MASTER

Investigating supply deviations in an inter-organizational collaboration
a case study at a Dutch online retailer

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Investigating supply deviations in an inter-organizational collaboration

A case study at a Dutch online retailer

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Abstract

This report presents the results of a detailed study into a network problem in a strongly linked inter-organizational collaboration. Organizations are increasingly collaborating outside the organizational borders to reach their highest business potentials. However, inter-organizational collaboration has been discussed in literature with varying and overlapping concepts, due to which research in this topic is at an early stage and practical reference models, frameworks and appropriate solutions to network challenges are missing (Camarinha-Matos, 2008; Bititci, 2012). The aim of the study is to find the root-causes of a supply accuracy network problem and to propose solutions by a network-wide research approach. First, the literature was structurally explored to find acknowledged challenges of network collaborations. Second, the network and the problem were explored by a wide-spread analysis to find the root-causes of the problem. Then, an operational process redesign was developed to align network performance measurement and network evaluation. It was concluded that aligned objectives and performance measurement are essential in network improvements. Therefore, the benefits of strongly linked inter-organizational collaboration can mostly be exploited when objectives and performance measurement are aligned within the collaboration.

Management summary

Introduction

Organizations are increasingly collaborating outside the organizational borders to reach their highest business potentials. However, difficulties are experienced in structuring and optimizing the collaborations, which could either bar the full benefit of networks or could even lead to disruptiveness (Lehtinen, 2010).

This thesis focuses on a problem experienced in the order fulfillment process of an online retailer (OR) in the grocery industry. In order to fulfill online customer demand, OR is replenished by a supply network including OR's main partner (MP). OR and MP are mutually dependent as they represent the same brand to the outside world, and they are part of the same retail holding. Therefore, OR and MP are considered a strongly linked inter-organizational network collaboration. However, OR has seen structural deviations in its supply, which can directly impact online customer order fulfillment.

The practical objective of this thesis research focuses on the discovery of the inter-organizational order fulfillment process and the investigation into the network problem at OR. This is supported by existing literature on collaborative networks. Based on the conclusions of the problem analysis, the theoretical foundations of inter-organizational network collaboration are evaluated and elaborated on. The following research question is stated:

> *What are the causes of the supply deviations problem and how can the collaborative network cope with the problem?*

Research design

The thesis follows the regulative cycle of Van Strien (1997). As OR and MP constitute a strongly linked inter-organizational collaboration, a network wide problem-solving approach is required to ensure an efficient and integrated solution (Håkansson et al, 1989). The research approach is visualized in Figure 1. First, a systematic literature analysis is performed to discover challenges in collaborative network. They are used to guide the problem analysis at OR. Then a widespread analysis was performed into the network and the network problem including an AS-IS analysis, a data analysis and a root-cause analysis. Based on the conclusions of the problem analysis, a solution design to cope with the supply deviations and to improve the network collaboration was designed and evaluated.

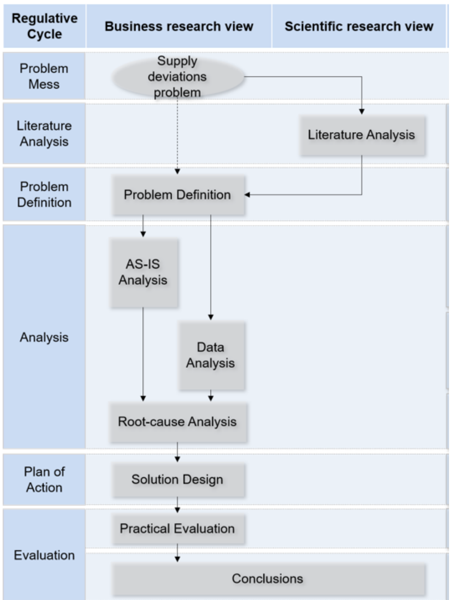

Figure 1 Thesis research design

Analysis

The literature analyses resulted in a challenges framework that mentioned five domains of network challenges: IT management challenges, relationship management challenges, knowledge management challenges, performance and risk management challenges and sustainability management challenges. Based on joint decision making and the sharing of benefits, data, information, resources and risks, the network collaboration was defined as an extended enterprise.

As operational inter-organizational diagrams were non-existing in the network, the analysis first captured the current inter-organizational context of the problem. The Zachman framework was used to determine the perspectives in the context analysis. After the development of five inter-organizational models, the challenge found in literature were identified in the network. Especially IT management challenges, knowledge management challenges and performance measurement challenges were found in the current order fulfillment process. Although MP and OR are a collaborative network, the domains showed to be highly intra-organizational focused. Then, the analysis focused on the supply deviations problem. First the impact of supply deviations on OR's performance was quantitatively proved, which substantiated the need for further research. The detailed problem definition concluded that supply deviations are either caused by acknowledged causes, which are defined and communicated by the network, or unknown and undefined causes. As an analysis into the supply deviations data of OR shows that almost 40% of the weekly supply deviations has an undefined root-cause, these causes were the scope of a root-cause analysis. The root-cause analysis aimed to discover the most important and impacting causes of undefined supply deviations and entailed three phases: (1) identification of root-causes by expert brainstorms, (2) a qualitative and quantitative impact evaluation per root-cause, (3) detailed root-cause analysis into the specific process and information systems (ISs). After a detailed root-cause analysis into the undefined supply deviations, they concluded to either result in perceived supply deviations and actual supply deviations:

- perceived supply deviations strongly impact the quality of the supply deviations data and stock level quality. They are concluded to be caused by inaccurate manual check-in into the warehouse management system of OR.
- Actual supply deviations are concluded to be caused by supplying DC inaccuracy, business-IT misalignment and insufficient quality of data bases.

The following Ishikawa diagram shows an overview of the found causes of supply deviations. Cause investigation was considered complicated due to (1) limited inter-organizational expert knowledge (2) the low data quality of the supply deviations caused by perceived supply deviations.

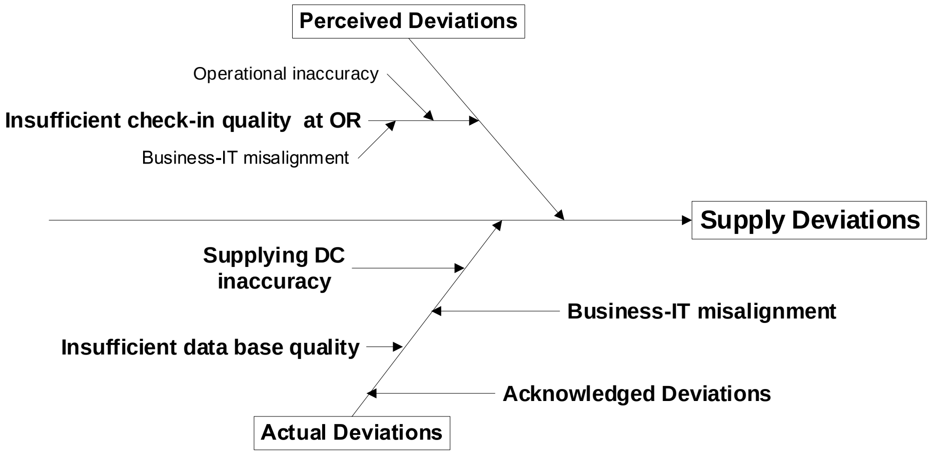

Figure 2 Ishikawa diagram with concluded root-causes of supply deviation

Solution design

The solution design proposed a reactive operational solution design in the scope of OR and preventive solution directions for the network. In the reactive solution design, it was concluded that OR could better cope with supply deviations by improving the supplier performance measurement in the inbound process. The perceived deviations must be eliminated in order for the network to thrust the data and to act on the results. The redesign is developed following the RePro-procedure (Vanwersch, 2014). It proposes to eliminate the manual check-in at OR, because a manual check-in on product level will never result in reliable data quality. Supplier performance was concluded best measured by a sampling activity by a third party or a weight control activity in the inbound process. For the performance measurement to substantiate network wide process improvement interventions, a structural evaluation process is designed that must be agreed on by all stakeholders. The conceptual performance evaluation process is designed based on process control in steady state models ('t Veld, 2011) and evaluates the supplier performance and their impact on the online customer. The essence of the performance evaluation framework is that the network jointly acts when mutually determined norms are exceeded.

As the value of a network wide approach was acknowledged, tactical and strategic preventive solution directions for the network were explored in literature. Literature concludes on solution directions for the identified root-causes and network challenges. The following topics were concluded beneficial for effective network collaboration: network data quality management, network wide performance management, integration of network activities, and integration of ISs by new technologies will result in an effective collaboration. It is recommended to the network to further explore these solution directions.

The solution designs were evaluated with an expert panel representing the network. The evaluation mainly showed the misaligned objectives of OR and MP, which bars network and process improvements.

Conclusions

Overall it is concluded that although OR and MP are strongly linked and mutual dependent, they do not exploit the full benefit of the collaboration by applying a network wide perspective. The intra-organizational focus results in a general supply chain collaboration. Problems like supply deviations disappear when the entire network aligns performance measurement and objectives. Therefore, this thesis concluded that the benefits of strongly linked inter-organizational collaboration can mostly be exploited when objectives and performance measurement are aligned within the collaboration. The implementation of the reactive solution design and the network wide performance measurement is recommended to the network of OR. Due to the investigation of a specific and practical problem and due to the bounded evaluation phase, generalizability is a limitation of the research. Furthermore, the ambiguity of the collaborative network concept resulted in validity limitations in the conclusions based on the literature search.

Preface

This report is the result of my master thesis and the final piece of work for my master study Operations Management & Logistics at the Eindhoven University of Technology. With the completion of this project I am looking back to a challenging and somewhat rough ending to a very fulfilling time in Eindhoven. It marks the end of my student life which I truly enjoyed for the past 6 years.

Not only on academical level, but especially on a personal I developed myself beyond expectations. The university life and in particular my international experiences have taught me more about the possibilities, opportunities and challenges that are around me. I have been inspired to explore what is important to me, what kind of person I want to become and what friends I would like to surround myself with. I am now looking forward to my next step in life, full of new experiences.

Without the help and support of some people, I would not have been able to reach this moment at the of finalizing my master thesis. Therefore, I want to take this opportunity to thank a few people.

First, I would like to thank my first TU/e supervisor Irene. You gave me the comfort to be honest and acknowledge my feelings. Your positive approach and faith in a good ending has stimulated and motivated me to continue with this project and not give up. In addition, I wish to thank my second supervisor Paul Grefen for his flexibility during my project.

Second, a thank you to both my company supervisors Jonathan and Rowan, for your business insights, support and time. The opportunity to complete my master thesis project at one of the leading Dutch (online) retailers has proven to be both interesting and educational. Combining theory with actual operational business practices has been a challenge, but one from which I have learned lots.

Third, I would like to thank my dearest friends. I am very grateful for our friendships, and I have experienced how much I can rely your support. With our group of study friends (the metanerdies), we have been motivating each other to reach the highest results, while having a great time together. My Animo-friends have shown me how to have a great time and be ambitious by inspiring me to grasp various opportunities. I like to especially thank Tamara, Iris, Nika, Kathelijn and Ilvy. I believe that this final project would not have been realized without your comforting words, welcoming distractions and help.

Last, I would to thank my family for their continuous support in all my decisions over the past years. I love the way how we, as a family, support and appreciate everyone in their own rights, whatever their interests might be.

Laura Buijk

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1 Introduction

This thesis presents the result of a graduation research project on collaborative business networks commissioned by a large online grocery retailer in the Netherlands. Organizations are increasingly collaborating outside the organizational borders to reach the highest business potentials. However, difficulties are experienced in structuring and optimizing the collaborations, which could either bar the full benefit of networks or could even lead to disruptiveness (Lethinen, 2010). This chapter introduces the practical and theoretical motivation of this thesis research.

1.1 Practical thesis motivation

An online retailer and its partners experience challenges in the replenishment of the online retailer. For confidentiality reasons, the online retailer that commissioned this research will be referred to as OR. OR is a web-based home delivery service offering all assortment of the main collaboration partner, further referred to as MP. MP is a large Dutch supermarket chain. OR is an important player in the online grocery retailing industry in the Netherlands (Statista, 2017).

OR and MP are mutually dependent, as they are two organizations that represent one brand for the outside world. Additionally, they are part of the same retail holding. In Figure 3, the supply network structure of OR is described. The replenishment of OR by MP's supply chain compromises 85% of the total replenishment. Some providers supply directly to OR to accelerate the supply of mainly fresh products. OR produces the customer orders and ships them to the customer.

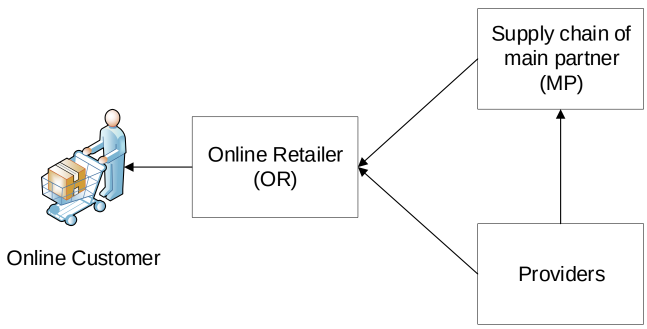

Figure 3 High-level supply network structure of OR

Data of OR has shown a structural deviation between OR's replenishment orders and their registered receivals. OR places daily orders at its suppliers based on the received and forecasted online customer reservations. Incomplete or incorrect supplies can directly impact online customer order fulfillment due to the just-in time replenishment strategy of OR. Online customers can order from four weeks to one day before delivery.

