashboards could also be used to implement some alerts based on product stock and show supplier reliability in a better way.

In our opinion, the most important thing for all these interviewees is that they must define their KPIs first before they are able to build an efficient dashboard. These KPIs should be the key to their monitoring practices, and thus should be clearly defined and built in the dashboard to optimize their analysis.

Non-technical solutions

An example of non-technical solutions was mentioned by I6, namely, the capabilities of the employees of the organization should be reviewed, to assess whether the employees entail the data analytical capabilities that are necessary for data analysis. Thus, the employee knowledge about the importance and value of data should be extended, helping them understand why data can help them during their work. More knowledge is also a solution to the problem expressed by I5 that the data they receive from external parties is often not accurate or complete. When the knowledge of the value of data is extended to the external data suppliers, this could increase the quality of the data that is received. Lastly, an essential point for these improvements is an improvement in communication, including communication about the value of data itself to employees or external parties, but also about the tools that may be already available to support employees. This should help us understand both the possibilities, but also the current pain points in the organization. I7 and I8 also mentioned that the technical basis for the solutions is already in place. However, they also mentioned that some of the values in the dataset should more properly be filled in by employees to improve the data quality and thus improve the results of data analysis.

4.3.5 Data

Since data is not flowing freely in the organization, changes are needed on different organizational levels, such as the applications used, data storage, and IT architecture. This should allow data to be shared better between the different parts of the organization. However, next to the availability of data, culture is also an important part of a DDO. If the data is available but not used accordingly, the benefits diminish. This why we asked questions about the relevant data in the interviews, with the goal of finding out what the different departments see as useful data for improving their current decision-making. Finding out what data they want to have for their decisions can increase the acceptance of the dashboards. The interviewees mentioned different data sources as relevant, which confirms the view that scattered data should be

more widely accessible in order to provide better data usage throughout the organization.

4.3.6 Future

I1 focused on the future of the IT architecture, where he indicated that the current architecture should be transformed to a model where the business units are able to freely access their data. IT should make data easily accessible and ready for transformation, whereafter business units are able to combine this data with their own data in an ETL layer, allowing for the creation of valuable information. I2 and I3 envisioned a future where they would have access to different dashboards that would help them in their daily work. They trusted that the organization would be able to provide them with this. I4 mentioned that he would prefer it if the organization in the future has a data structure that would allow reporting on each different data field, which would lead to more extensive insights. He also mentioned that forecasting software would be a nice future addition when the market has stabilized. I8 mentioned that a team should be built that increases the data demand for decision-making of the business units. In the future, this will make sure that the operations team fulfills its main goal of providing high-quality data and enabling proper use of data by the business units.

4.4 Maturity analysis

We performed a maturity analysis to assess the data-driven state of the Purchase-to-Pay process in the organization. The maturity model that was used for this was constructed as described in Section 3.2. Using processes from 5 domains to evaluate the organization, several improvement areas were shown.

4.4.1 Results

For the maturity analysis, it was necessary to discuss the developed model with employees within the organization. Due to the technical specifications of the model, the BI/Data team was chosen as the most qualified for this maturity analysis. This team consists of three members, who were interviewed separately to get a complete picture of the current maturity. Next to an analysis of the maturity of the entire organization, this also allowed us to compare the opinions of the different interviewees.

The results have been summarized by diving deeper into the improvement areas that resulted from the maturity analysis. The best practices that were already implemented by the organization will not be elaborated on, as our research focuses on finding recommendations for the organization.

4.4.2 Produce project plan

All interviewees mentioned that there is currently no documented project plan for data projects. This means that it is currently unclear which steps must be taken during data projects. All interviewees mentioned that the techniques and tools they can use are clear and defined, which should make the plan easy to develop. Currently, the steps that are necessary to develop the solutions to a project are implicitly done by each of the BI/Data team members individually, with limited communication within the team. Interviewees mentioned project plans are currently not developed as the projects are too small, and it would increase the workload. However, for the future, we recommend that a project plan is built, especially if projects are larger. This gives the BI/Data team and the rest of the organization more insights into how far the project is finished, and what steps have to be taken to finalize them, while also bringing more structure and overview into the projects.

4.4.3 Model building

All interviewees mentioned that model building, such as algorithms, AI, or Deep learning is not used during the data-related projects they work on. We recommend the BI/Data team to investigate these techniques, to get more insight into where and how they may add value. One interviewee mentioned that some models are used within the organization, such as star models for data schemes. However, these models do not align with models mentioned in the maturity analysis (AI/DL). The interviewees mentioned that currently algorithmic models are not used as the organization is not ready, in terms of data quality, availability, and validity, to use these models efficiently. They feel that the organization should become more mature in these areas before algorithmic models can be used for improving processes or decision-making.

4.4.4 Evaluation and review

The maturity model has several processes concerning review and evaluation, namely the review of the processes that are finished, the review of the project, and the production of a final report for the project. The interviewees mentioned that these review steps are currently not implemented, making it hard to evaluate problems and learn from them for future projects. We suggest proper project documentation as a first step for the organization, as this is something explicit that can be reflected upon. After this documentation is in place, it can be used to review the project and the processes within it. It is not clear to the interviewees why evaluation and review are currently not performed. Two interviewees mentioned that they had not thought of such a system to improve processes, which could explain this situation.

4.4.5 Data governance

The data governance part of the maturity model consists of many different processes (see Appendix B), most of which were not completely or correctly implemented according to the interviewees. While some processes were not performed at all, such as data asset valuation or governance frameworks, others were done partly, such as data strategy, issue management, or data standards, allowing for much room for improvement. Luckily, the BI/Data team mentioned that most of these processes are currently under review. While this is a positive development, we feel that the most gain can be achieved by making the processes that are currently performed more concrete. Much of the data governance processes are performed to some extent, but their underlying steps are not defined, meaning their steps are only clear to the employees performing the task. Also, the lack of definition of steps leads to little information transfer. With more process documentation, processes become clearer in the organization, and information can be shared. Lastly, the interviewees mentioned that internal communication is currently not up to standard. This communication is important, as it can help improve data awareness within the whole organization. We conclude there is a lack of data governance because data-related processes have developed quickly in the last few years, and there was little urgency to document these processes.

4.4.6 Data classification for security management

Data security management is performed to some extent by the BI/Data team already, but it became clear that one important step was not touched upon by them yet, namely the classification of the confidentiality of information. This should create an overview of the available information and its confidentiality. Currently, this is not implemented in the organization, leading to an inconsistent view of the importance of information. This classification also determines accessibility rights and the level of security. We advise that the BI/Data team tries to develop a classification scheme to classify different sources of information in cooperation with management, to ensure a coherent view of information confidentiality within the whole organization. Interviewees mentioned these classification schemes are not in place yet as there is no real incentive for developing them. The interviewees expressed that they cannot classify information on their own, so due to the lack of incentive from management such a scheme has not been developed yet.

4.4.7 Reference and master data management

Organization-wide reference and master data are essential to create coherent information and avoid inconsistencies within an organization. These types of data sets are currently not implemented in the organization. Once the organization decides to work more with data, we expect that these datasets are a necessity. Therefore, we recommend that the BI/Data team starts building such datasets as soon as possible. This helps the organization work faster on data adoption and helps the BI/Data team to save much time in dataset matching. The value of this investment is recognized by the interviewees, as they mention they have started implementing reference and master datasets. As the reference and master data are only seen as important for a short period of time, the BI/Data team has not had enough time yet to implement this correctly.

4.4.8 People management

People management, explained in the model as the guidance of employees to be able to work with the solutions that the BI/Data team provides is currently also insufficient. The interviewees mentioned that there are certain structures in place that can communicate the importance of data, namely data owners within different business units. However, they mention that this is not used enough, and data owners should be used more in the future. A strategy may help with using these people as effectively as possible. All interviewees mentioned that currently no training is available for employees to be able to work with the solutions and/or tools that the BI/Data team provides. We feel these training modules should be developed and implemented in order to increase awareness of the possibilities and increase the chance that solutions are used effectively and efficiently. Solutions can then have more value for the organization, as less end-user support is needed, and end-users can ask more specific questions regarding the support they need. As with other problems, the time has limited the possibilities of the BI/Data team to focus on training and communication. Thereby, it can also be argued that the current BI/Data team members were not selected for their communicative expertise but were hired based on their capabilities in working with data solutions. This could also be a reason why there is currently little in place concerning the communication and training of data tools.

4.4.9 Organizational governance

Organizational governance focuses on the organization itself and the data use of its employees. The three practices within this process, namely corporate culture,

efficient leadership, and communication strategies, are all not performed completely or correctly. Thus, the organization is not fully committed to the change to a data-driven organization and the changes that are necessary to make the shift to a DDO are not getting enough attention. It should be clear that the commitment and investment of the whole organization, including leadership, are needed to realize this shift. Thus, it should be possible for the BI/Data team to communicate this lack of commitment to their superiors or the management, and it management should also check if what the management claims they want is in line with their current practices. This feedback loop can help improve the change process and empower the whole organization with the potential benefits of data usage. Currently, the interviewees acknowledged that management is trying to put more focus on data, but this is not explicit enough in their eyes.

4.4.10 Project management

Project management looks at managing projects with data. The interviewees expressed that such a system is not in place. Projects are managed to some extent, for example by monitoring their use after deployment, but not with an explicit system with metrics. Projects are weighted based on their importance and potential value, but not systematically. Also, some interviewees mentioned that not all employees understand the analyses that the BI/Data team delivers to them. When projects become bigger, this becomes of higher importance, as more people have to work with the solutions that are built. Lastly, a project portfolio is not in place, which can keep track of the running projects. We suggest implementing this because such a portfolio helps to give an overview of what projects are currently being worked on, and how these projects are progressing, and to help support decisions on whether to continue or stop with projects. Without such an overview, these decisions are hard to make, as there is little evidence to support the decision. This kind of management is not in place as it is time intensive to build such a portfolio and KPIs for projects are often not defined.

4.4.11 Meta-data management

For meta-data management, we obtained many different answers concerning the implementation of processes. This was interesting to see, as there was apparently no consensus amongst the BI/Data team members about how certain processes are implemented. This can be due to multiple factors, namely, we assume that it can be the case that some team members are not informed well enough of all the practices other people in their team do. Another reason can be that the interpretations of the practices differ, which could lead to different answers. However, these incon-

sistencies should be cleared up in order to give all the team members a common understanding of the current implemented practices. On top of this, we suggest that extra documentation can help increase this knowledge, as this will create a place where all processes are defined, and this can be referred to when necessary.

4.5 Formalized documents

The formalized documents used in the organization mainly focus on culture and strategy. The organization was able to provide several documents that were related to these topics, which were analyzed and compared with the strategies and cultures found in literature. Based on these analyses, interesting insights could be found in both areas.

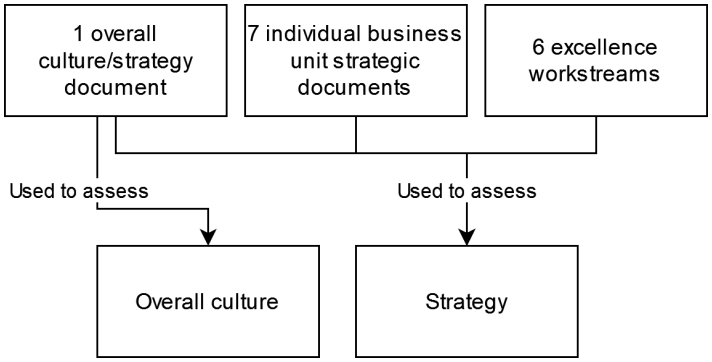

Figure 4.2: Overview of the documents used during the analysis

4.5.1 Strategy

The current strategy of the organization consists of three parts: an overall strategy, strategic stories that are specific for business units, and excellence workflows. All three different strategy concepts were reviewed in order to check whether data is incorporated in them.

When looking at the organization's current overall strategy, no real mention of data usage can be found. However, data use is inherent in some of the current strategic points. For example, one statement concerns the importance of making technology that fulfills the needs of people in their workplace. It can be argued that data usage is an essential element in this, as data can demonstrate the importance of technology in a work environment. For example, this can be shown by usage numbers, by data about user experiences, or through increasing production numbers after data implementation. Next to this, the proposition about creating true value could be in line with data usage. That is, the use of data in an effective way could help add true value to some of the employees in the P2P process, as they expressed

some issues with the current data usage. Data solutions can help employees solve these problems, by creating products that make their work easier and more effective.

Next, the strategic stories of the individual business units were reviewed. In these strategic stories, differences exist in terms of data inclusion. Out of the seven different business units, four of them clearly indicate the use of data in their strategy. This can be seen in the inclusion of KPIs in some of their strategies, which indicates that data is used to assess and improve situations. Next to this, one of the strategies includes a project portfolio, which indicates data inclusion as it is necessary to gather and analyze data to maintain a portfolio. Lastly, one business unit showed the inclusion of data in their strategy by indicating that data should be transformed to get meaningful information and be used to make products better. Other strategic stories don't state the use of data explicitly. However, for most of them, some elements of their strategy implicitly are related to data. For example, two business units have data incorporated in the products and services that they offer to clients. If data has such an important role in their products, it is also of importance for the improvement of these products. Other business units have strategic goals that are in line with data usage, such as the leveraging of existing partners or expanding the number of clients in their client database. These goals need proper data integration to monitor progress and deliver results.

Lastly, the excellence workstreams are reviewed, showing differences in terms of data inclusion. Out of the six workstreams, three clearly indicate the incorporation of data for their improvement. These workstreams stress the importance of data quality, interoperability, and consistency to help make informed decisions. On top of that, data is seen as something that can be used to monitor processes, for example, with KPIs that make current performance insightful, but also as something that should be used proactively to enhance the workstreams and to create maximum value. One other workstream does not explicitly mention data inclusion but mentions data as a tool to monitor different markets. Thus, data is used to some extent in this excellence workstream. The last two workstreams do not mention the use of data for their improvement.

Thus, differences can be seen between the strategies within the company. The overall strategy does not really focus on explicit data inclusion, whereas the strategies for the individual business units and the excellence workstreams do have a clearer focus on data in some cases. The organizational strategy is thus ambiguous concerning data usage for processes and decisions.

4.5.2 Culture

We assessed documents that capture the culture of the organization. Although it is hard to capture the entire company culture in a document, it is still important to consider these types of formalized documentation, because they do represent an important part of the vision of the organization of what the culture should be, and what values should be central. We analyze the culture of the organization by systematically checking how it complies with the DDO cultural traits identified in Section 2.2.

- *Open, with broad data access for all of the different employees*

Broad data access is not mentioned in the culture documents of the organization. Having an open culture is something that is mentioned, but this refers to the personal barriers between employees, and not data flows.

- *Questioning should be inquisitive, where everyone can ask questions about additional information and is able to challenge assumptions. Analyses should be rated on accuracy, not on who did the analysis.*

Inquisitive questioning is something that is mentioned in the culture of the organization. It is made clear that hierarchical positions should not matter in discussions, but that the quality of arguments should. This is completely in line with the optimal DDO strategy. The open culture of the organization is also in line with this point, as this implies that everyone can challenge opinions and ask questions.

- *Learning, where results are reviewed, evaluated, and understood, to be used for improvement*

The organization shows in its cultural statements that learning is important, but the review process is not mentioned. This is thus not a perfect fit, as in a DDO the review and evaluation process is an important step in the learning process.

- *Embracing data driven approaches, with responsibility and accountability for data. This thus means that decisions should be made based on data, and not on intuition.*

The organization does mention accountability in its culture statement, which confirms that employees are responsible for their own actions. This is thus not a perfect fit due to the lack of focus on data, but the statement of the organization can be brought in line with the one of an optimal DDO by adding that the organization should embrace data driven approaches.

- *Enabling experimentation and innovation, where employees participate in transformation, and they can do their own analyses. Enabling should also be achieved by providing the necessary tools and data to the employees.*

This point is completely in line with the culture of the organization, as it explicitly states that cooperation is important to them and that different employees from different parts of the organization should be included in experimentation. On top of this, they mention that the culture should be open to new ideas, and thus that experimenting with new ideas is encouraged.

- *Trusting in the quality of data and the results that follow from it.*

Trust is mentioned in the cultural statements of the organization, but this refers to trusting employees, and not trusting data. However, an interpretation of this statement can be that the trusting of employees inherently means that the results from analysis must be trusted, as employees should trust that their coworkers perform analysis correctly. Thus, the statement is not explicitly in line with the one of an optimal DDO, but it can be inferred from it.

- *Understanding, with a focus on broadening the data literacy of the complete organization. This thus includes all employees and managers.*

While the organization does focus on learning, there is no real cultural statement that emphasizes data literacy. This means that the current culture of the organization is not in line with this statement. To get a culture that is more in line with the one of a DDO, the increasing data literacy of the organization should be made more explicit.

Overall, it is clear the strategy and the culture are not completely in line with the strategy and culture of a DDO. For strategy, it is evident that the overall strategy can be formed to be more in line with the one of a DDO. However, this is not explicit yet, and this can only be inferred from it. For culture, the comparison shows that there are several elements that are covered by the current culture of the organization. However, some of the elements of an optimal DDO culture are not implemented yet. Although this is the case, most elements can be steered towards the current culture of the organization, which means that the culture is expected to be quite ready to incorporate more data-inclusive statements.

Chapter 5

Case study: Gap analysis

In this chapter, the gaps we identified based on the assessment are discussed. Each of the assessment activities is summarized individually. The results of the interviews, maturity analysis, and the formalized documents have been compared to the literature to find the gaps between the assessment activities and the literature. Using this, the assessment has been able to identify different areas of improvement. These gaps are summarized into four main areas of improvement, which show where improvement is needed the most. After a focus is put on two gaps, additional assessments were done for roles and processes, to obtain additional information for the recommendations.

5.1 Interviews

Interviews with different employees working in the P2P process showed the initial need and problem areas for more data incorporation in the P2P process. An overview of the problems identified can be found in Table 5.1. This showed the gaps in terms of data demand that is not yet fulfilled, and why there is a demand for better data incorporation in the organization. Also, an analysis of the different sub-processes in the P2P process showed that there were some steps where data use is not fully implemented yet. This also demonstrates a gap in the as-is situation of the organization.

Problem	Description	Explanation
Data availability	Interviewees do not have proper access to relevant data or finding data that answers questions is hard to find.	This is due to on premise storage of data, data silos, and external data not provided by suppliers.
Data quality	The data in the sources is not as accurate and reliable as possible.	This is due to suboptimal inter-system communication, manual reporting mistakes, and data not being up to date.
Data validity	Data is not checked for errors and consistency. This leads to conclusions that are not correct when this data is used for analysis.	This is as unverified data can be used for analysis, received external data is incorrect, and no real control system implemented.
Data value awareness	Employees do not see the added value of data, they and do not use data and its conclusions consistently.	This is due to wrong interpretations leading to wrong conclusions, and the importance of correct data not being clear to employees.
Forecasting	Forecasting software is not able to make good, reliable forecasts. Also, reviewing the initial forecast is not possible, and thus improvement of the forecast is difficult.	This is due to the low quality of data and disruptions in the supply chain. In addition, links between sales and purchasing are not always in place for proper forecasting.
Architecture systems	The architecture of the different systems within the organization is scattered, leading to problems with data. Links between systems are not always in place.	There is a scattered architecture due to legacy, with uncoordinated implementation of different systems over time.
Data literacy	Employees do not have the knowledge to work with data and interpret its conclusions. This knowledge gap is possible at multiple levels.	There is a lower literacy because skills needed for different roles have changed, while the people in these roles have stayed the same.
Standardization of processes	A lack of standardization in processes leads to inefficient analyses, as they must be done manually.	Manual analyses are time-consuming and inefficient. Standard processes are not developed yet due to a lack of time.