The mutual dependency and the network structure of MP and OR derive the need for a network wide problem-solving approach. As MP and OR represent one brand, problems impacting the customer centric performance of OR also impact the performance of MP. Thereby, an efficient and integrated solution cannot be designed by a focus from one side of the problem. Therefore, the supply deviations problem is considered a network problem in a strongly linked inter-organizational collaboration.

The growing popularity of e-commerce in the Netherlands as well as worldwide, requires OR to prepare for a sharp increase in demand (Statista, 2018). The more orders, the more misalignment in the network impacts the performance of OR and MP. Intra- and inter-organizational processes and IT systems need to be evaluated to ensure feasibility for the increasing load (Drews, 2014).

1.2 Theoretical thesis motivation

More and more organizations look for opportunities in cross-organizational collaborations like MP and OR. Grefen (2013) identified five developments that have forced organizations to co-operate in inter-organizational business processes. Among other factors, these developments have led to change and adaption of organizations. Regardless of size, enterprises are collaborating to fulfill clients' demand by meeting their needs concerning cost, time response, and quality. This is done by integrating various distributed business processes and making relevant information available to all entities (Chituc, 2006). Through collaboration, companies aim at sharing resources and exchanging information; reducing risks, costs and time; increasing their market share; and enhancing the skills and knowledge of their network partners.

The degree of intertwinement of business partners is rising. To capture and understand the extended environment in which enterprises act, concepts like collaborative networks are deliberated in the literature (Drews, 2014). Camarhina-Matos (2008) defines a general collaborative network as "an alliance constituted by a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by a collaborative network". OR and MP are two separate organizations that collaborate to achieve compatible goals. However, they are part of the same holding and therefore not completely autonomous. For this reason, the strongly linked collaboration between OR and MP is approached as specific case of collaborative networks.

A large number of research projects have been reported worldwide in the last decades covering inter-organization collaboration or collaborative networks (Dirr, 2018; Camarinha-Matos et al., 2004; Parung et al., 2008). Bititci (2012) identified that the networked way of doing business has increased and concludes that the research on the current theme is at an early stage. Lack of reference models for collaborative networks is a common concern found in the literature, which is pointed out as an obstacle for a more consistent development of the area (Camarinha-Matos et al, 2008).

By a research into the network problem in the strongly linked inter-organizational collaboration of OR and MP, this thesis will contribute to the elaboration of a sounder theoretical foundation of the value systems, success factors and challenges of inter-organizational collaboration.

1.3 Research objective

This research will focus on the network problem experienced by OR by identifying inter-organizational challenges and solutions. This is supported by existing literature on collaborative networks. As the problem is located in the inter-organizational order fulfillment process of the network, this will be the scope of the analysis. Therefore, the following objective is concluded:

Practical objective: Creating insight into the inter-organizational order fulfillment process and the supply deviations problem at OR.

Based on the objective, the following research question is defined:

Main research question: What are the causes of the supply deviations problem and how can the collaborative network cope with the problem?

2 Research methodology

This chapter introduces the methodology used to answer the main research question and objectives. First, the research cycle and research approach are described in Section 2.1. Then, the scope is defined in Section 2.2. In Section 2.3, the research questions are stated. The methods used to answer these research questions are described in Section 2.4. The chapter ends with Section 2.5, which contains a graphical overview of the research methodology and the thesis outline.

2.1 Research cycle

This research follows the methodology of Van Aken et al. (2007) for business problem-solving projects in organizations. Business problem-solving projects are projects that are designed with the aim to improve the performance of a business system by at least one criterion. The set-up of these projects follows the classic problem-solving cycle, which is explained by the regulative cycle of Van Strien (1997). The regulative cycle is an appropriate framework for this research since it enables a “structured organizational problem-solving process that is guided by grounded design rules” (Van Strien, 1997).

The research approach of this thesis is visualized in Figure 4. The research covers the design phase and the basics of the learning phase. The problem mess is described in the introduction. Preceding the problem definition, and slightly deviating from the regulative cycle of Van Strien (1997), literature on the current knowledge of the network collaboration topic is explored. The detailed problem definition, the comprehensive analysis and diagnoses and the solution designs, focus on the practical thesis objective. Intervention and evaluation are equivalent to the change and learning phase in the organization’s perspective (Van Aken et al., 2007). The implementation or the plan for implementation will be out of scope in the research, but the solution designs will be evaluated cursorily. To grasp the full potential of this research, further research could expand and execute the change and learning phase.

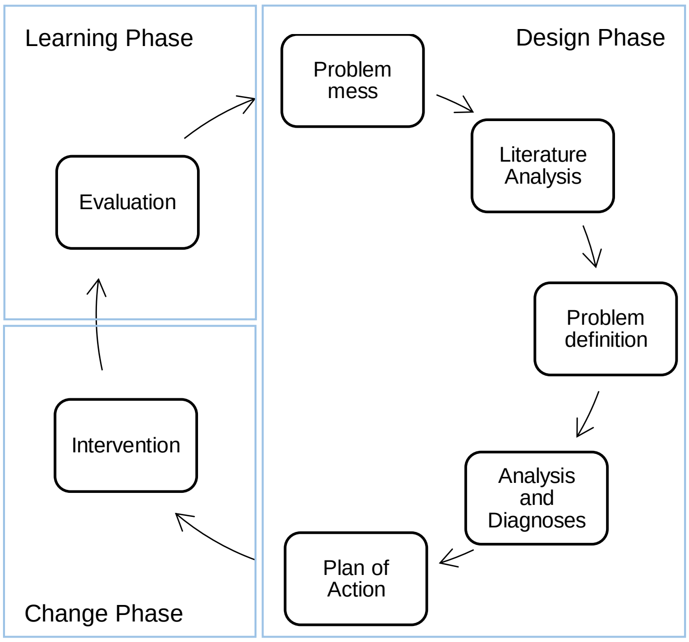

Figure 4 Research approach

2.2 Scope

The research is scoped to problems and challenges of inter-organizational collaboration and focusses on cross-organizational process management. The problem of OR is found in the order fulfillment process. Therefore, this is the scope of the business view in this research. The order fulfillment process starts with receiving orders from (online) customers and ends with delivering the finished goods (Lin, 1998). It encloses the replenishment of OR by the supply network due to the just-in-time replenishment strategy of OR. The thesis focusses on the B2B relations and in particular on the inter-organizational collaboration with MP, as OR is most dependent on MP.

The BOAT framework (Business, Organization, Architecture, and Technology) is used to point out which dimensions of the order fulfillment process are most essential and will therefore be analyzed in the analysis and diagnoses phase. The framework introduces a method for designing and analyzing networked e-business models based on a clear and structured separation of concerns by distinguishing between different dimensional aspects: The B and O aspects represent the business-oriented dimension, and the A and T aspects cover the technology-driven dimension needed to support the business dimension of a specific e-business scenario (Grefen, 2016). The analysis will focus on the organization (O) and the architecture (A) dimensions. The organizational dimension evaluates the structure of the inter-organizational order fulfillment process to identify the causes of the supply deviations problem. As the order fulfillment process is dependent on the inter-organizational order flow and warehouse management systems, the architecture dimension is additionally evaluated to identify the causes of the supply deviations problem. Solving the supply deviations problems increases the chances of reaching the given goals of the network in the business (B) aspect. Since a well-designed architecture is the essential starting point to arrive at an integration of multiple technology classes (T) (Grefen, 2016), the analysis will focus on the architecture aspects and not on the technology details.

Due to the comprehensive network and problem analysis, argued in Section 2.4, and the time restrictions of the master thesis, the solution design is scoped to the organizational aspect (O) of the network as this dimension is concluded to have the most impact on the network problem.

2.3 Research questions

Based on the main research question, research cycle and scope, the following research questions are stated. The research first identifies inter-organizational network challenges in literature by means of the collaborative network concept to guide the analysis into the network problem at OR. Subsequently, the specific problem and solution are investigated.

1. What are the challenges of inter-organizational collaboration?

2. What are root-causes of the network problem of OR?
    a. What constitutes the network?
    b. What is the network problem?
    c. Wat does the current order fulfillment process look like?
    d. What are the extent and impact of the problem?
    e. What are the root-causes of the problem?

3. How should the network cope with the problem?
4. How does the network evaluate the proposed solution design?
5. What can be concluded about or added to the current theoretical foundation

2.4 Research methods

The research methods used to answer to research question are elaborated on per phase in the research cycle:

Literature analysis
To answer the first research question, a (systematic) literature search is conducted to identify the challenges of operating in an inter-organizational collaboration. As the concept of collaborative networks is deliberated in literature to capture and understand the extended environment in which enterprises act (Drews, 2014), this concept is used in the literature search. “A systematic literature review (SLR) is a well-defined methodology to identify, analyze and interpret all available research relevant to a specific question, area or phenomenon of interest, thereby providing ways to perform comprehensive, unbiased and repeatable literature analysis” (Kitchenham, 2007).

Analysis and Diagnoses
To find the root-causes of the network problem at OR and to answer research question 2 , the problem analysis requires an comprehensive and network wide approach for three reasons: (1) Focusing on one side of the problem, from the perspective of one organization, will not result in an efficient and integrated network solution (Håkansson et al, 1989); (2) The problem is experienced on the operational level of the order fulfillment process, but the root-causes could be originating in intra- or inter-organizational supporting processes; (3) Mutually dependent collaborations encounter different challenges than general buyer-supplier relationships (Camarinha-Matos, 2004). A broad analysis is required to ensure discovery of the most important root-causes.

For these reasons, it is beneficial to approach the problem from different perspectives in a widespread analysis. This is supported by conducting an analysis using multiple research methods:

- An AS-IS analysis is conducted to capture the current order fulfillment process and to identify challenges acknowledged by literature. This is the first analysis because currently inter-organizational diagrams are non-existing, and the context of the problem must be discovered. The Zachman framework (Zachman, 1987) is used to determine the perspectives in the AS-IS analysis. It is an enterprise architecture framework developed to systematically model a complex environment. The framework is not a methodology but rather a template describing how different abstract ideas are viewed from different perspectives. Enterprise architecture can help to overcome problems due to integrating organizations, especially software-intensive systems (Goethals et al., 2004). Other enterprise architecture frameworks, like TOGAF, represent a smaller number of viewpoints and aspects or they are an approach to realize an architecture rather than indicate perspectives (Urbaczewski et al., 2006).
- A data analysis into the registered supply deviations is used to determine and the extent and the impact of the problem on the network performance. Trends in the data are evaluated to scope the root-cause analysis to the most important issues.
- A root-cause analysis will uncover the causes of the supply deviations problem. The analysis does not aim to be complete but identifies the most important root-causes of the supply deviations problem and in turn the according network challenges.

Plan of action
In the plan of action phase, solutions designs are proposed to avoid future supply deviations impacting online customers. This phase will elaborate on research question 3.

A reactive solution design is proposed for OR to better cope with the supply deviations problem and to avoid customer impact. The solution design proposes a process redesign based on the RePro-procedure (Vanwersch, 2014). It is a systematic technique for redesigning processes based on a set of process improvement principles (Vanwersch, 2014). Although the RePro technique is designed for care processes, the integration of the best practices into the RePro principles ensures “wide applicability in across various industries and business processes” (Reijers, 2004). Compared to the redesign heuristics described by Dumas (2013), the RePro-technique has a more extensive set of process improvement principles and includes an application procedure.

Preventive solution directions are proposed because independent of what coping strategy is defined, preventively hedging against risks of supply deviations is beneficial to the network performance. The thesis analysis has an operational and specific scope. Therefore, the literature is explored to propose solution directions for network collaboration improvement on a tactical and strategical management level

Evaluation

Evaluation of the plan of action in the network is essential for network wide solution designs to be affective. The evaluation is performed by a cross-organizational expert panel and directs the recommendations for network improvement. As no standard evaluation protocol for process redesigns is found in literature, an interview protocol is designed.

With the results of the thesis analyses, the theoretical foundation on inter-organizational collaboration is discussed. Identified challenges and solutions found in literature are evaluated for completeness. As this thesis focusses on a specific problem in a practical environment, scientific generalization is not an expected attribute of the thesis research (Leung, 2015).

2.5 Research outline

The outline of the research, including the phases of the research approach, methods, questions and chapters, is visualized in Figure 5.