Table 5.1: Summary of the problems identified in section 4.3.3

5.2 Maturity analysis

By going through the maturity model with different employees, the processes of a DDO were compared with the current processes in the organization. This showed multiple different topics that could be of interest, which are summarized in Table 5.2. The different problems in the current situation are clarified using this.

Problem	Description	Explanation
Produce project plan	The structured steps of different processes are not formalized in any document. This limits the evaluation of processes, and leads to limited insights.	Projects that are being done currently are small and project plans would significantly increase the workload when used in small projects. As developing such a plan is a timely process, this is currently not done yet.
Model building	Algorithms, AI, or Deep Learning are not used yet for analysis. This limits the predictive power of data.	The organization is not ready to use these techniques efficiently due to limited data quality, availability, validity and skills.
Evaluation and Review	Processes are not reviewed and evaluated after they are completed. This limits the improvement of processes as it is not clear where something goes wrong.	It is not completely clear why this is not implemented, but an explanation can be that such a system has not been thought of.
Data governance	Different data governance elements are not implemented yet. This limits the control that the organization has over data and its value.	The organization has grown quickly over time, which has resulted in too little time spent on these tasks.
Data classification	Data is not classified based on the confidentiality of its information. This limits the knowledge of what data is the most valuable, and what should be protected the most.	TThere was no real incentive to develop this yet. As this must be developed in cooperation with management, the incentive needs to come from management in order to finalize such a classification scheme.
Reference and Master data management	There are no real reference and master data tables to refer to. This limits the ability to have coherent information in the organization.	The importance of such tables has increased quickly, which means that the organization did not have enough time yet to implement it.

People management	There is too little material in place to help employees work with data. The structures that are in place are insufficient, and training for BI tools should be implemented. This limits the use of data in the organization, due to limited knowledge.	Due to time limitations of the current BI team, this has not been implemented yet. Also, as this task is added to their role, the current employees may be less suited for this communicative task.
Organizational governance	The organization is not fully committed to the DDO. This can be seen in culture, leadership, and communication strategies. This limits the speed of the shift to a DDO.	The structure of the organization focuses on individual responsibility, which limits the control that management wants to have over employees.
Project management	Running projects are not managed using data, like KPIs or other mechanisms that manage project performance, value, or importance. This limits the value of projects.	Building such a system is time consuming, and KPIs are not defined yet in the business. Without the knowledge of what to monitor, monitoring itself becomes difficult.

Table 5.2: Summary of the problems identified in section 4.4.1

5.3 Formalized documentation

Lastly, formalized documentation of the organization was reviewed, to see whether these were in line with the strategy and culture of a DDO. Using this review, the different strategies of departments, workstreams, and overall organization came to light. This showed that there are some parts of the organization where data incorporation could have a more prominent role in the strategy.

For culture, the documentation was not completely in line with the culture of a DDO. Some key elements of a DDO culture are currently missing in the culture as defined by the organization, as can be seen in Table 5.3.

For strategy, it could be seen that there were differences between the overall strategy, the strategies of the individual business units, and the excellence workstreams. These differed in the way they currently include data in their strategy, and how they aim to include it in the future. This was an interesting insight, as there is apparently no real consensus within the organization on how to include data more in decision-making.

Cultural statement	Explanation
Open, broad data access	It is not mentioned in the available documentation that employees should have broad access to data.
Review and evaluation for learning	To learn from the past, results should be reviewed and evaluated to find issues. This is not mentioned in the cultural documents of the organization.
Trust in data	Data and its results should be trusted to ensure proper use of the results in decisions. This is not explicitly mentioned in the current cultural documents.
Data literacy	There is no real statement in the current cultural documents that focuses on the increasing of data literacy. This should be made more explicit to increase the value people see in data usage.

Table 5.3: Summary of the problems identified in section 4.5.2

5.4 Results

We used the different results that came from the assessment methods, and combined the information to identify four main areas in which the organization can improve: culture, data governance, reference and master data, and tasks standardization.

Culture

The culture of the organization is currently not focused enough on using data in decisions. Concerning culture, there are a few points on which the organization should focus. First, the current strategy of the organization does not have a proper focus on data. Second, the attitude, awareness and literacy of employees concerning data should be improved to prepare the organization to become more data-driven. Lastly, the culture also concerns communication within the organization, which is about the available tools, the value of data to an employee in general, and the possibilities for employee training. Communication should be central for effectively showing employees the possibilities and value of data usage in order to become more data-driven as an organization. The challenge here, however, is how to implement these elements without changing the core elements of the organization.

Data governance

The assessment showed that there is room for improvement when comparing current data governance tasks with best practices. Data governance should be imple-

mented companywide using data policies and strategies, to effectively govern data. These practices have a major role in the success of a shift to a DDO. Efforts could focus on governance structures, for example, a council, and what members of the organization should then be a part of this council. Next to this, the organization could investigate which of the data governance practices can have the highest impact and implement those first.

Reference and Master data
Reference and Master data are not fully implemented in the organization due to legacy, as different systems are currently used in a fragmented environment. This leads to difficulties when connecting existing systems or introducing new systems, due to the data silos of individual business units. Reference and Master data can help ensure consistency in decision-making, but in order to efficiently implement it, an implementation plan should be defined to prescribe how to include master records within the organization. The implementation risks should be considered, as this can have a big impact on the business practices of the organization.

Standardization of tasks
While other improvement areas have a wider focus, this area focuses on the P2P process only due to only these processes being put up for review. Currently, tasks in the P2P process are often done on an ad hoc basis, implying that there are no defined process instructions on how to tackle steps in its phases. This could also be a topic of interest, as better documentation would give certain benefits that ad hoc processes do not have, such as being put up for review, to see whether processes are optimal. Next to this, evaluation of the results is easier to do if processes are better documented, what was done and where things went wrong can be better understood. However, documentation is often not produced because people find it a boring task. Therefore, documenting processes should be facilitated in such a way that it becomes more attractive for people.

5.5 Limiting scope

Using the four main areas of improvement identified above, we discussed with the organization the focus areas of this research, taking the potential value, possibilities within the limited time, and interests of both the researcher and the organization into account. We chose to combine culture and data governance to focus upon because the organization is currently already working on a process to implement data governance in the organization, both on the level of the P2P process and other processes. However, the importance of data governance is only becoming clear to the people

involved in the data governance implementation team, whereas a DDO is focused on having this awareness companywide. The culture of the organization could be leveraged, to increase effectiveness. By immediately combining this cultural shift with data governance, and thus with the definition of new roles and responsibilities, a lot of potential value can be unlocked in the limited time scope of this research.

As each of the P2P phases have certain key decisions, we investigated which of the phases of the P2P process were the least developed in terms of data usage (Section 4.2). The interviews with the P2P process employees showed the demands in terms of data usage, while the maturity analysis showed the possible data that could be supplied to employees for analysis.

Culture influences the behavior of an organization, thus changing strategy to focus on data usage can help the organization make a big leap forward in terms of data inclusion in its processes. Culture includes the overall strategy or vision of the organization, and the central values which are pursued within all layers of the organization. Next, culture entails how problems are tackled and solutions are built. This includes structures for problem solving, standardization in processes, and knowledge transfer within the organization.

5.6 Extra assessments

The focus areas, culture and data governance, showed that there were two additional assessments needed, namely a role assessment and a process assessment. These showed whether tasks and responsibilities were filled in correctly and whether DDO processes were implemented. Here, literature sources are used to compare the current situation of the organization with the desired situation.

5.6.1 Roles

Three different categories were identified in the role analysis. First, the roles of data analyst and data engineer were sufficiently implemented for the time being. The tasks of these two roles are currently performed to a sufficient standard. For the role of data analyst, it was mentioned that both the IT department and the individual business units have analysts in place with clear responsibilities and tasks. For the data engineer, the IT department has an employee whose main task is preparing data for analysts. These two roles are thus implemented sufficiently for now, but this may not be future proof. In a future situation, where data is used more within the organization, it might be necessary to have more employees in these roles.

Second, the roles process automation manager, data visualization specialists, financial analysts, data owners, data specialists, and CAO are only partially imple-

mented. These roles are currently implemented up to some standard, but not all their tasks are performed structurally. For the Process automation manager, it was mentioned during interviews that there is currently no specific person responsible for the tasks of this role. Some of the tasks are performed by certain employees, but structure and overview are lacking here. Data visualization specialists have already an important role in the organization, with employees being responsible for these tasks within the IT department and within the individual business units. However, the current data team is not able to meet the increased demand for visualizations. Extra training could be useful to improve the data literacy of some employees, to relieve some of the pressure on the current data visualization specialists. Financial analysts tasks are also already partly implemented, but during interviews it was mentioned that these employees are not focusing on the appropriate KPIs to implement a data-driven strategy due to a lack of KPIs, leaving room for improvement. Next, the interviews showed that there is still a lack of data owners in the organization. Some of the tasks of this role are currently being performed with one employee responsible for overseeing the data strategies and promoting data use. Nonetheless, to execute and monitor these strategies there are still more data owners needed, who are responsible for their data sets. Without these, executing data strategies is difficult as no one bears the responsibility to make sure these are carried out correctly. Next, it became clear that the role of data scientist is also not correctly supported. While some business units have employees responsible for this, this is not enough to fully leverage the skills of these employees. Lastly, the role of CAO was partially supported. The current IT manager in combination with the product owner take on some of the tasks that belong to the CAO. Nonetheless, considering the full list of tasks and responsibilities, it is not clear to whom some of the tasks belong.