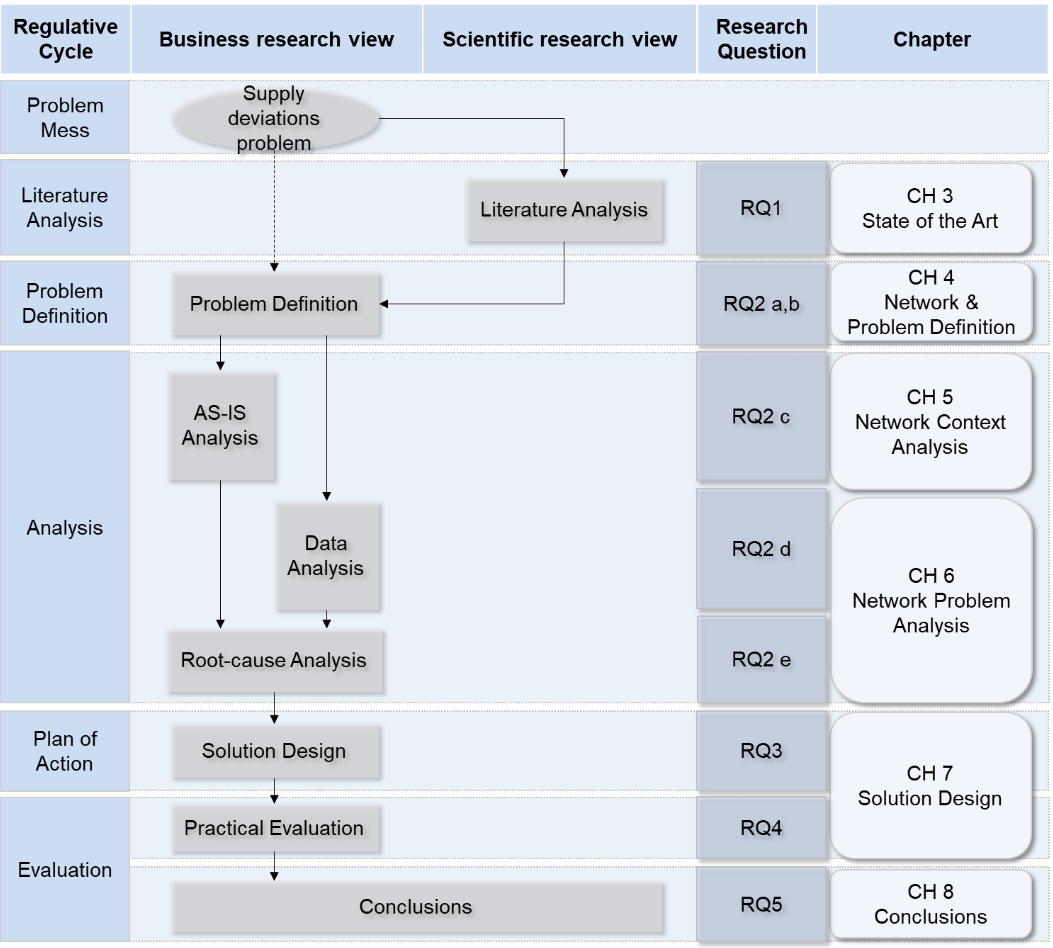

Figure 5 Research outline

3 State of the art

This chapter describes the state of the art of research into challenges of collaborative business networks. The goal of the literature search is to indicate challenges and pitfalls of inter-organizational collaboration. The challenges of inter-organizational collaboration found are used to reflect on the network collaboration of OR. The literature analysis followed the three-phased process defined by Kitchenham (2007). The complete search protocol is added to the Appendix 10.1.1. The search concluded in a systematically selected article pool of 23 articles listed in Appendix 10.1.2. The following research question is stated:

What are the challenges of cross-organizational process management in collaborative business networks?

After a thoroughly read of the article pool, a framework containing the main challenges of collaborative business networks is developed with help of a coding strategy explained in Appendix 10.1.3. The framework based on the selected article pool shows that the main challenges can be distinguished in five domains: knowledge management, IT management, relationship management, performance and risk management, and sustainability management. These will be shortly described in the following subsections. Appendix 10.1.4 shows to complete framework and Figure 6 gives a visual overview.

1. IT management

IT management in collaborative networks is according to the resulted article pool most challenging. To enable users as well as systems to interact in a secure and seamless manner despite a heterogeneous system environment is challenging. Different partners have different infrastructures or IT landscapes; the interoperability among heterogeneous systems is the solid foundation for the networked enterprise to work seamlessly and effectively (Li, 2010).

System security

System security and information confidentiality are acknowledged as difficult aspects, due to the diversity of systems and parties involved (Preuveneers, 2017; Franqueira, 2013; Gogoulos, 2014; Hoerigl, 2010; Li, 2010). Especially when it is becoming more common to outsource critical business processes and to completely move IT resources to the custody of third parties resulting in individuals who are neither completely insiders nor outsiders of a company (Franqueira, 2013). An unnecessary degree of dependence on identity management and complexity in identity management needs to be actively avoided in a large system (Hoerigl, 2010).

IT implementation

Karvonen (2016) indicates factors due to which IT implementation become challenging in networks: (1) when there is large autonomy between the organizations, (2) when tools are not as beneficial for both enterprises, (3) when there is additional complexity due to units, functions or locations, (4) when there are great differences in concepts, cultures, processes, skills and management styles, (5) when openness is not always accepted and when companies collaborate in several networks. Hinkka (2013) concludes on another challenges factor of IT implementation: division of costs and benefits. Especially when developing tracking systems where the benefit for the downstream organization is clearly smaller, like RFID tracking.

Business-IT alignment

According to Buskhsh (2012), business and IT alignment is of the utmost importance for inter-organizational collaboration, because it is the only way for communication and collaboration to add value to the business. The interoperability among heterogeneous systems is the solid foundation for the networked enterprise to work seamlessly and effectively. Li (2010) also argues that the design of the collaborative information system across heterogeneous infrastructures determines whether the networked enterprise can get to success.

2. Relationship management

Managing relationships in networks is also indicated as challenging by the article pool. Relational benefits are critical in ensuring information sharing and mitigating relational risk in the network (Cheng, 2013). Operational and tactical challenges in managing a successful network relationship mainly occur when there is a multi-side set-up, when there is no respect for other's professional and organizational identity and when there is no special attention on learning how to collaborate (Ylitalo, 2016). The relationship challenge of collaborative business networks is comparable to the difficulties experienced in cross-border integrations, like international acquisitions and mergers. Ambos (2009) concludes that in cross-border integration, aligning is not simply about recognizing the value of the distinctive capabilities of individual units and designing formal structures that successfully align with them. It is also about understanding the need for dynamic interaction between formal corporate structures and individual units' desires to retain power and influence, which have significant implications for the development of their organizational capabilities. Zhang (2015) investigated a topic that covers a relationship management network challenge of another nature. As collaborative networks can become more global, the interest in a multilingual corpus for multilingual information analysis, research and service increases. It is necessary to find effective ways to bridge the gap caused by different languages, and multi-lingual information processing has been gaining more and more attention in recent years.

3. Knowledge management

The third domain in the framework is concluded to be knowledge management. Knowledge is one of the primary reasons to collaborate in networks and an essential resource to cope with the complexity of inter-organizational value creation processes (Krenz, 2014). However, several challenges for knowledge management in networks are discovered.

Data quality

With the increasing variety and interconnectedness of the software landscape of an organization itself and within the network, data quality becomes an essential and critical factor. Poor quality or errors within data can affect many different systems and companies. Even for the wide-spread data exchange standard Electronic Data Interchange (EDI) to work efficiently, a higher degree of context alignment between sender and receiver is required (Schaffer, 2017). Schaffer's interview study (2017) shows that errors in data entry, inconsistent terminology, data migration and integration and missing data quality strategy are the primary reasons for the companies' master data problems.

Knowledge sharing

In complex e-business scenarios, real time information exchange among heterogeneous and geographically distributed networks is an important knowledge sharing challenge (Chituc, 2017). Ensuring interoperability among those networks has become of utmost importance in especially the execution of e-business. Krenz (2014) focuses on another challenge of inter-organizational knowledge sharing. There exists conflicts between knowledge management objectives and general management objectives, which complicate knowledge sharing. Three conflicts were acknowledged: (1) Compensation between cognitive proximity and distance; A high degree of autonomy and heterogeneity in the network usually comes along with a certain cognitive distance between the actors and is the fundament for high problem-solving skills of cooperating actors that are not blocked through group thinking and conformity. (2) Compensation between dynamics and stability; the process of knowledge identification must compensate constant long-term network structures, but also changeability in dynamic features of the network. (3). Compensation between knowledge transparency and non-disclosure; a high level of transparency increases the risk of inadvertent knowledge drain (or industrial espionage), which in turn strongly affects the willingness to share knowledge.

Knowledge transparency

As acknowledged by the third conflict of Krenz (2014), there is a need to regulate the availability of transparency in a way that the necessary willingness to share can be raised and competitive knowledge can be protected against loss risks. Mau (2008) states more profoundly that in some industries, process transparency and information readiness are essentials to reduce other risks in (e-)business networks. Especially in the food manufacturing industry the process transparency is of the utmost importance. If the quality of the process is affected anywhere in the supply chain and the non-conform behavior is not traceable due to missing and documentation, a disaster is born. Long-term orientated knowledge management must be considered, since on the one hand, one requires all information to avoid data loss, whilst on the other hand an information overflow that nobody can handle must be avoided.

4. Performance and Risk management

Evaluating the effectiveness of achieving direct outcomes in inter-organizational relationships is challenging. This is mainly due to the multifaceted objectives of many alliances and the inadequateness of only measuring performance by financial outcomes (Babiak, 2009). Networks have become dynamically characterized by a complex flow of tangible and intangible features. This tight interdependency among resources belonging to different firms creates a huge amount of compliance assessment points which are potential sources of risk (Lo Nigro, 2011).

Performance measurement

Direct application of dominant performance measurement models or frameworks into the context of an extended enterprise can lead to suboptimal or even disastrous results (Lethinen, 2010). Performance measurement literature appears to be biased towards intra-organizational measures of performance, potentially leading to neglect of inter-organizational business processes and relational ties. However, these are central determinants affecting the success and performance of extended enterprise or other collaborative networks. Babiak (2009) states that two questions are essential in assessing performance of a network: (1) how effectiveness is defined for the organizations involved, and (2) what the criteria for the evaluation of their effectiveness are. He states that only by identifying these criteria, performance measurement can ultimately be carried out in networks.

Mitigating risk

Next to measuring performance, risk is a critical factor in assessing a network. When a firm links it’s business to other firms, it accepts a dependence. Such dependence can lead to opportunistic behavior followed by the risk of not achieving the desired objective can arise. In order to encourage firms to bear this risk, a proper profit-sharing mechanism. However, network risk is hard to quantify. Next to that, if network risk is not decomposed, manager risk efforts are often not effective because of the multifaceted consequence of a hedging action (Lo Nigro, 2011)

5. Sustainability management

One article has discussed the sustainability responsibility that indirectly arises when networks grow. Sustainability might not directly be seen as a network related challenge, but as networks become larger and more global, they are pressured by consumers, NGOs, other firms and even governments to reframe their conceptions of responsibility away from a narrow internal mind-set and beyond their immediate organizational boundaries (Bostrom, 2015).

3.1 Conclusions

The goal of this literature review was to gain insight into the cross-organizational network challenges by evaluating the 'state of the art' of the literature on challenges in collaborative networks. In the AS-IS analysis, these conclusions will be used to evaluate the network collaboration at OR.

The systematic literature review concluded on a network challenges framework consisting of five main domains. The framework is visualized in Figure 6. In the analysis of the AS-IS situation, these recovered domains will be used to evaluate the network collaboration in scope. Further research is needed to empirically evaluate the framework and to identity existing solutions to these challenges. The insights from this literature study will mainly direct deeper analysis into collaborative networks and warn organizations for the variation of challenges arising in collaborative networks.

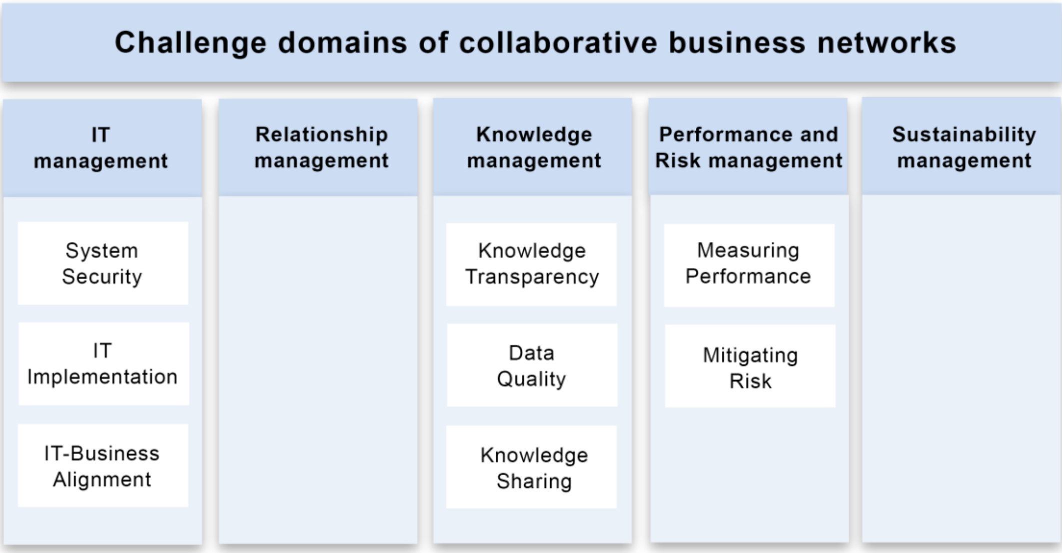

Figure 6 Challenges framework concluded by SLR

4 Detailed network and problem definition

This chapter further introduces and describes the network and the problem after the short introduction in the practical thesis motivation. The collaboration between OR, MP and the direct suppliers is described in Section 4.1. The deviation problem between OR's replenishment orders and their registered receivals is explained and defined in Section 4.2.

4.1 Detailed network description

In this section, the network in scope is described based on exploratory interviews with experts from MP, OR and a direct supplier.

Figure 7 shows the collaboration between OR, MP and other network partners in an operational framework structured by the levels of inter-intra-organizational integration of Baratt (2004). These partners constitute the supply network. OR and MP were concluded to be a strongly linked inter-organizational collaboration due to the mutual representation of one brand and the identical holding company. They cannot be defined as a general supply chain, as they share risks and benefits (Parung et all (2006). The operational framework shows that the network partners OR and MP collaborate on all decision levels, from capacity and strategy decisions to day-to-day orders. MP sells groceries to offline customers via a large network or physical stores and OR offers the same assortment to online customers. The individual strategies must be aligned to constitute the strategy of the brand. For example, the organizations must align the quality of the customer service in terms of assortment variety, product availability and customer contact. Evaluation of objectives is performed intra-organizational. Direct suppliers are integrated in the network to accelerate the supply of mainly fresh products. OR has set service level agreement with these suppliers. The collaboration with the direct suppliers can be typed as a general supply chain.

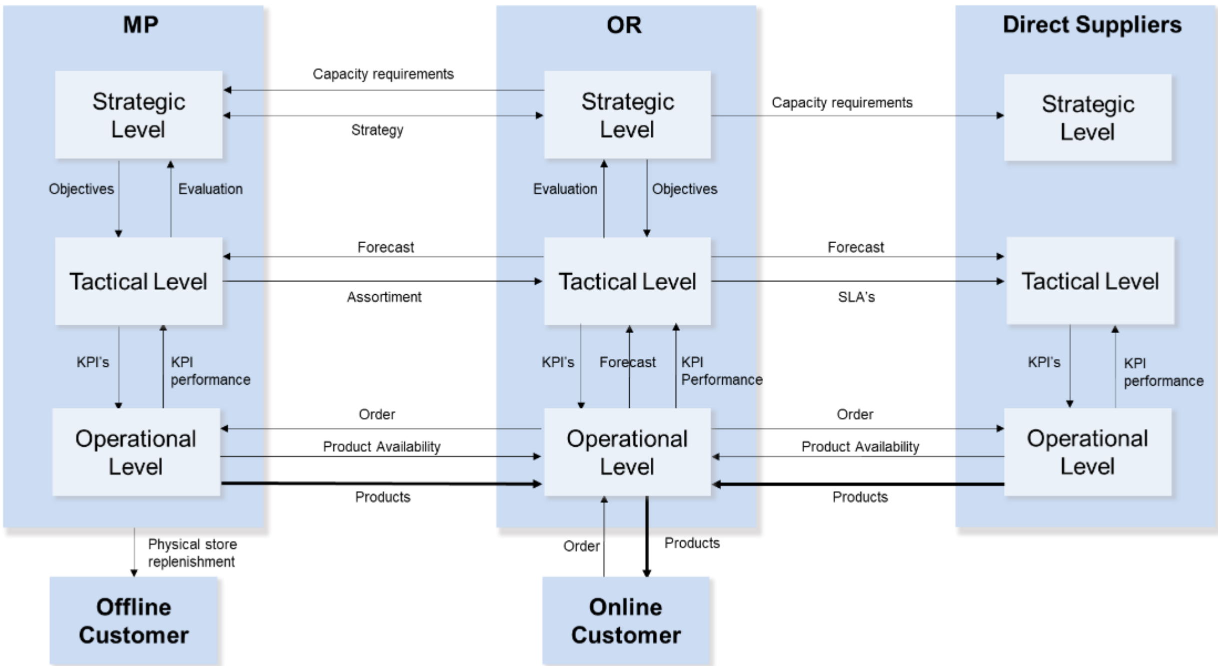

Figure 7 Operational network framework (Barratt, 2004)

4.2 Detailed problem definition

The problem experienced by OR are deviations between the order of OR and the incoming supply by their partners. This problem is located in the customer order fulfillment process of OR. The process starts with the receival of orders from online customers, includes replenishment of OR by the supply partners and ends with the order delivery of online customer. By an exploratory analysis at OR, the following conclusions that will define the problem definitions are conducted.

The data of OR shows there are two types of registered deviations; products that are not or partly delivered, and products that are delivered in surplus. Consequently, the following two categories are defined:

- deviations due to short supply
- deviations due to excessive supply.

The cause-and-effect diagram in Figure 8 depicts the consequences of short and excessive supply at OR. Due to short supply, stock levels at OR are decreasing. This indirectly influences the online customer through lower online product availability. The online customer is directly influenced when reservations cannot be supplied. Due to the increasing popularity of e-commerce, customers can easily switch between retailers. Consequently, this may result in a potential loss of customers to competitors. On the other hand, excessive supply are products that were supplied while not ordered. At OR, excessive supply results in buffers and other capacity issues. The buffers affect the optimal circuit allocation, as shelves might need to be enlarged. For the supply network, excessive deviations can result in a product return flow. When accidental supply is unknown, they have impact on warehouse stock level reliability of the suppliers which in turn affects warehouse replenishment management.

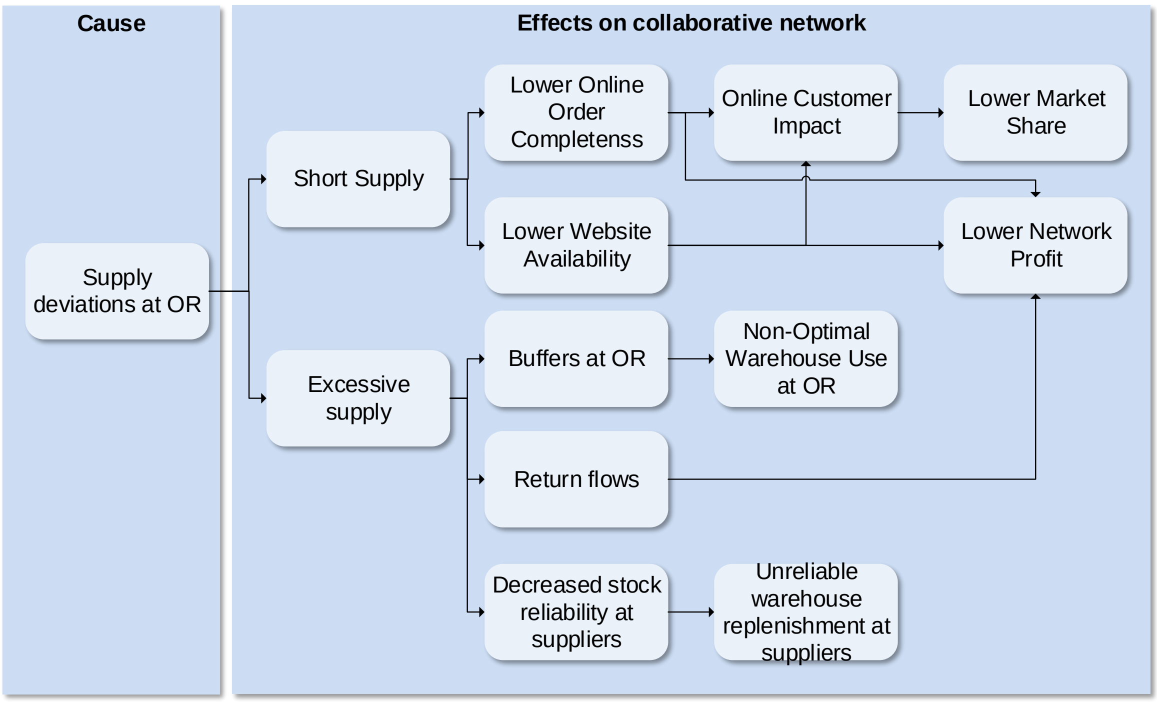

Figure 8 Cause and effect diagram of supply deviations

Although the supply deviations were concluded a network wide problem, OR is primarily impacted by the problem. Hence, OR, and more specifically the preparation department of OR, who are responsible for the day-to-day replenishment of OR, is referred to as the problem holder.

Supply deviations can be caused by several intra and inter-organizational factors. To gain insight into the variety of causes of supply deviations, exploratory interviews are held with the problem holders. Although the supply deviations can be partly explained by problems acknowledged and communicated by the network, a share of the deviations cannot be explained by currently identified supply issues. The typology of causes of supply deviations concluded from the exploratory interviews is depicted in Figure 9 and described:

1. The acknowledged causes

Based on observations of the supply process, exploratory interviews with the problem holder and documentation on the replenishment process at MP, the acknowledged problems are described. The acknowledged problems are concluded to be either TOS or known supply problems: **(a)** Temporarily Out of Stock (TOS) is communicated by MP or the direct suppliers when a product has known unavailability for more than 48 hours. A cause of TOS is out of stock at the providers due to production mistakes, capacity constraints, packaging upgrades or material scarcity. Forecast errors in the supply chain can also result in TOS due to insufficient service contracts with providers. OR continues the ordering process for products with known unavailability to ensure these products are delivered immediately after re-availability. This results in products being registered as supply deviations, although they were already acknowledged deviations at time of ordering. **(b)** Known supply problems (KSP) are deviations caused by unpredicted unavailability. Although the unavailability was unpredicted, these causes are categorized as KSP as their causes are registered and communicated to OR. Several reasons are defined for products that are ordered but can suddenly not be supplied. The cause-codes of known supply problems that have been communicated to OR in 2018 are products not yet physically processed in DC, quality issues, pick zone issues and insufficient stock. Exact explanations of the cause-codes are given in Appendix 10.2.1.

2. Undefined causes

Undefined deviations have causes that are not specified by the supply network. They can either be (a) supplied shortly and have no known of specified cause or (b) supplied in excess which always has an undefined reason. Issues that lead to undefined deviations could be known intra-organizational, but this is not defined or communicated to the partners.

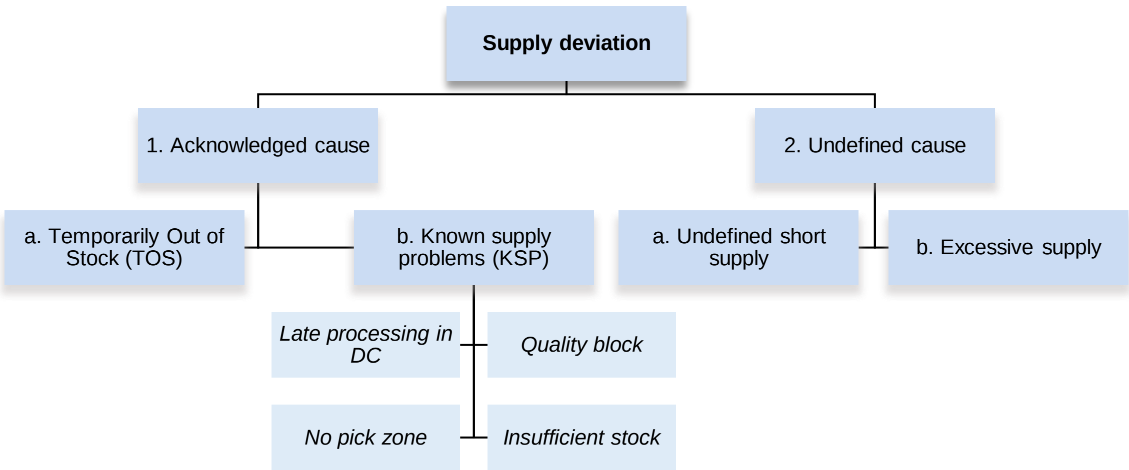

Figure 9 Cause typology of supply deviations at OR

This concludes that the problem is defined as deviations in the replenishment of OR, that include both excessive supply and short supply. These deviations either have acknowledged causes or undefined causes.

5 Network context analysis

This chapter focuses on capturing the current context of the problem. Insight in the current context helps the problem-solving analysis and is a valuable contribution to the network to substantiate future decision making. By reflecting the challenges identified in Chapter 3, the risks in the network context analysis are analyzed.

In this context analysis, the order fulfillment process is analyzed by means of an AS-IS analysis of the network. The AS-IS analysis follows the order through the supply network from customer order until customer consignment. This process crosses organizational borders as the replenishment of OR is supplied by MP and the direct suppliers. Currently, no diagrams of the network crossing organizational borders are available, which emphasizes the need of a thorough AS-IS analysis and implies the intra-organizational business focus. As the thesis scope comprises, the context analysis focusses on the collaboration between OR and MP, as MP is the most important and largest partner of OR. However, to ensure a complete understanding of the network, the basic flows between OR and the direct suppliers are included.