Finally, the roles of Master data manager and Data stewards are not supported at all. However, the interviewees expressed the importance of these roles for the next stage of becoming a DDO. The master data manager is currently not supported due to the lack of master data. A project is currently running to further investigate how this could be implemented in the organization, showing they understand the need for this role. Implementing data stewards is also a part of this project, but there is currently poor support in place to perform data governance.

5.6.2 Processes

The process assessment was based on the four processes indicated by Patil [14], namely daily dashboards, metrics meetings, standup meetings, and democratization of data. More information about these processes can be found in Section 2.5. We checked whether and how these processes were implemented in the organization.

Role	Description	Implemented sufficiently?
Data analyst	Uses standard and/or specialized tools to improve business performance	Sufficient
Data Scientist	Connects data to business requirements. Also, able to use predictive modeling software	Partially
Master Data manager	Aligns and manages databases, to ensure the availability and quality of data	Insufficient
Process Automation manager	Implements and operates Robotic Process Automation tasks	Partially
Data visualization specialists	Creates infographics and/or data dashboards	Partially
Data engineers	Obtains, cleans and munges data and prepare it for analysis	Sufficient
Financial analysts	Manages KPIs by focusing on internal financial statements and forecasts	Partially
Data Steward	Executes the data governance strategy by applying principles, monitoring systems and keeping track of processes	Insufficient
CDO/Data Owner	Creates and executes data ana analytics strategies. Also, oversees data standards, supports data projects, and identifies new business opportunities	Partially
CAO	Promotes the data-driven culture of the organization and enhances data-driven practices. Makes the organization see the value of data on c-level	Partially

Table 5.4: Overview of the roles used in the role assessment

We found similarities in the implementation of the processes. Daily dashboards, metrics meetings, and standup meetings were implemented to some extent in certain parts of the organization. Daily dashboards are dashboards filled with KPIs that are consulted every day. This helps to monitor progress and take appropriate action on time. It was mentioned during interviews that dashboards are used in some of the business units more actively than in others. However, a substantial part of the organization did not use dashboards to its full potential. This was due to a lack of defined KPIs, and low data literacy of employees.

Metrics meetings are meetings where employees can ask questions about data sets, metrics used, and results, increasing data literacy. There were differences in

its implementation between the business units, as some used the meetings effectively, but in other business units there was less data value awareness and lower data literacy which resulted in a lower use of metrics. Metrics meetings were not implemented due to the lack of urgency to implement these, and a lack of knowledge of employees why these were needed.

Standup meetings are meetings where employees are physically standing up and discuss their progress and goals for the day. This can make meetings more effective by decreasing the time they take. These were also partly implemented, as some business units would use the standup meetings already or were in the phase of implementing them, while others were not aware of them. This was due to some business units not being familiar with this style of meeting.

Democratization of data is making data widely available to all employees in the organization. This allows maximum value derivation of data. The organization has tried to make the data as widely available to employees as possible, but certain limitations apply to this process, such as privacy-sensitive information that cannot be shared due to legislation. The organization had to deal with this tradeoff between free access and legislation, by providing access to data upon request and allowing employees to manipulate the data with tools to derive insights from it. These requests ensure that data is shared in accordance with regulations. When employees are unfamiliar with the tools to manipulate the data, the organization is also offering employees pre-built dashboards for analysis. This increases access to data and insights as much as possible.

Chapter 6

Case study: Recommendations

In the case study, we used different techniques to assess the organization based on the use of data for decisions within the P2P process. The assessment has shown several areas that could be improved on to become data-driven. Based on these areas, six recommendations have been made for the organization based on the unique situation of the organization. These recommendations are elaborated in this chapter, showing in more detail what they entail, why they are important, and how the recommendations solve the identified problems. Finally, an implementation plan is presented. The organization should use these recommendations to improve its way of doing business.

6.1 Adopt strategies to include data usage

The analysis of the formalized documentation, as discussed in Section 5.3, showed that there is a big difference between the individual strategies of the business units when we look at data inclusion. As the organization focused on individuality, it can be argued that the individual strategies of the business units are also of high importance to the work that is done, as business units have a weak connection with the overall strategy of the organization. For each of the workstreams, it should be reconsidered whether data is currently included in their strategy, and whether this is up to date with their current way of working. Then, it should be examined whether there are some strategic points where (more) data should be included. Based on this, a data-inclusive strategy can be built for each of the business units, helping them incorporate data better in decisions and giving a reason for their employees to consistently implement this.

6.2 Implement data trainings to increase data literacy

In all three of the assessment techniques (Chapter 5) it became clear that the organization's data literacy is insufficient. During the interviews, it was mentioned that not all employees have the skills to fulfill their changing roles concerning the incorporation of data in their decision-making. The assessment of the formalized documents also showed no statements concerning the improvement of the data literacy of the employees. Furthermore, the maturity analysis showed that there are no real systems in place to help employees work with data. Therefore, this recommendation focuses on the implementation of training modules, which can be used by employees to increase their data literacy. These training modules should improve their knowledge about the data itself, the tools that can be used for analysis, and how to interpret results. An example of this can be training modules that explain better the forecasting software, to assist employees in working with this software. When data literacy becomes higher throughout the organization, the barriers to using the tools and techniques that are available become lower [72]. With this knowledge, it could also be easier for the employees to understand the value hidden in the data, and how they can use this in their work. Thus, the implementation of training for the organization helps increase the use of data and its tools for different processes within the organization.

6.3 Focus on processes lacking behind

As the organization is quite large, it is necessary to focus on the areas within the P2P processes that need improvement the most. In order to increase the data maturity of the entire organization, it is most useful to start at the processes that have the lowest maturity. Therefore, we analyzed the individual processes of the P2P process to indicate where data usage is the lowest. This analysis, detailed in Section 4.2, showed that four processes have the lowest data maturity, namely contracting, sourcing, inventory management, and service/support. In these processes, data is not efficiently included yet to drive decisions. Therefore, the organization should focus on improving these processes first. This improvement should focus on the multiple factors that are also explained in the rest of Chapter 5, such as training, culture, strategy, and the assessment of roles and tasks.

6.4 Create a data-driven culture

During all assessments, we found that the current culture of the organization is not in line with the cultural aspects identified in Section 2.2. First, the interviews (Section

4.3 and 5.1) showed that the employees did not always have proper data value awareness, failing to see the value of data. The results of the maturity analysis in Section 5.2 showed that the organization is not fully committed to becoming a DDO, especially in terms of culture, leadership, and communication. Lastly, the analysis of the formalized documents also showed that some aspects of the DDO culture are not met, which could be seen in Section 5.3. Thus, a change in culture is needed in order to transform to a DDO, which entails several elements, namely:

- Make the focus on data usage for decisions more explicit. This can be done by including the importance of data inclusion in the formalized documents.
- Make sure management supports data inclusion and let them do this publicly and explicitly.
- Processes currently done within the organization should be restructured to make better use of data.

These different actions help increase the awareness of the value of data in the organization. The support of management is a key element, as they can set an example for the rest of the organization. Making data usage explicit in the culture incentivizes current and new employees to follow this. This is because when they need to explain why they use data, they can always refer to cultural documents stating that incorporation of data is important. Thus, these cultural changes help the organization focus more on data inclusion by making it an explicit part of their culture, with the support of the management. This helps increase the awareness of data value within the rest of the organization. Informal communication can also be used as a tool to improve the attitude of employees toward data, implemented such that employees of different business units can discuss problems they encountered with each other, enabling them to learn from each other. This can be implemented by inviting employees to informal gatherings, for example over dinner, to discuss this.

6.5 Assign employees to not implemented roles

The role assessment discussed in Section 5.6.1 showed that some roles needed to be filled in better within the organization, to better divide tasks, roles and responsibilities. First, the organization should research how to fill the roles of Master Data Manager and Data Steward, as these are the least implemented. This can be accomplished by retraining current employees in the first stages, and by hiring new staff when the demand for insights from data increases. Next, the organization

should focus on improving the roles that are partially implemented, namely the Process Automation Manager, Data Visualization Specialists, Financial analysts, Data Owners, and the Chief Analytics Officer. As these roles are already implemented to some extent, the organization should examine how to improve its current structure, and how to divide better the responsibilities and tasks that are inherent to these roles. These roles should be the main focus of the organization in the first stage, but in later stages, the organization may need to reconsider the currently sufficiently implemented roles, which are the Data analyst and Data engineers.

6.6 Standardize ad-hoc processes

Next, the process assessment showed that certain processes were not standardized. This was one of the main points from the interviews discussed in Section 5.1, where it became clear that most processes were still done manually. Standardization means that it is clear what processes entail, their inherent steps, and the results to be expected from it. This was lacking in the current situation. The maturity analysis in Section 5.2 showed that there are no real plans for projects and that due to this the review and evaluation of projects is lacking, which limits their improvement. The recommendation, therefore, is focused on making processes explicit within the organization, allowing for improvement through evaluation. In addition, knowledge transfer is facilitated if processes are documented. This documentation should be reviewed regularly, especially after big system updates.

6.7 Risks

While the potential benefits of implementing these suggestions are clear, there are also some risks that the organization should consider during implementation. As data and automation are often seen as job replacers, the impact this transition has on jobs should be made very clear to employees. Employees should be involved closely during the training modules, making clear what the potential benefits are specifically to them. This can clarify their opportunities due to this change. Immediately changing to a data-driven culture is difficult, so the focus should first be on teaching employees to work with data, instead of making data instantly leading. The traditional intuition-based decision-making approach should first be assisted with data, slowly working to a situation where data becomes a more determining factor. Experience–based decision-making should not be eradicated, but it should evolve in small increments into a new way of working, keeping these elements of the original culture in place. Using a structure such as defined in research [73], results should be able to be measurable within a year [74]. Then, the difficulty arises whether the

new implementations change the core values of the organization. For the organization of the case study, it should be assessed how the recommendations affect entrepreneurship, as data inclusion can result in more business opportunities through more transparency, but also into more bureaucracy and control. These two conflicting possibilities should thus be closely monitored to ensure a healthy balance, which can be achieved by having monthly conversations with the parties involved. Here, concerns and problems can be discussed, giving room for improvement.

6.8 Implementation Plan

The recommendations we found revolved around many different topics that should be improved. However, to implement them, it is necessary to define in what order they should be implemented. Therefore, this section discusses what to focus on first, in order to solve the problems in an effective manner. Out of the six recommendations, the first recommendations to act on should be strategy and training, taking the focus areas into account. This will influence the culture, roles and process standardization, leading to several benefits. The overview of this implementation plan can be found in Figure 6.1.

Strategy

The strategy recommendation was based on online strategy documents, which should not be very difficult to update, making data usage more explicit. Documentation can be reviewed and changed accordingly, giving extra emphasis to data usage for existing and new employees. Next to strategy, training courses should be developed and offered to different employees. These training courses should put an emphasis on increasing the awareness of the potential value of data and increasing the skill level of employees to work with data tools. The training courses should mainly focus on the areas in the P2P process that need data skills the most. These are the areas where the data maturity is the lowest, and data is thus used the least, namely contracting, sourcing, inventory management, and service and/or support.

Training courses

Next to the previously stated benefits, training courses can also have a positive impact on the recommendations for culture, roles and processes. Culture can be changed by the awareness aspect of the training, which helps ensure that there is an increased focus on data inclusion and usage by helping employees understand why such a focus is beneficiary. This can also help increase the awareness of the management, leading to them to become better examples for data inclusion behavior.

Roles can be impacted by training too, because when the skills of employees are improved, there is a higher chance that they do not need as much help from the current data team. This makes the data team more future proof, as they need to spend less time on fixing more trivial problems, giving them more time to perform more difficult tasks, increasing their skills. This also makes their roles more future proof and even allows them to spend more time growing into the roles that are currently not filled. Lastly, the training courses can have an impact on the standardization of processes, namely when training courses are built to improve the skills of employees, certain processes must be explained in more detail to be able to present them in the training. These explanations can serve as the standardized version of a process, and thus solve the current issues with standardization and documentation.

Roadmap

To increase knowledge and skills of the whole organization, roadmaps can be built using the step-by-step guide of Kayabay [75]. The increased knowledge and skills help the organization include more employees in the decision-making process, as well as helping different stakeholders in discussions about possible solutions to problems, or possible metrics to measure. This model can be used to increase the consensus among the different stakeholders, which leads to more confident decisions. This also allows for a strategic way to plan many different data science initiatives on a company-wide scale.

Benefits

We can forecast the benefits for the organization after these recommendations are implemented. Firstly, we expect that the c-suite of the organization will have more measurable progress and will be able to assess problems in the organization more quickly. This is possible because more data usage and inclusion in decisions should make it easier to monitor multiple projects. These recommendations also help increase their grip on data, and thus their Data Governance. Data governance consists of multiple processes that require different types of skills and thereby awareness of their importance. These are processes such as data strategy, data policies, standards, and management of projects (see Appendix B). As these processes require skills and awareness, the updated strategy and implemented training should assist in increasing data governance. Implementing other recommendations can serve as a steppingstone to improving data governance, especially as its importance can be made clearer to the rest of the organization. The value of implementing data governance practices should become easier to explain when the employees who have to deal with the changes understand their concerns, and their impact on the organization.

For the product owner, it should become easier to promote the use of data in the organization. Increased awareness should help explain why data is important, and with the use of more explicit data strategies, it should become apparent why this is necessary for the whole organization.

Lastly, there are also benefits for the employees overall. The employees in the P2P process should have fewer difficulties using data in their daily work, as they need less help from the BI/Data team to fix simple problems. Their projects are then finished quicker, as they do not have to wait until the BI/Data team has time to handle their problems. In addition, due to the increased use of data, it should be easier for them to monitor their own performance. The BI/Data team should get more time to focus on solving difficult problems, and less on easy fixes due to the lowered workload of these issues. This gives them the opportunity to excel and continuously improve in their work.

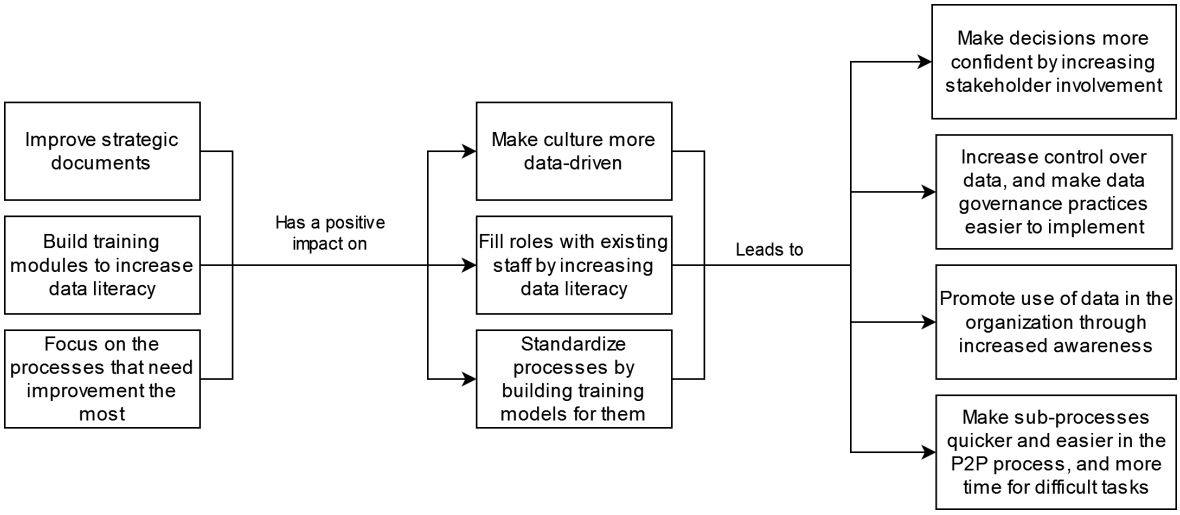

Figure 6.1: Schematic overview of the implementation plan

6.9 Summary

This chapter presented and discussed the recommendations that resulted from the assessment. The recommendations revolved around the changes in culture, strategy, training, focus, culture, roles, and processes. The recommendations are elaborated on individually, but their connections also become clear in the implementation plan. This shows that the recommendations do not stand on themselves, but solving one of them also has an impact on other recommendations. Once the organization implements these recommendations, its data maturity increases. We thus recommend that the organization starts to make plans to implement these recommendations as soon as possible.

Chapter 7

Validation

This chapter focuses on the last step in the DSRM [1], which is the validation of the developed framework. This framework consists of three parts, namely the assessment methods that were applied in the case study, the indicated gaps that came from this assessment, and the final recommendations. This chapter starts by presenting the profile of who participated in the validation. Then, the chapter elaborates on the results that came from the interviews concerning assessment, gaps and recommendations. These results have been used to improve the framework and the recommendations and as input for the discussion.

7.1 Interviews

In line with the methodology proposed by Wieringa [1], we interviewed three experts from within the organization who were not involved in the previous research. These experts came from different parts of the organization, with expert knowledge in the data field, the procurement field, and the controller role. The project was assessed from different angles resulting in a complete evaluation. The experts are described shortly in Table 7.1 to show their relevance to the research. We gave a presentation to them which entailed details about the assessment steps, the gaps found, and the recommendations. The experts were first asked to give their own interpretation of these three parts. After they gave their own interpretation, the results of our research were shown.

After this, the experts provided feedback, allowing us to compare the methods, gaps, and recommendations of this research with their opinions, without influencing their judgment beforehand. The validation process gave insights into their own way of tackling problems, and their feelings towards the steps taken during our research.

Expert 1	Specialized in data and thus relevant to the data questions this research tries to answer.
Expert 2	Worked in several departments and has had a lot of experience concerning the procurement process and its problems.
Expert 3	Worked as a controller within the P2P process, and thus knows a lot about the people, processes, data, and problems within the P2P process.

Table 7.1: Profile of the experts who participated in the validation

7.2 Assessment methods

In the first section, we asked the experts to mention their assessment methods for finding problems in the P2P process. All of them indicated similar methods that they would have used. Most often interview sessions were listed as an important method to gather information about the current state of the P2P process. It was also mentioned to look at the processes themselves, and the data that was currently available.

Then we confronted them with the methods used in our research, and all experts expressed that they agreed with the methods that we proposed. However, one expert suggested that there should be an increased focus on a hands-on approach as an extra assessment technique. This technique consisted of spending a day with a certain employee, and watching the different tasks this employee does. By looking at this behavior, it is easier to see the intricate reasons for certain actions and show less obvious problems. This hands-on approach helps thus identify the current problems in an organization. Our recommendations have been adapted to include these suggestions.

7.3 Gaps found

The experts gave several answers when asked about the current gaps in the organization. Problems due to legacy were mentioned by all experts, namely the fragmented system landscape of the organization, which existed due to the many different systems implemented over the years. This included different types of systems, such as customer support, sales, and inventory management. The lack of system interconnectivity made it impossible to exchange data freely within the organization. According to their opinion, this held the organization back in transitioning to more data usage. This has also compromised companywide uniformity in processes according to one expert, which results in problems when streamlining processes.