As described in the research methods in Chapter 2, the Zachman framework is used to determine the perspectives of the AS-IS analysis. The BOAT-framework used in the thesis scope points to the business management perspective and the architect perspective. In the business management perspective, the What? And How? questions are concluded relevant to clarify the context of the order fulfillment process. Zachman recommends a business process model and a conceptual data model. To emphasize the inter-organizational aspect in the models, it is chosen to model a conceptual data flow model. It will show the flow of the conceptual data in the network. As the order fulfillment is a logistics process, the Where?- and the When?- question in the business management perspective are also concluded relevant. It is results in a business logistical system and a master schedule respecitvely. In the architecture perspective, the distributed systems architecture is chosen to show the inter-organizational system architecture. In Table 1, the concluded perspectives are visualized in blue in the Zachman framework.

The diagrams were modeled based on 12 semi-structured interviews with experts with multiple perspectives on the network. The interview protocol is added to Appendix 10.2.2. Next to the interviews, daily observations have contributed to a thorough understanding of especially the business process flows and data flows. After modelling the diagrams, they were validated by the interviewees to ensure network wide confirmation.

	What?	**How?**	**Who?**	**When?**	**Why?**	**Where?**
Executive perspective	List of important things in the business	List of Business Processes	List of important Organizations	List of Events	List of Goal & Strategies	List of Business Locations
Business Management Perspective	Conceptual Data/Object Model	Business Process Model	Work Flow Model	Master Schedule	Business Plan	Business Logistical System
Architect Perspective	Logical Data Model	System Architecture Model	Human Interface Architecture	Processing Structure	Business Rule Model	Distributed Systems Architecture
Engineer Perspective	Physical Data/Class model	Technology Design model	Presentation Architecture	Control Structure	Rule Design	Technology Architecture
Technician Perspective	Data definition	Program	Security Architecture	Timing definition	Rule speculation	Network Architecture
Enterprise Perspective	Usable Data	Working Function	Functioning Organization	Implemented schedule	Working Strategy	Usable Network

Table 1 Zachman Framework (Zachman, 1987)

5.1 Business logistical system

The business logistical system depicts the physical logistical network including all DCs in scope and the corresponding product streams. To minimize the diagrams' complexity and to tailor the diagrams to description goal, no specific modelling language was used. The attributes of the diagrams are described.

The business logistical system diagram, in Figure 11, shows the complexity of the physical logistics network which covers the entire country. The MP supply chain in scope of OR constitutes three regional DCs (RDC), a national DC (NDC) and four national DCs that are outsourced by MP (ODC). OR supplies their physical stores by the DC's that supply OR and other DCs (DC n). OR produces online customer orders in four RDCs and three NDCs. Many hubs and pick-up points are used to achieve the national delivery range. The solid lines signify direct replenishment streams and the dashed lines resemble the cross-dock streams. Products are grouped in streams, represented by the different colors, taking the supply frequency, the product type, the DC and other factors into account. Per stream, a team at MP is responsible for managing the collaboration with the corresponding suppliers of the supply network and for the replenishment of MP's DCs. The streams and color coding are described in Appendix 10.2.3.

5.2 Master schedule

The master schedule depicts the structural logistical schedule of the order fulfillment process. It aims to show the rapidity of the logistical operation in the network. A visualization of the logistical master schedule is given in Figure 10. To tailor the master schedule to the description goal, the schedule is modeled in a timeline based on no specific modelling language. To avoid extreme complexity in the master schedule, it simplified to the two production shifts, morning production and afternoon production, with one perishable supply stream and one non-perishable supply stream.

Customers can order up to four weeks until one day at OR before the customer delivery. There are two production shifts and two delivery shifts per day. In morning production, the customers are delivered on the same day. Afternoon production is delivered to the customers on the next morning. Before every production, where the customer orders are picked, and for every stream, a specific order moment (OBM) is determined where OR sends the replenishment order to their suppliers. On pre-determined moments, the products are shipped to the OR DCs. For non-perishables (NP) and perishables (P), the determined time windows differ as perishables have a shorter life cycle. The activities in the master schedule repeat daily and include more than 30 different incoming flows and order moments. As the figure clearly shows, the time window between the order moment, the arrival of the supply and the picking and delivery for the customers is very short, especially for perishable products, and all within three days. When supply deviations are detected on arrival at OR, there is only less than a day for non-perishables and a couple of hours for perishables to rectify deviations in order to avoid customer impact. Accurate supply is of the utmost importance to deliver online customers.

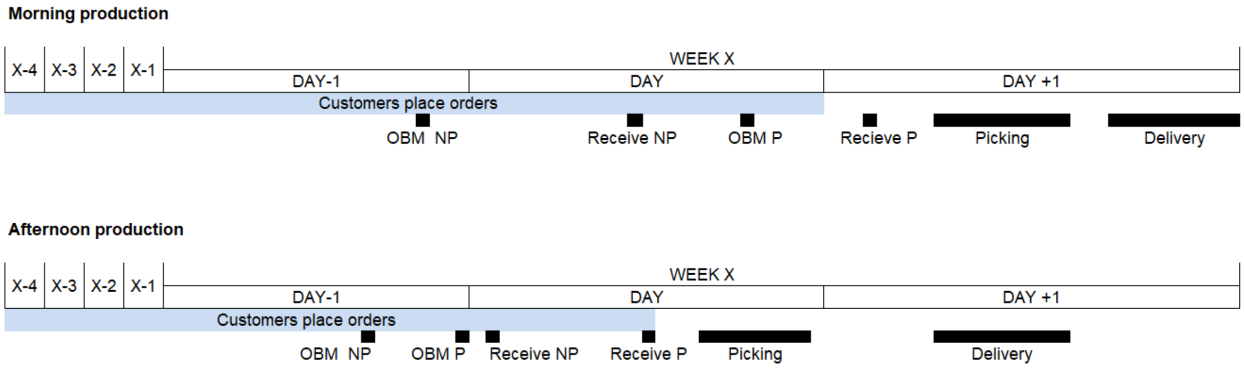

Figure 10 Simplified master schedule of logistical network operations

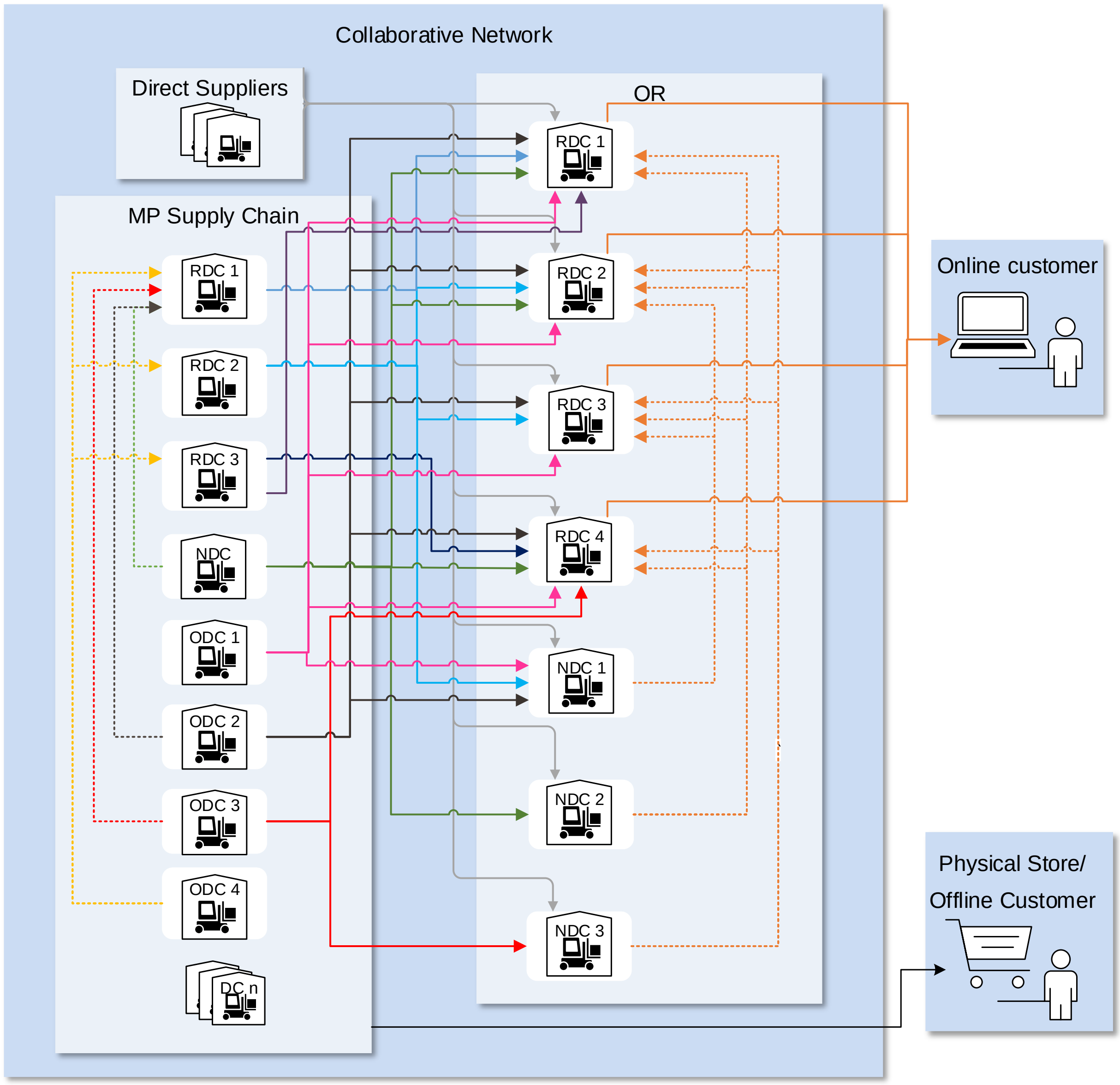

Figure 11 Logistical system diagram

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5.3 Business process model

The business process model is modeled by following Silver's method, because it leads to a complete BPMN model in a consistent, well-structured way (Silver, 2012). It aims to reach the principles of a 'good BPMN model': completeness, clarity, shareabililty between business and IT and structural consistency. The phases in Silver's method are visualized in Figure 12.

Figure 12 Phases of business process modelling (Silver, 2012)

First the process scope was defined. As apprised by the research scope, the model starts with an online customer order and is completed when the order arrives at and is paid by the online customer. It is assumed that there is always a customer delivery, either in full or partly. Then, the high-level map enumerating the major activities was conducted based on observations:

- Customer creates order
- OR creates replenishment order
- Supplier produces replenishment
- Supplier ships replenishment
- Supplier evaluates performance
- OR processes inbound supply
- OR produces customer orders
- OR ships customer orders
- OR evaluates performance

As Silver (2012) states, each high-level map activity becomes a sub process in the diagram. First the 'happy path' is considered after which the exception paths are added. Although Silver (2012) recommends no swim lanes in top-level diagram, as the process exceeds organizational boundaries swim lanes are added to ensure completeness and clarity. For the same reason, and as the order fulfillment process is highly dependent on the data flow, the most important systems of processes are indicated by the grey blocks.

Business process diagram

The business process diagram in Figure 13 shows the result of Silver's method. The main elements of the process are described below, and a more detailed business process flow description is added to Appendix 10.2.4.

The order fulfillment starts when online customers have ordered and all orders per delivery moment are consolidated. Based on the current stock, the WMS of OR generates a replenishment order, which is submitted at the specific order moments. For every production shift at OR, a new replenishment order is created. Orders are automatically distributed over the suppliers. At MP, first a transportation planning is created, including the volumes per truck. At the moment the warehouse production is released, the actual inventory is verified and orders that could not be fulfilled are summarized in the store order deviation message (SODM). After production, the suppliers create a shipping notification for the shipment, which is converted by MP to an EAB per DC of OR, containing all products supplied according to the supplier. MP tracks the performance of their DCs per day, which means in total for replenishment of OR and all physical stores. The replenishment KPI's of MP are summarized in Table 3.

Supply arrives at OR following the logistical schedule described in Section 5.1. During the storing activity at OR, the supply is checked-in into the WMS of OR. After complete check-in, the WMS derives a list with deviations between the order and the checked-in supply. This data is used to manually recheck the accuracy of the check-in and the supply. In case large deviations are discovered, this is escalated to the preparation department. When supply is stored, the picking activity of the previous shift is performed at the same time.

After customer orders are picked, a NA check is performed. A product in the order of the online customer that cannot be delivered to the online customer is defined as a NA. The NA check verifies that the products stated to be unavailable for order fulfillment during picking activities, are valid. Then, shipments from OR DCs are consolidated and delivered to the customer. The customer pays at the driver during delivery for the products that are delivered.