The three experts also mentioned problems due to the individual differences between business units. Due to the freedom individual business units have had in the past, they worked in silos for a long period of time. This individuality was in place as this improved efficiency in the past and allowed the individual business units to excel without being held back by other parts of the organization or by bureaucracy. However, this way of working was currently seen by all experts as inefficient, and they mentioned that the organization should strive to break these silos to create common goals, KPIs, and processes. Without these improvements, it is difficult for the organization as a whole to grow.

Two of the experts also addressed the lack of master data in the organization. They mentioned that this made it more difficult to implement data in processes, as there was no single source of truth. Next to this, one expert also mentioned that human error is still an important factor for current problems with data, for example, when new products arrived in a warehouse and registration was done manually.

When asked about why these gaps currently exist, the experts mentioned reasons, mostly related to culture, awareness, the individuality of business units, lack of documentation, and the lack of uniformity of data. These gaps are in line with the gaps found in Chapter 5. However, some nuances were put in the gaps indicated by the experts that were lacking in the initial results, namely a focus on the KPIs, the systems, and expert knowledge.

In these three gaps, the experts focused more on certain aspects than we did in our research. KPIs were not explicitly mentioned in our research as we focused on culture, but one expert mentioned that it would be beneficial to include KPIs in daily business. This was a useful suggestion and can help make our recommendations more actionable. For systems, one expert mentioned that the different individual systems should be better interconnected. Our research confirms this as master data was indicated as a problem during our research, which is necessary to streamline systems. However, as the organization was already working to implement this, we chose to focus on other topics.

Lastly, one interviewee mentioned expert knowledge as something that should be improved on a companywide level, meaning that the number of experts should be increased, and the ability to find the correct experts for questions should be improved. We feel that this should also be included in the culture of the organization, for example, through informal communication as this can help solve complex problems more effectively. This is why our recommendations suggested to create additional informal communication possibilities.

After our results were shown to the experts, no one had any additional comments. They indicated that the gaps found were largely in line with their views, taking the nuances and focus areas mentioned above into account.

Gaps from experts	Reasons for gaps
- Fragmented systems landscape	
- Systems not interconnected	- Culture
- Lack of common goals/KPIs	- Awareness
- Lack of master data	- Individuality of business units
- Possibility of human error	- Lack of single source of truth
- Lack of expert knowledge	

Table 7.2: Gaps and reasons mentioned during validation

7.4 Recommendations

The experts had different ideas on what to implement for the improvement of the situation of the organization, but some general themes were abstracted from their suggestions. First, two experts focused on communication, suggesting that more communication possibilities should be implemented for employees to discuss their problems and to get to know more about the tools that the organization offers. Examples of these possibilities can be informal activities such as dinner or lunch. Second, two experts mentioned that responsibilities should become clearer as this would help with task division, and employees would know who to contact. Third, one expert addressed the low data awareness within the organization, mentioning that this should be improved to have an incentive for data inclusion. This could be done in several ways, such as with training modules or e-learning programs. Lastly, the expert working in the data field mentioned that master data should be implemented to improve data sharing within the organization.

The remarks of the experts are thus largely in line with the recommendations in Chapter 6. After our recommendations were shown, the experts mentioned that they agreed with them, while also mentioning that some of the recommendations are already planned. Some experts suggested some recommendations that we had not explicitly mentioned, which we added to our recommendations later on. One expert missed the explicit focus on actual data inclusion in the recommendations, which could be used to verify claims made during the interviews. Our recommendations do not focus on explicit data inclusion itself, but on training modules that combine awareness and data literacy (see Section 6.2). Another expert had an increased focus on informal communication, whereas our recommendations largely focus on structured communication through training modules. Informal communication could be achieved by coupling employees from different business units with each other and letting them discuss problems and possibilities during an informal activity. The last expert mentioned a missed focus on certain security and/or accessibility issues. While some security issues and their importance were noticed

during our assessment, we chose not to further investigate these issues as security was already largely implemented, and other areas could be improved with higher priority. For example, the organization already had technical and social structures in place to increase security, such as Windows Defender and an e-learning course for employees about social engineering. On top of this, some ethical hackers are active in some parts of the organization. However, security remains important to keep in mind when data becomes more important in the organization.

Expert recommendations	**Missed in research recommendations**	**Changes in recommendations**
More communication possibilities	Informal possibilities for communication	Section 6.4
Clearer division of responsibilities	Focus on security or accessibility issues	Addressed in Chapter 8
Increase data awareness	Focus on data inclusion	Section 6.1 and 6.4

Table 7.3: Summary of recommendations and changes to recommendations

Chapter 8

Conclusion and Discussion

In this research we designed a framework that can be used by organizations that want to work data-driven to gain insight into their current data use for decisions, and find recommendations based on these insights. This framework consists of multiple assessment techniques, in combination with a gap analysis and recommendation building. A case study has been performed to test the framework to find recommendations for a specific process in an organization. An evaluation assessed whether the framework was appropriate, and whether the results obtained with our framework were accurate enough. This chapter discusses the results of our research by addressing the research questions, showing key findings, the contribution to practice and to science, the application of the research in other contexts, limitation of this research, and future work.

8.1 Answers to the research questions

1. How is a data-driven organization defined in literature?

A Data-Driven Organization is defined as: *An organization that is successfully able to turn data into value, with the use of management alignment, organisational culture, infrastructure, skilled personnel, analytics solutions, effective data management & governance*. Chapter 2 describes how our literature review led to the paper of Hendrikse [15] who proposed this complete definition of the DDO based on several literature sources [14], [23]. Individual elements from this definition were further researched, such as culture, strategy, roles, processes, and skills. We found evidence that these elements all significantly impact the successful shift to a DDO. Lastly, we identified several benefits and challenges of the DDO, substantiating its potential value and pitfalls. Potential benefits are better decision-making, increased productivity, and increased growth opportunities. The challenges revolved around data quality and governance, experience of working with data by both the manage-

ment and the organization, and shifting to data-driven decision-making.

2. How can an organization's compliance with the Data-Driven Organization be assessed?

In Chapter 3, we proposed a framework consisting of several methods to assess an organization , namely interviews, an analysis of formalized documents, and a maturity analysis. These methods can be used to find problems with the current state of an organization regarding their data usage for decision-making. First, interviews can be used in a semi-structured fashion to find out more about the experiences of employees. Second, formalized documentation helps get an overall idea of the central values and goals of an organization, but can only be used when these documents are available within the organization. Last, a maturity analysis can be used as a more structured way to find out which DDO processes are done sufficiently, and which need more attention. These methods have been used in our research to analyze the Purchase-to-Pay (P2P) process of an organization, as discussed in Chapters 4 to 6.

3. How can a gap analysis based on the assessment be used to find the areas of improvement?

The gap analysis was introduced in Section 3.4, where it became clear that its main task is to analyze the current situation of an organization by comparing it to our model, and to find improvement areas by comparing information obtained from literature sources concerning best practices with the current state of the organization. During the case study in Section 5.4, this method was applied to find four gaps in the current way of working within the organization. The assessment methods included an analysis of culture, strategy, role division, and processes. The gaps that were found revolved around culture, data governance, reference and master data, and standardization of processes. These four areas are the main points of improvement according to the results of our assessment.

4. What steps need to be taken to prioritize the improvement areas found during the assessment process?

Prioritization consists of the following steps: (1) Compare the results from the assessment with the preference of an organization and the field of knowledge of the researcher to find some common ground; (2) look at what areas have the potential to be addressed within an earlier specified time frame; (3) taking these results into account, make a final decision on what to focus on. In this way, changing business requirements can be taken into account, and priorities can be shifted accordingly. In Section 3.5, the prioritization of the improvement areas found was first discussed, and Section 5.5 shows an example of this process as applied in the case study.

5. How does this assessment and the prioritization behave when used in a case study of an organization?

The assessment methods yielded useful results in a case study, namely a lot of interesting insights which helped identify several gaps. Gaps were prioritized and based on this our research continued with a focus on culture and data governance. Finally, six recommendations were given in combination with an implementation plan to improve the organization. The assessment and prioritization are reported in Chapters 4 to 6.

6. Do the results found during the case study remain valid after evaluation?

Based on expert opinion, it was possible to evaluate whether the assessment steps were complete, whether the indicated gaps were recognizable, and whether the recommendations were accurate. Three experts gave their interpretations and comments on the steps taken in our research. This validation showed that the experts agreed with the methods that were used, the gaps that we had found, and the recommendations that resulted from them. Next to this, the validation showed that the framework that we developed was deemed accurate, as the experts did not have any additional comments on it. Our validation results are reported in Chapter 7.

8.2 Key findings

1. Organizations are struggling to identify problems that obstruct them from shifting to data-driven decision-making.

The identification and prioritization of data-related problems and the limiting factors of existing culture are the main challenges to organizations shifting to data-driven decision-making. Literature sources have also identified universal challenges in the shift from traditional experience-based decision-making to data-driven decision-making (Section 2.8). The case study of this research showed this in a real-world situation, as information about current problems had to be gathered from several places, such as interviews, a maturity analysis, and an analysis of documents (Chapter 3).

2. A combination of assessment methods can be used to identify problems and suggest recommendations about the use of data in an organization.

The research combined different methods to assess an organization. By having different methods as input, some of which were semi-structured, and others were

structured, it was possible to generate input for the recommendations in the broadest sense. The combination of the case study and the validation has shown that this package of methods can be used to properly identify problems and suggest recommendations.

3. Purchase-to-Pay is an intricate process where data can play an important role in increasing efficiency and reducing errors, as well as increasing the ability to adapt.

The P2P process is an integral process for many organizations, consisting of different steps that handle the purchasing of goods and/or services (4.2). The use of data within this process can help increase efficiency and improve decision-making (2.7). Thereby, the case study showed that within the P2P process, differences concerning data usage can occur between phases, and that the most problems existed in the subprocesses where data use was lower. Human error resulted in problems and the speed of handling different requests also decreased. Using data to improve these processes was seen as a possible solution for some of these problems, as this would allow for automation and less human intervention. Literature sources are in line with the case study, as both literature and the study confirm the idea that the integration of data in decision-making improves the ability of an organization to adapt to new situations by allowing real-time monitoring of variables and allowing immediate action.