Performance measurement process at OR focuses on customer-centric service levels. In Table 2, the three key performance indicators (KPI's) of OR are listed. Supplier performance is weekly measured and registered. The supplier performance measurement process is not structurally designed as feedback to the suppliers but is communicated to the management of OR. The service levels are calculated by the following equation:

$$S\%\ week\ x\ per\ stream = \frac{Total\ negative\ supply\ deviations\ of\ week\ x}{Total\ orders\ in\ week\ x}$$

KPI MP replenishment	Description
Service level (S%)	The supplied percentage of the demand. The service level is measured per day per DC, which means in sum for OR and all stores by the following equation: $S\%\ day\ x\ per\ DC = \frac{Realized\ in\ colli}{(realized\ in\ colli\ +\ acknowledged\ deviations)}$
Availability	The % of (offline) customers per day that ran into a shelf with more than 1 product available.
Shop image	% of shelves with stock above acceptable norm
Annulments	The total of annulments and write-downs in relation to sales

Table 2 Replenishment KPI's of MP

KPI OR	Description
Order Completeness	Percentage of orders that are completely fulfilled
Website Availability	Percentage of hours that the products are available on the website.
Freshness complaints	Percentage of products without any freshness complaints

Table 3 Three main KPI's at OR

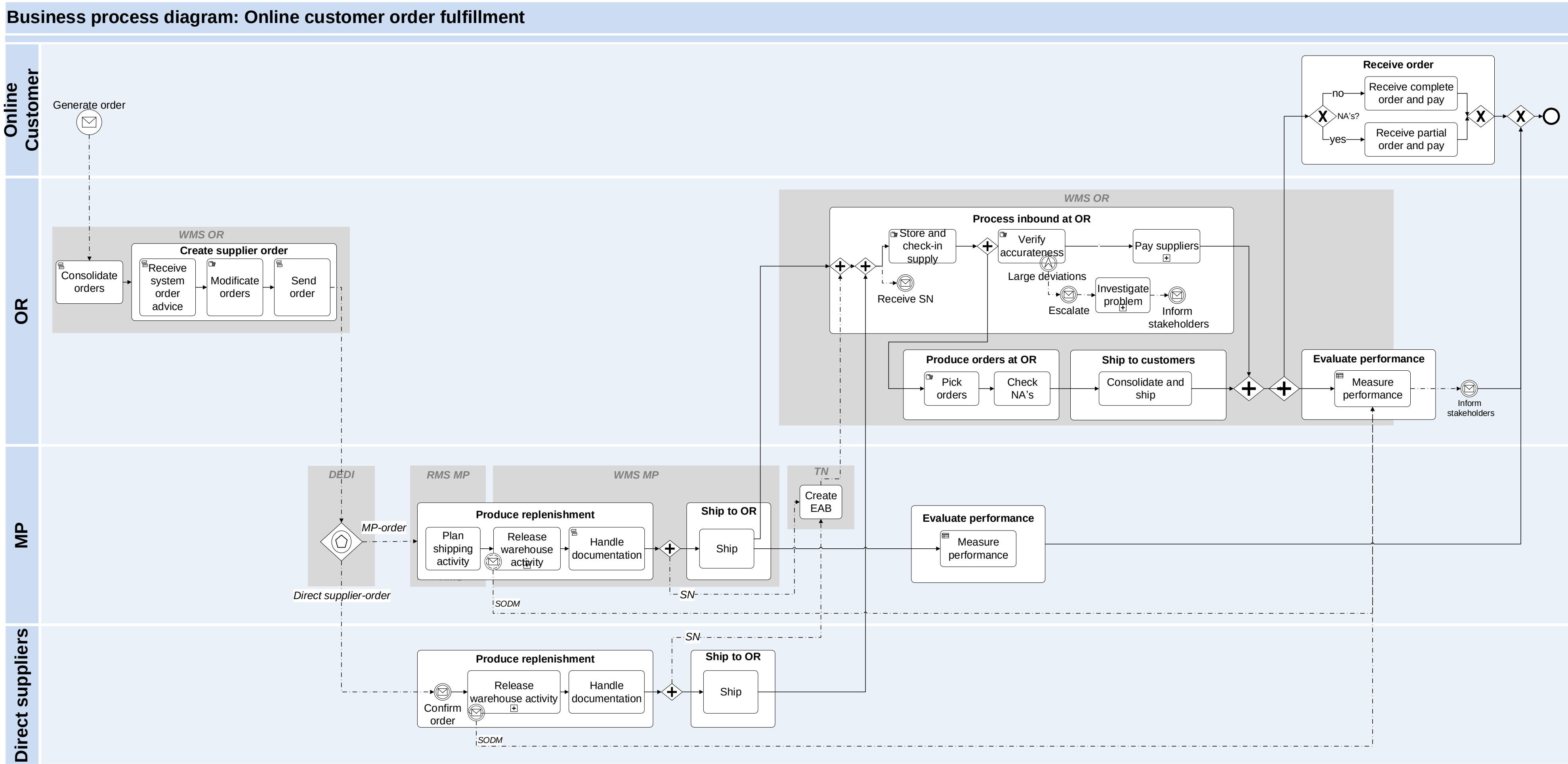

Figure 13 Business process diagram

5.4 Conceptual data flow model

The inter-organizational conceptual data flow is visualized by data flow diagrams (DFD). These are diagrams that show the flow of data or information from one place to another (Aguilar-Saven, 2004). By focusing on the inter-organizational data flows, it provides context to the network problem. The steps visualized in Figure 14 are commonly used in designing the conceptual data flow diagram. The highest level, the context diagram, functions as an overview. As typically more detail is needed for analysis, Level 0 is modelled to identify the most important data flows.

Figure 14 Phases of DFD modelling

First the list of activities in scope of the conceptual data flow diagram is created, following the main activities in the business process diagram. As shown in the business process model and the network structure diagram in Figure 7, performance data is intra-organizationally shared and therefore not included in the conceptual data flow diagram.

Conceptual data flow diagram

The following Figure 15 shows the context diagram. In the customer order fulfillment process, three entities are considered: the customer, OR and the supply network. OR develops a customer demand forecast (CDF) to ensure accurate replenishment and complete fulfillment of customer demand (CD). For the same reasons the supply network develops a store demand forecast (SDF) which includes OR and aims to fulfill the warehouse demand (WD). All entities share product availability and financial data. The level 0 DFD is added to Appendix 10.2.5. In this diagram, the provider entity is added to better visualize the data flow of the forecasts. The supply network communicates the warehouse demand forecast (WDF) to the providers to ensure daily orders are expected.

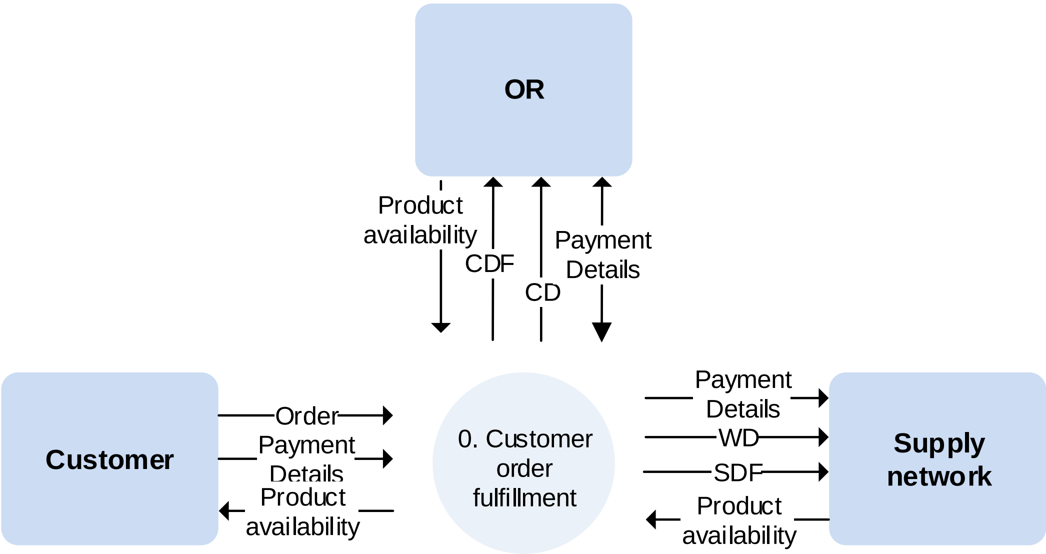

Figure 15 Context level conceptual data flow diagram

5.5 Distributed systems architecture

Grefen's three-dimensional design cube provides a design space or context for a specific architecture design process, with special focus on the structural development of models in a complex environment (Tummers, 2017). Therefore, the design cube is used to scope the distributed information system architecture. The concluded dimensions are elaborated on in Appendix 10.2.6 and summarized in the following Table 4.

The goal of the IS architecture is to identify the function of the ISs within the order fulfillment process and their interaction. Therefore, it is chosen to focus on a black-box aggregation level. This indicates the most aggregated architecture view. For the same reason, the case type components are considered. These components describe an abstract view on the general software system classes and their functionality. The realization dimension follows the conclusions on the BOAT-framework in the scoping of the master thesis. The architecture will focus on the function of the ISs in the order fulfillment process, hence, the chosen aspect dimension is the process aspect.

Dimension	Conclusion
Aggregation Dimension	Level 1: a black-box
Abstraction Dimension	Level 1: class type components
Realization Dimension	Level 3: Architecture Perspective
Aspect Dimension	Process aspect

Table 4 Conclusions of three-dimensional design cube (Grefen, 2016)

No notorious modeling method for system architecture is found, hence, it is chosen to model the architecture by basic shapes to limit complexity. The legend of the diagram is shown in Figure 16.

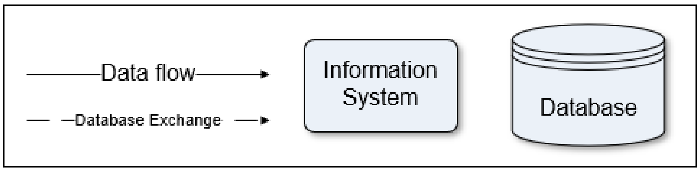

Figure 16 Legend of distributed IS architecture diagram

Distributed systems architecture diagram

As the scope of the research follows the order flow, the complete detailed distributed information system architecture of the order flow is given in Appendix 10.2.7. It shows and describes the interaction between the databases and systems starting at the generation of a replenishment order at OR. The diagram ends with the shipping notifications arriving at OR and in the financial systems of the network.

A distributed systems architecture diagram that is scoped to the interaction between the OR and MP systems is visualized in Figure 17. It shows the databases, IS systems and data flows that operate inter-organizational. The timings of the data flows are indicated in the diagram as it clearly shows misaligned data processing flows.

The warehouse management system of OR has several main functions in the order fulfillment processes: (1) It collects the customer orders and corresponding customer data, (2) it tracks stock levels of the DCs, (3) it manages picking and filling operations at the DCs via barcode scanners, (4) it generates and sends the replenishment orders.

The data used in the WMS is based on two databases: the main product database (PDB) managed by MP and the advanced product database (APDB) managed by OR itself. The PDB contains the product master data of the entire MP assortment. It directly communicates the logistical parameters of the product, including the supplying DC, the product stream and product availability, to the WMS by an overnight transaction. In the APDB, OR enriches the product data of the PDB by adding a website name, photo and other data necessary for the e-commerce. The APDB communicates the product parameters to the WMS via a near real time connection and an automatic overnight transaction as a safety net.

The warehouse management system of OR sends the replenishment order to demand distribution system of MP (DEDI). This system receives standard order messages and collects, verifies and distributes the orders to the information systems within MP. Depending on the capacity of DEDI, it takes several minutes for the order to be received. DEDI verifies order quality, ensuring products are ordered on the correct product stream. If DEDI cannot match an order line with the data from PDB, the order lines will be rejected. DEDI is updated around 7 hours before the WMS is updated, and exactly during this window most orders are placed (between 10:00 and 23:45).

The internal IS structure of MP also passes on replenishment orders to the direct suppliers and shipping notifications from the direct suppliers using electronic data interaction standards (EDI). An EDI is an automatic electronic data interchange between computers of different organizations, resulting in structured communication and all MP systems are fully geared to communicate with suppliers through EDI.

As mentioned, the internal IS structure of MP is further described in Appendix 10.2.7.

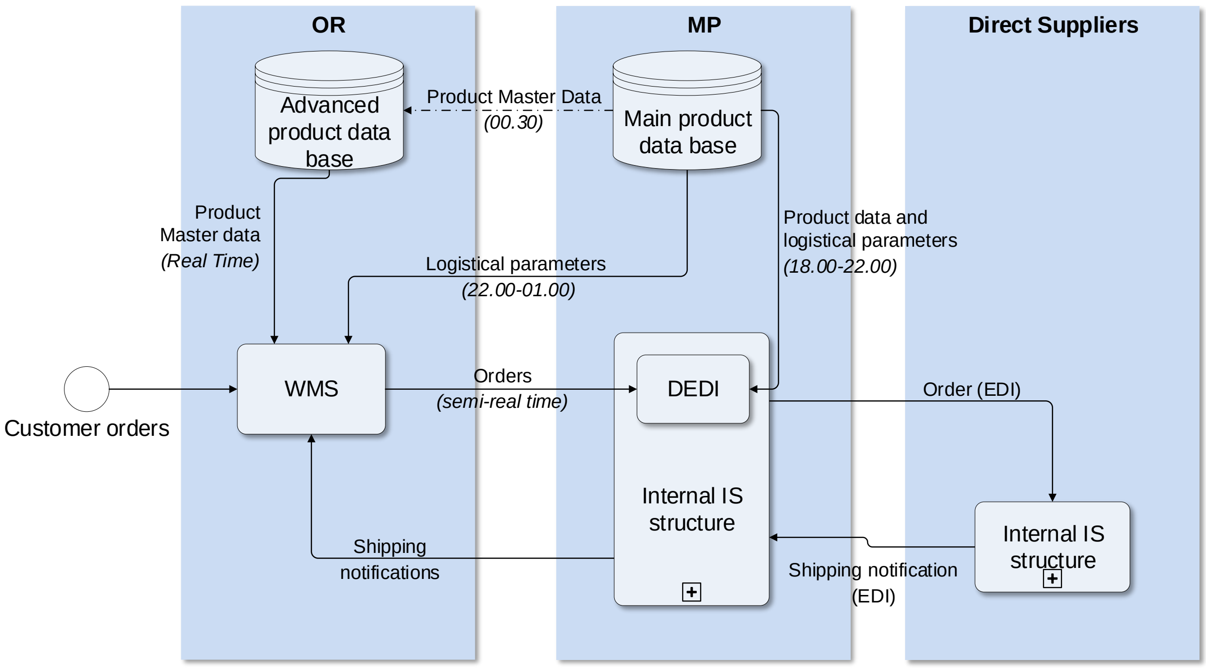

Figure 17 Scoped distributed IS architecture diagram

5.6 Conclusions

The resulting diagrams of this chapter benefit to the insight of the inter-organizational collaboration, because diagrams crossing organizational borders were non-existing. Moreover, the interviewees had firm knowledge about the responsible aspect of the order flow, but know-how on cross-organizational process overviews and corresponding cross-organizational impact of actions was limited. By means of the inter-organizational collaboration challenges identified in Chapter 3, the risks in the current network situation are analyzed. The AS-IS analysis follows the five concluded domains from the article pool. The conclusions guide the root-cause analysis of the network problem or will guide any other future problem investigations and interventions.