4. A data-driven organization is not only fueled by technology, but also by the attitude and knowledge of employees.

Despite technology being an important factor in the transformation to a DDO, our findings show that this is not the only determining factor for success. The case study showed that having certain technologies implemented does not immediately mean that data will be used efficiently. An important factor contributing to the DDO is that its employees should be able and willing to work with the data and tools that are provided to them. Without this, data and its results will be unused, and its potential benefits will diminish. This is why training modules were an important part of the recommendations, as they can increase the willingness and ability of employees to include data in their daily work and decisions. Technology is thus not the only determining factor in the transition to a DDO, but the culture of the organization also plays an important role in this transition.

8.3 Contributions

In this research a framework was built that can be used to assess the state of data inclusion in an organization. This research has made several contributions, which

are divided into contributions to practice and contributions to science.

8.3.1 To practice

First, we have developed a framework that uses different assessment techniques to identify problems concerning data usage for decisions in an organization. Second, we used our framework in a case study, where we were able to successfully draw recommendations and an implementation plan for making the P2P process more data-driven, deemed useful and accurate by the organization after validation. Practitioners can use this framework in an organization to find improvement areas and assist them in improving on these.

Using different methods, it became clear that there are certain problems in the P2P process of the organization we studied. These problems are mentioned by people who currently have difficulties working with data, but also by the employees that already work with data. This shows the urgency to tackle these problems, and thus implement the recommendations given in Chapter 6. The problems that employees experience limit them in their daily work. We recommend the organization to implement the stated recommendations, using the implementation plan in Section 6.8 as inspiration.

8.3.2 To science

In available literature we could not find a framework to assess the data-driven state of an organization while delivering concrete recommendations for improvements. Our research filled this gap, by building a framework and testing it in an organization. Previous literature [13], [28], [31], [32] often stays theoretical, by giving optimal cultures, roles, or processes without connecting these to change management. Our research bridged the gap between literature and the real-world by giving insights into how to adjust theoretical models to fit practice, and how to take the existing culture and people of an organization into account when designing solutions. We recommend that the academic world should connect more often with real world organizations. While there is no proven recipe to achieve this, several suggestions can be made. An option is that the suggestions made in research are applied more often to real world cases instead of hypothetical ones. For example, Berndtsson [28] elaborates on the factors that influence a data-driven culture but does not apply his advice to practice. Information about how organizations tackle challenges to become data-driven should be more centrally accessible to organizations to make it easier for them to find the appropriate solutions for their problems. This could be achieved with an information center for data-driven transformation that organizations can enquire about. Information sharing across businesses can be also increased to help

organizations learn from the mistakes of others.

First, we demonstrated the need for a framework consisting of clear steps to help organizations find problems concerning their data usage for decisions. Second, we have used a real-world case to test literature models and found that a combination of three models is able to assess an organization effectively. Third, our research has shown the necessity to put current company culture central to build effective recommendations, instead of current literature focusing only on the ideal culture in a DDO without taking the existing culture into account.

8.4 General applicability

Our framework was developed in such a way that it should be applicable in more situations than the one in which it was tested. By using generic methods, the framework can be adapted to different processes and to organizations of multiple kinds and sizes. The framework also allows for the inclusion of an industry-specific and up-to-date maturity model to tailor it to the situation. We aimed to form a basis for continuous improvements and help organizations learn from best practices. While the framework was successful in the case study, it needs to be tested in different situations before we can conclude that it is widely applicable. More testing will probably show problems with the framework, for example, for certain industries where there is not a fitting maturity model available, limiting the knowledge that can be derived from this step. These problems that may arise need to be solved before we can state that our framework is widely applicable, as the maturity analysis is a boundary condition of our framework to draw conclusions.

8.5 Limitations

Some limitations apply to this research. First, the framework that was developed in this research was only tested on one single value stream in one organization. It can be argued that it can also be used for other organizations or processes, but this has not been tested yet. Having only tested this on one process in one organization limits the future application of our framework, as the assessment steps may not work as well in another organization that does not match the case study organization [76].

Second, the information has been gathered to build the recommendations and the validations by using interviews. While we looked for interviewees from different parts of the organization, the number of interviewees was limited for some of the topics. This could have led to a bias in the results for the problem identification. For the validation, three experts were interviewed, which could have led to bias in the answers in the validation [77]. A larger research population may have led to different

results. This also introduces the possibility of researcher bias as a limitation. The interviews were performed by one interviewer in a semi-structured setting, allowing a focus on a certain narrative [78]. While it was tried to prevent this by using clearly defined methods, bias could still have played a role in this research.

Third, the methods that are used in the framework have been selected in a certain time frame, such as the maturity model of the case study. It is possible that these methods have become outdated due to the rapidly growing body of literature about Data-Driven Organizations. In case this research is replicated at another organization later, the methods may have to be updated to improve the results [79].

Lastly, a limitation is the attitude of an organization toward digital transformation. In different organizations that have different forms of management, other types of employees, or work in a less technology-savvy industry, the results might not be replicable [80]. The research is thus limited to its environment, which was a professional, technically developed organization with well-educated employees, with a focus on becoming data-driven.

8.6 Future work

Future research should focus on the unresolved topics of this research, for both the academic world and the organization of the case study. During our research we identified some topics for future research. First, future work should focus on expanding the scope of the research. As we tested our framework solely on the P2P process of one specific organization, it should be applied to other processes and organizations, in order to determine whether it is widely applicable. We suggest starting with different processes in similar, professional, technology savvy organizations, before shifting to different industries. Second, the number of interviews that were conducted during problem identification and validation could be increased. This may lead to new insights the current research does not contain and increase the validity of the evaluation by incorporating more insights into the results. Lastly, the framework can be extended with new assessment methods, such as informal communication as proposed during the validation. These new methods could improve the speed or quality of the assessment process or update the framework to new standards defined in literature.

For the organization of the case study, future work can be divided into different phases. The initial problems concerning data literacy and strategy should be addressed in the first phase, to make sure initial steps are taken to become data-driven. This can result in more data usage throughout the organization, adjusting the way of working so that other aspects of the DDO can be taken into account. The second phase should then focus on dividing responsibilities among roles, and on providing

more process standardization. The third phase should start when the culture of the organization has been adapted, as then data security, the use of techniques such as AI, or meta-data management will become more important. The organization could also implement a central knowledge database to share information about their developments externally. Overall, the data-driven maturity of the organization should be increased incrementally by solving problems during each phase.

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Appendix A

Interview Guide

This is the final interview guide that was developed in order to guide the semi-structured interviews that were done for this research. This interview guide was made using the steps that of Kallio. [58] For some questions there are several sub-questions that can be used to guide the interviewee during the interview.

A.1 The interview guide

Introduction

- Do you agree with this interview being recorded?
- What is your name and your role within the organization?

Current situation

- What decisions are currently made by your department, and how are these decisions made?
  - Are they based on data or on experience?
- Which of these decisions can, in your vision, be improved with data?
  - What data is available for these decisions?
- Which of these decisions would you classify as a key decision?
- What problems are you currently experiencing in your work concerning data?
- What solutions are there/do you see as possible solutions for these problems?

Data

- What data would you like to have in order to do your work better?

- What data do you have available for improving the processes that happen afterwards?

Vision

- What is your vision of a data-driven organization?
  - Can you give examples of the ideal situation?
  - What parts of the current way of working do you feel is lacking behind?
  - Future responsibilities
  - Ambitions
- Where do you see the organization after 5 years?

Conclusion

- Are there other interesting topics that have not been discussed yet?
- Is it possible to contact you after this interview if there are further questions?
- Would you like to receive the results of this research?

Appendix B

Maturity analysis overview

Process	Base practices	Explanation
Business Understanding	Determine business objectives	Understand what the customer wants to accomplish, and define business success criteria based on this.
	Assess situation	The situation can be assessed by taking several topics into account, such as project requirements, risks, availability of resources, and a cost-benefit analysis.
	Determine data mining goals	Define what the goals are from a technical perspective.
	Product project plan	Develop the plan by selecting technologies and tools for the project, and build detailed plans for each of the project phases.
Data Understanding	Collect initial data	The initial data should be collected and loaded into an analytics tool to give the possibility for a first overview of the available data.
	Describe data	A first examination of the data should be done to describe its properties. These can include data format, number of records, or field identities.
	Explore data	Data exploring is a deeper dive into the data itself. By using queries and visualizations, relationships of the data can be found.
	Verify data quality	Data verification is important to assess the quality of the data. It should be used to report any problems with the data quality.

Data Preparation	Select data	Here the data that will be used for the final analysis is selected. This is based on several inclusion or exclusion requirements.
	Clean data	Cleaning the data should improve its quality. This involves tasks such as correcting wrong values, or imputing/removing them.
	Construct data	When constructing the data, it should be tried to create new attributes by combining different parts of the dataset, or even combining different datasets.
	Integrate data	If different data sets are combined, this is called integration. From different sources a new set is created.
	Format data	It might be necessary to re-format data, as the data might not be saved in its optimal format.
Model Building	Select modeling techniques	The most appropriate modeling techniques should be selected. This can be chosen from a range of different algorithms, such as regression, neural nets, or deep learning.
	Generate test design	As the techniques should be tested on applicability, a data set might be split up into a test set and a training set. This should help with the validation of the model.
	Build model	The model building can be an easy step, as it is as easy as applying the model to the dataset.
	Assess model	By assessing the different models, it can be seen which model fits the data the best. This should be done by interpreting the results in such a way, that the business context is taken into account. Also, the success criteria made in the first step can be leading in which technique to choose.
Evaluation	Evaluate results	During evaluation the different models are evaluated based on whether they meet the business success criteria. Based on the evaluation the best algorithm(s) can be chosen.

	Review process	The review of the process is used to see if the process of data analytics was done properly. This should show whether all steps are done correctly, and if anything should be corrected.
	Determine next steps	Based on the evaluation and the review, it should be determined if deployment is the correct next step, or whether extra iterations or new projects are necessary.
Deployment and Use	Plan deployment	A plan should be made that shows the steps that are needed to deploy the model to users.
	Plan monitoring and maintenance	After the project is deployed, it should be monitored to prevent problems arising. The maintenance part will help assist users when help is necessary.
	Produce final report	The final report should be produced, where all of the projects findings and results are summarized. This can help as a guidance for future projects, but also as a tool to reflect on the project.
	Review project	During the project review, everything is assessed based on whether it went well. This can show improvements for future projects, by teaching valuable lessons from things that went wrong.
Data governance	Data strategy	Build and maintain a data strategy. This contains plans for maintaining and improving data quality, integrity, security and access. It can also include plans to use information to competitive advantage and support enterprise goals. Should thus include strategies and goals.
	Data policies	Implement data policies, which are short statements/rules for governing the creation, acquisition, integrity, security, quality, and use of data. These should also be effectively communicated and monitored.
	Data architecture	Data architecture should be monitored and supported with data governance.

Data standards and Procedures	Data standards and procedures should be reviewed, approved and adopted. These standards should be effectively communicated. The methods and techniques could include modeling standards, meta-data standards, database recovery, data security, reference data, merge data and BI standards.
Regulatory compliance	The data governance should ensure that the organization is complying with governmental and industry regulations. The compliance to these regulations should be monitored.
Issue Management	Issue management should be done with data governance. Issues concern data, such as quality, naming, security, regulation, conflicting policies, etc. The data governance should implement control mechanisms for finding, tracking, and discussing of issues.
Data management projects	Define the business case for data management projects, which focus on implementing a data strategy. This can be overall data management, but also more specified management such as management of architecture, warehousing, quality, etc.
Data management services	Data management services should be implemented to define the services. Data governance can be used to estimate the needs for these services.
Data asset valuation	Data assets should be valuated, to determine the business value. This can be done using several techniques, but should be done. Also liabilities can be found looking at what information is not available now.
Communication and promotion	The importance of data, and the value of data should be properly and continually communicated and promoted to stakeholders. The policies should be understood by all data producers and consumers, and awareness should be in place about roles and responsibilities. This can be done in several ways.

	Governance frameworks	Is a data governance framework currently used to employ the data governance.
Data Security Management	Understand security needs and requirements	Requirements should be found at different places, such as the concerns of stakeholders, government regulations, proprietary business concerns, and legitimate access needs.
	Define data security policy, standards, controls, and procedures	Combine the efforts of IT security administrators, data stewards, audit teams, and legal department to build an approach to security. Security standards that can be defined concern data access, data storage, and device disposal. Controls and procedures should be in place to ensure policies are followed.
	Manage users, passwords, views and permissions	Privileges of individual accounts should be monitored and updated. Privileges should be defined by roles, and users should only be in one group. Changes in roles should be approved. View management and permissions should prevent inappropriate access.
	Monitor user authentication	This is needed to gather information about who is connecting and accessing assets, and alerts for unusual situations. This can be done either actively or passively.
	Classify information confidentiality	Use a classification scheme to classify data. This scheme should have several levels of confidentiality. This should include databases, tables and views.
	Do a data security audit	Helps analyzing the activities related to data security management. Should be done by analysts independent of the data. Analyzing current processes and assessing whether they are up-to-date should be included in this audit.
Data Warehousing & BI Management	Understand BI needs	Here the business context should be defined, with a list of sample questions that could be asked about the data. The quality of the data should be commented on too. Pathways of a solution can also be included.

	Define the DW architecture	For this, different roles should be combined for building the Data Warehouse. Components such as servers, databases, and security should be taken into account. Make sure it is clear what data is taken into account, and integrate the DW architecture with the reporting architecture.
	Implement Data warehouses and BI tools and User interfaces	A warehouse integrates data from multiple sources. This provides analysis for knowledge workers. BI tools or UI can help with making data insights clear. What is applicable should be assessed.
	Process data for BI	Involves all of the processes that are necessary to prepare and process data. These are the staging areas, mapping sources, data cleansing and transformations. Policies should be developed for these processes.
	Monitor data warehousing and BI performance	It should be clear what is going on in the BI activities, to reduce end-customer support. Bottlenecks should be monitored, and solved where possible. Also, a regular overview of statistics of BI is essential. This can show where optimization can be applied.
Meta-data Management	Understand meta-data requirements	Requirements should be obtained from both business and technical users in the organization. different roles should be analyzed to find the requirements. Business users must understand the intent and purpose of meta-data management.
	Define meta-data architecture	Must consists of the layers: meta-data creation, meta-data integration, meta-data repositories, meta-data delivery, meta-data usage, meta-data management. It can be either centralized, distributed or hybrid. The preferred form depends on the needs of the organization.
	Develop meta-data standard metrics	Metrics are needed to measure the effectiveness of meta-data. Metrics should be quantitative.

	Implement meta-data environment	The implementation of this environment should be incremental to increase acceptance. It is possible to start with pilot tests, and then build a roadmap to change.
	Create and maintain meta-data	When software is used, data models should be adapted to the organization's needs. Repositories of meta-data should be periodically scanned and updated. Quality should be maintained to keep acceptance high.
	Integrate and manage meta-data	This is about integrating the external and internal meta-data, to create more insights. This can be done using ETL tools. Control activities are necessary to manage the meta-data. These controls are quite standard.
	Distribute, deliver and analyze meta-data	Layers should be implemented that deliver the meta-data to the end users and applications that use it. There is often a link between the meta-data and the BI. As meta-data is used in different parts of the organization, such as BI, business decisions and business semantics, it should be properly analyzed.
Reference and Master data management	Understand reference and Master data needs	Analyze one subject at the time to integrate reference and master data requirements. Analyze all of occurrences of business entities across all databases, and find out if and why there are multiple instances of an entity.
	Identify master and reference data sources	Understand the up-stream and down-stream sources and needs to ensure quality data. The lines from the data to the source(s) should become clear.
	Define and maintain data integration architecture	An architecture is needed to ensure reference and master data stays up-to-date. A possibility is that a main reference data hub supplies data to other applications and databases. This should ensure that the R&M data stays up-to-date.
	Implement management solutions	Iteratively implement R&M data management solutions guided by architecture and priorities.

	Define and maintain match rules	Build rules that make clear how matching and merging of data from multiple systems should be done. This will improve data quality and remove redundancies.
	Establish golden records	Golden records, aka the most accurate and complete R&M data, should be made using different techniques. This includes a vocabulary and golden master data values.
	Define and maintain hierarchies and affiliations	Hierarchical relationships can be defined to show relations between terms. Also affiliations can help with showing structure.
	Plan and implement integration of new data sources	When new data sources are integrated, it should be assessed on quality, integration cost, impact on match rules, and responsibilities.
	Replicate and distribute reference/master data	Make sure the R&M data are used as foreign keys in other tables, to ensure correct replication and duplication.
	Manage changes to reference/master data	Employees should be responsible to create, update and retire reference and master data values. Changes should be applied to replicated data.
People Management	Organizational structures	Knowledge scientists should be in the organization, which can be existing personnel. This increases the importance of data in the organization. Communication is important to make clear what is expected, and thus empower knowledge scientists.
	Academic training	Build integrative courses that helps knowledge scientists to build the skills needed for data engineering, machine learning, communication and human computer interaction.
Organizational Governance	Corporate culture	The culture of a company should be focused on using data for decisions. This should be done with efforts to explore new knowledge, and build a vision of how big data fits with the overall strategy of the company. This vision should be clearly documented and communicated, and managing drivers for this culture.

	Efficient leadership	Leadership should be focused on supporting and enabling data usage in decisions. This can be done by committing to big data projects, to send a signal to everyone in the organization. Also, multi skilled teams can help transforming data into business decisions. Managers should also be open to letting their decisions be led by data, and become more literate in understanding analytics.
	Communication strategies	Communcation strategies are needed to align the business goals with the culture. This can also help with the understanding of why data usage for decisions is important, and for which reasons the organization wants to implement this.
Project Management	Encompass business needs in projects	Projects need to be aligned with the business goals, which means that they should entail the different needs that are inherent to the organizations strategy.
	Enhance project planning and control with data analytics	Different metrics can be put into the system in order to manage project planning better. These metrics should be defined to make sure that analytics can be used efficiently for monitoring. Projects can be planned in advanced, and ongoing projects can be controlled better in real time.
	Employees working on projects should understand the data analyses	When data analytics becomes more important in projects, project members should be able to work with the tools that are necessary to do this. On top of this, the information that is retrieved from the data should be understandable by the project members. Training and education of data literacy should be done to increase this.

	Align the data analytics with the business strategy	The business strategy contains different goals that should be achieved by doing business. This should also be reflected in the data analytics, as this should be used to support the strategy. Information that is deduced from the data should thus support the analysis of reaching the goals that are in the strategy. Clear plans should thus be made what should be monitored, and data analytics should be provide the correct analysis to show this data.
	Implement a project portfolio to address the project management using data analytics	A project portfolio is a way of monitoring projects and assessing their performance. Data analytics is a useful tool in finding and monitoring different parameters of projects. This can help with finding out which projects to continue, and which should be stopped. Clear KPIs should thus be set up for each project in order to be able to monitor it's performance. Analytics can then be used as a tool to support decision making.

Table B.1: Overview of the elements assessed during the Maturity Analysis