1. IT management

The business process diagram shows that the order flow in the order fulfillment process is highly dependent on the interoperability of the different ISs. However, architecture diagram shows that the ISs and databases are intra-organizational focused and interact via (structured) data messages. This means that the network highly depends on the quality of the product data to ensure the interaction between the systems is seamless. Especially the two databases with different owners strongly increases the risk of insufficient data quality and therefore the risk of misalignment between the ISs. Next to that, Figure 17 shows the different processing windows of data between the databases and ISs, which also poses risks to misaligned ISs. Another business-IT misalignment that results in unnecessary supply deviations is the time gap between the inventory verification at MP's warehouses and the actual shipment. A product is communicated unavailable immediately after release of the warehouse activities and coded as an acknowledged supply deviation. However, the actual shipment to OR is hours after the release, in which time supply could arrive resulting in product availability and higher order completeness.

For these reasons, business-IT alignment is concluded to be an important challenge in the current network. Especially due to the fast and dynamic environment of the e-commerce. If attempts are considered to improve business-IT alignment, the network must note the challenges of IT implementation. Several factors of acknowledged by Karvonen (2016) that complicate IT implementation are found in the network: There exists a large autonomy between the organizations and there is additional complexity due to units, functions and locations. System security is not identified as a challenge in this network.

2. Relationship management

Although the network is categorized as an extended enterprise, the interviews showed that there is a lack of knowledge about cross-organizational or even cross-departmental dependencies or activities. OR used to be a small part of the network, but as the e-retailing market is growing intensively the importance of the online operation must be acknowledged. As Ylitalo (2006) concluded that challenges in managing a successful network relationship mainly occur when there is a multi-side set-up, MP and OR need to attack this challenge and improve collaboration.

3. Knowledge management

Naturally, knowledge management is a challenge in the e-commerce business. From the interviews that resulted in the AS-IS analysis, it was concluded that the willingness of sharing knowledge is no issue in the investigated network. However, it is concluded that knowledge sharing, and data quality can be improved in the current network.

Knowledge sharing in the order fulfillment process can improve the generation of forecasts and the management of product availability. By merging the knowledge of the partners, supply problems can be reduced which largely impacts the order fulfillment completeness:

- As shown in the conceptual data flow diagram in Figure Figure 15, forecasts are generated intra-organizational and communicated to the supplier or provider. The accuracy of all forecasts can be increased by sharing the factors that may influence forecasts. By a more accurate forecast of online reservations, the suppliers can optimize their replenishment strategy which will result in fewer acknowledged supply problems.

- As customers can order as of 4 weeks before delivery, an increase in structured sharing knowledge about the product availability would result in better customer order management by OR and therefore increase the customer order completeness.

Due to the dependency of system interactions seen in the distributed IS architecture model, the quality of data is essential to achieve a seamless order fulfillment flow. The quality of the product master data and the corresponding logistics data is the input for the entire network operation. Vermeer (2000) proved that although EDI increases the structure of communication, usage can also lead to negative impact on process performance in case of insufficient data quality. The structured data messages between OR and the suppliers can be compared to the usage of EDI. It also intends to achieve structured communication, hence the same conclusions concerning data quality apply. At OR no structural processes to identify or measure data quality are found.

4. Performance and Risk management

As concluded by Lethinen (2010), the use of intra-organizational performance measurement in the context of extended enterprises can lead to suboptimal or even disastrous results. Unfortunately, this situation is identified in the network. The KPI's of OR are not aligned with the replenishment KPI's of MP. Next to misaligned goals between OR and the replenishment by MP, the method of measuring supplier performance at OR also leads to inaccurate results as seen in the service level calculation. Identified issues are:

- No difference between acknowledged problems and undefined problems
- Excessive supply is not considered whilst these do cause buffers or capacity issues
- The performance per DC is not calculated
- Reliability of check-in inaccuracy in not considered

The DC performance measurement calculated by MP is not weighted nor complete. Deviations in supply have a larger impact on the online customer compared to the offline customer. The online customer already ordered the products whilst the offline customers are more likely to choose a different product in case of unavailability. This difference in impact is not considered in the performance measurement of the DCs. This is also seen in the perception of MP on OR, as in most processes OR is seen as a large physical store whilst it must be acknowledged that e-retailing has many different opportunities and challenges.

The little flexibility and the dependency on suppliers due to the speed of the process visualized in the master schedule in Figure 10 increases risks of errors impacting the customer. The logistical master schedule shows that there is no flexibility to correct mistakes which increases the need to preventively manage risks in the fulfillment process.

Although the quality of the supply is verified by sampling activities at the supplying DCs, the exact impact on the online customers is unknown for all network partners. The check-in activity at OR provides data on the quality of supply, but the extent and causes of deviations are not tracked. Only incidental large deviations identified by operations are investigated with the goal to prevent a structural problem.

5. Sustainability management

The extent of transportation in the network could be evaluated in perspective of sustainability. Responsibility of sustainability is becoming an important challenge, mainly due to the national and prominent existing of the brand.

6 Network problem analysis

This chapter describes the analysis into the supply deviations problem at OR. The previous chapters have defined the problem and the network (Chapter 4) and have described the current state of the order fulfillment process (Chapter 5). The objective of the detailed problem analysis is to discover the root-causes of the problem. These root-causes will guide the solution design for the problem. The scope the network problem analysis, the network is further scoped to the replenishment in the order fulfillment process of OR by MP. This is indicated in Figure 18. The network problem analysis contains two analyses: a data analysis and a root-cause analysis.

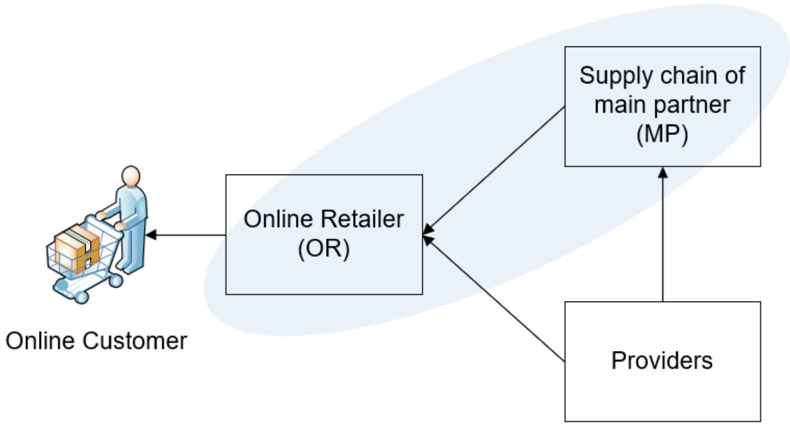

Figure 18 Rescoping of high-level supply network structure of OR

Firstly, a data analysis is performed. The results of the data analysis are especially interesting for the network in scope as they contain detailed insights. Therefore, the data analysis is described in Appendix 10.3, specifying the methodology, the data collection and the results comprehensively. In the thesis research, the data analysis is used to (1) substantiate the need for a root-cause analysis by determining the impact on the performance of the network. (2) further scope the root-cause analysis, which is required due to the restrictions of the master thesis and the extent of a root-cause analysis in the network collaboration. This is done by the identification of trends in deviations in general causes, in DCs, or in product streams. The conclusions are described in Section 6.1.

Secondly, the root-causes of the supply deviations are uncovered by means of a root-cause analysis described in Section 6.2. This chapter ends in Section 6.3 with a conclusion on the network problem.

6.1 Trends in supply deviations data

A data analysis into the supply deviations data is performed and added to Appendix 10.3. The conclusions relevant for the root-cause analysis are discussed in this section. First, the impact is described. It substantiates the need for further research. Second, the discovered trends are described. These are used to scope the root-cause analysis in the following section.

6.1.1 Impact of supply deviations

The impact of supply deviations is measured by the customer impact, by the impact on NA's and on the KPI's, and the extent in which deviations occur in absolute and relative terms.

As previously defined, a product that is ordered by an online customer but cannot be delivered is one NA. NA's can be internally caused due to for example breakage or shelf live expiration. It can also be externally caused, by the supply deviations. Based on the results of 2018, on average there are 15.000 NA's per week. 67% of these weekly NA's are caused by supply deviations (Figure 19).

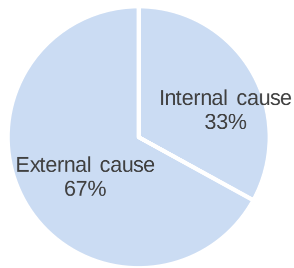

Figure 19 Distribution of NA causes

By means of simple linear regression the relation between short supply and the KPI's, order completeness and website availability, is statistically examined. For order completeness, the relation with short supply was significantly proven ($r(32) = 0.41$, $p<0.05$). The relation between website availability and supply deviations is concluded insignificant ($r(32) = 0{,}31$, $p > 0.05$). This indicates that other additional factors impact website availability.

As described in the cause and effect diagram in Figure 8, not only the customer is impacted by deviations. Short and excessive supply also results in inefficiencies in the inter-organizational process. An overview of the extent of the deviations is given in Table 5. It shows that 3.5% of the total OR replenishment deviates from what was ordered. This constitutes an average deviation of 36.000 colli per week, containing around 200.000 customer unit sizes. A colli is the standard logistical packing unit. The deviation percentage in 2018 is slightly higher than in 2017, probably related to the 6% increase in replenishment volumes. This implies that the higher the replenishment volume, the higher the probability on deviations.

The impact analysis concludes that on average around 10.000 products per week cannot be delivered to customer due to supply deviations, which significantly impacts the order fulfillment KPI of OR. On average 5000 colli per week is supplied in surplus, which negatively impacts operations at all network partners. The benefits of research into the causes of supply deviations and solutions are therefore demonstrated. It must be noted that the data has several limitations. However, the impact on online customers is significant and the conclusions prove the need for investigation into the data quality of supply deviations.

	Week 1-36 2018		**Week 1-52 2017**	
Average weekly short supply	30.804	85%	26.973	83%
Average weekly excessive supply	5.302	15%	5.366	17%
Average weekly deviation	36.105	100%	32.339	100%
Average weekly order	1.046.127		979.888	
Average weekly deviation % (=deviation/total order)		**3.5%**		**3.3%**

Table 5 Extent of supply deviations

6.1.2 Trends in supply deviations

Trends in deviations and causes are investigated to direct the root-cause analysis. They are compared in total and between product streams, supplying DCs, and receiving DCs.

Interesting conclusion drawn concerning the trends in deviations:

- The data analysis concluded on the variation in the relative deviation varying from 2.4% to 4.5% over the weeks of 2018. This average weekly variability of 7500 colli proves that the problem is influenced by multiple factors and incidental issues.
- Although grocery sales are highly seasonal (Pierre, 2017), there is no seasonality detected in the relative deviations.
- There is a significant difference in deviations over the weekdays: on Tuesday, Wednesday and Saturday the relative deviation is the highest. This significant difference is only seen in the deviations received at NDC2.
- Based on the higher deviation percentages of the receiving NDCs compared with the receiving RDCs, it is concluded that the probability of mistakes increases with the number of different products to be supplied.

The data analysis into the causes uses the cause typology defined in Section 4.2. It concluded that a supply deviation has either an undefined cause or an acknowledged cause. In Figure 20, the concluded distribution of these general causes is shown. Interesting conclusion drawn on the trends in causes of deviations:

- 62% of all weekly deviations are caused by acknowledged causes. As the causes are known, attempts to minimize these acknowledged problems would benefit the performance of OR.
- A shocking 38% of the weekly deviations has an undefined cause. Excluding excessive deviations, which always have an undefined cause, 24% of the deviations is undefined.

Although the variations on supply deviations hint to the type of root-causes of the problem, it does not conclude on obvious trends. However, the distribution of the causes clearly shows a high share of undefined causes. Performance of the network would clearly benefit from insight into and a reduction of these undefined deviations.

The previous section has proved the impact of the problem based on the current data. In this section, the large share of undefined causes has been identified. Therefore, the root-cause analysis will focus on uncovering the undefined causes. Again, it must be noted that the quality of the deviation data is limited. However, resolving the undefined problems is the first step of improving the quality of the data.

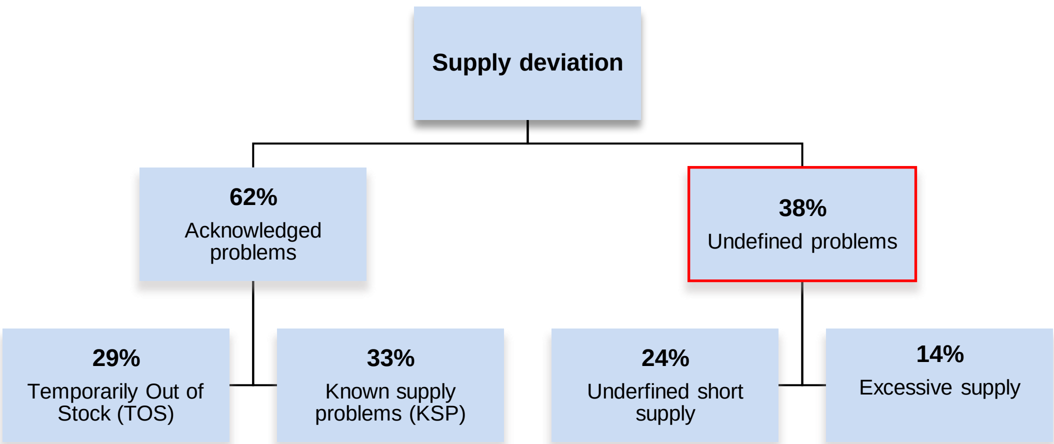

Figure 20 Results of data analysis into concluded cause typology

6.2 Root-causes of undefined supply deviations

In this section, root-causes of the undefined supply deviations are investigated. These root-causes will guide the solution design of the problem. The structure of the root-cause analysis and the according sub-sections are visualized in Figure 21.

The root-cause analysis performed in this master thesis consist of three steps:

1. Identify general root-causes by expert brainstorms
2. Impact evaluation of general root-causes by impact sample analysis and expert ranking.
3. Identify detailed root-causes into network process and systems.

In section 6.2.1, the first step is described. The general root-causes are discovered by structured brainstorms with experts. Not all these identified root-causes can be investigated in detail within the boundaries of the master thesis description. Deeper process and system understanding is required. Therefore, in step 2, each root-cause is evaluated to determine which root-cause is prioritized in the detailed root-cause analysis in step 3. The impact evaluation per root-cause is based on two analyses: (a) An impact sample analysis on product level which measures the impact of the discovered cause on the performance of OR. (b) An expert judgment analysis which qualitatively concludes on the most impacting causes. The evaluation is described in Section 6.2.2. In step 3, a more detailed root-cause analysis is performed for three general root-causes. The conclusions of the detailed root-causes are described in Section 6.2.3. The root-cause analysis ends with a conclusion on the root-causes of undefined supply deviations in section 6.2.4.

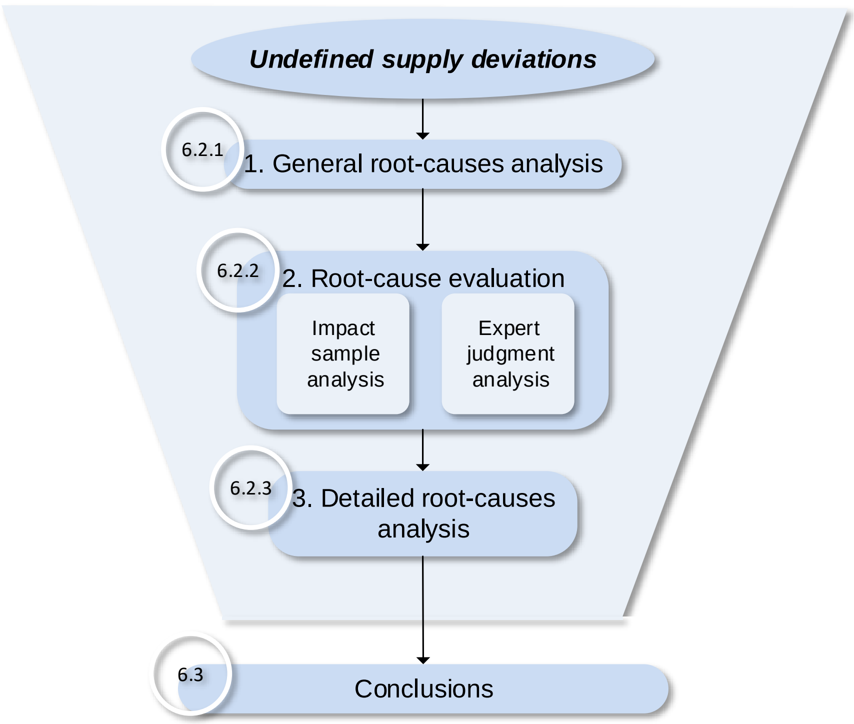

Figure 21 Structure of root-cause analysis

6.2.1 General root-causes of undefined supply deviations

In this section, a list of general root-causes of undefined supply deviations is created. First the methodology is described. Then, the results are concluded in an Ishikawa diagram.

Analysis Methodology

Figure 22 shows the methodology used to discover the general root-causes.

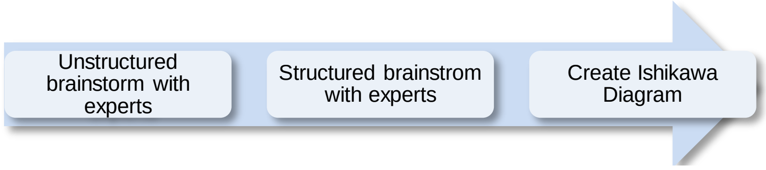

Figure 22 Phases of general root-cause analysis

First, during several unstructured brainstorms with the problem holders and the supply network, undefined causes of deviations were discussed. In the second half of the brainstorm, the discussion was structured by an integrated approach following the business process flow and distributed systems architecture modeled in the AS-IS analysis. The brainstorm has the same goals as a focus group, however according to Greenbaum (1993) “a focus groups consist of a discussion of approximately 90 to 120 minutes, led by a trained moderator”. Hence, the complete requirements of a focus group where not met and therefore the term brainstorm is used.

Since the problem covers different organizations, selecting experts is challenging as none oversee the complete process. For that reason, it is chosen to first focus on the problem holders. The AS-IS analysis showed that they have investigated large deviations. Hence, they considered to have the most insight in the complete impact of the problem and of all causes. The DCs of OR acknowledge the supply deviations and report them, but they do not investigate the cause of the problem. Hence, these stakeholders are not part of the brainstorms. It is acknowledged that the network partners can have valuable input and will therefore be visited in the detailed root-cause analysis in phase 3. Seven brainstorm sessions where held with 8 experts of the preparation department. The participants and coding (B1-B7) are listed in Appendix 10.4.1

Results of general root-causes analysis

From the brainstorms and the document analysis, several causes are concluded, and they are visualized in the Ishikawa diagram in Figure 23. A brief explanation per cause is given below, including the coding of the analysis. Some causes do not result in physical supply deviations, but in administrative supply deviations. Inaccurate stock levels impact the replenishment process. Hence, they cannot be neglected. **Therefore, they are referred to as perceived deviations**. The order of the list does not indicate impact or size of the problem.

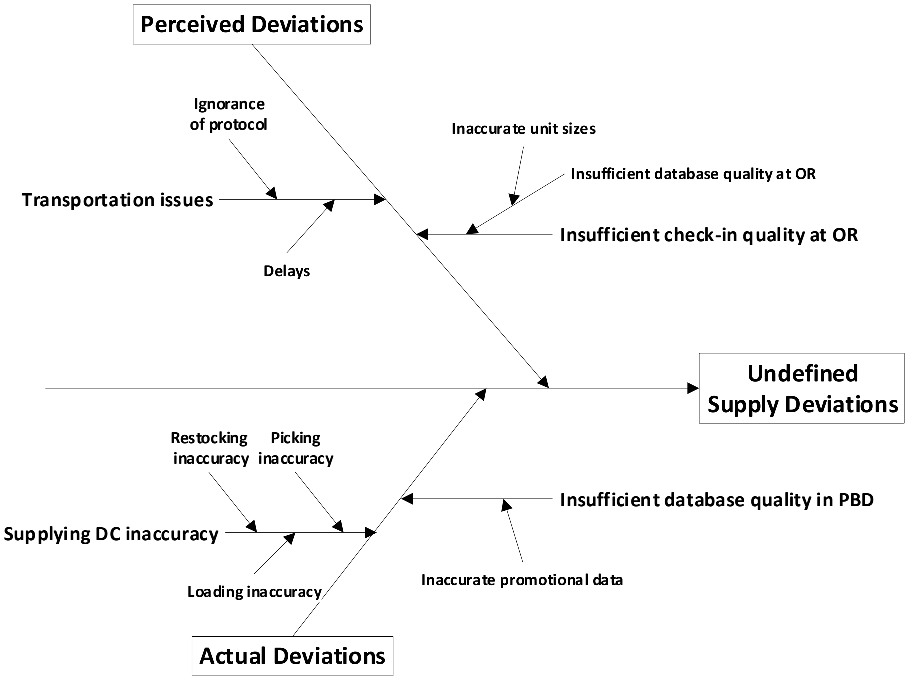

Figure 23 First-tier causes Ishikawa diagram

Insufficient data quality

Insufficient data quality causes disruptions in the order flow and perceived supply deviations [B1, B3, B4, B7]. Database issues identified are:

- Insufficient check-in quality at OR
  Supply is manually checked into the WMS of OR. Due to the human aspect, the time restrictions and the volumes of supply, the check-in is considered an error prone process [B1, B2, B3, B4, B5, B7]. This cause results in perceived supply deviations, because in case of a check-in inaccuracy the product has physically arrived.
  - Insufficient database quality at OR: Inaccurate unit sizes
    In case MP substitutes unit sizes, OR still checks in with the regular unit size resulting in incorrect stock levels in the WMS. As there are no physical deviations, this causes perceived supply deviations impacting data quality and therefore next replenishments [B1, B5, B7].
- Insufficient database quality in PDB: inaccurate promotional data
  Promotional data is inaccurate in the product data base, resulting in misalignment between data and reality which impacts order fulfillment [B1]. In this case, insufficient database quality results in actual deviations.

Transportation accuracy

When trucks expected to arrive at OR deviate from schedule or when there is not enough capacity to unload, supply is not in time for the production shift and this could be registered as a deviation in supply [B1]. The just-in-time replenishment and production is highly dependent on the delivery schedule. Thereby, if truck drivers do not follow protocol on arrival at OR, loads could go temporarily missing [B5]. In this research, this cause is classified as perceived because the products are arriving but not in time.

Supplying DC inaccuracy

During production in the supplying DCs, inaccuracies can occur which result in supply deviations.

- Picking inaccuracy
  Picking is a manual process that could result in mistakes [B1, B2, B3, B5, B6, B7]. Inaccuracy in picking operations can lead to short supply, excessive supply or product shuffles. Product shuffles are suspected when for example X colli of buttermilk is supplied instead of normal milk [B1, B2, B3, B5]. Human inadvertence during picking or insufficient process and protocol design are root-causes for the picking inaccuracy.

- Restocking inaccuracy
  When a product is misplaced in the DC, this could also lead to product shuffles as only the location must be verified in the WMS during a pick in the DCs of MP [B1].
- Loading inaccuracy
  As trucks are loaded with around 50 load carriers and the logistics network exists of many cross-docking situations, there is a possibility that a load carrier is left behind. The mistake can be discovered when the load carrier is found in the DC, or when OR is missing a severe share of the supply. As OR receives a shipping notification with the total supply per supplying DC, it demands deeper document analysis in the transportation department to verify if all missing products originated from one truck [B1, B6].

Reflecting the discovered causes of supply deviations on the challenges found by literature in Chapter 3, knowledge management and IT management challenges are recognized in t*he insufficient data quality* causes. Supplying DC inaccuracies and transportation issues are operational risk challenges in which the partner is dependent on the other partners in the network. In the framework, the dependency was described in the risk management challenges.

6.2.2 Impact evaluation of general root-causes

The general root-causes of undefined supply deviations were uncovered in the previous section. As explained, not all these root-causes can be investigated in detail within the boundaries of the master thesis description. Therefore, the impact of the general root-causes are evaluated by two analyses:

a) An impact sample analysis on product level which measures the impact of the discovered cause on the performance of OR.
b) An expert judgment analysis which qualitatively concludes on the most impacting causes.

The impact analysis also substantiates the discovered premier root-causes. The combination of data and experts ensures reliable impact results. Both perceived deviations and actual deviations are considered because perceived deviations can also impact online customers by inaccurate stock levels.

a) Impact sample analysis

The impact of the causes on the network is measured by determining the impact on the externally caused NA's on product level. The level of detail is the difference with the impact analysis in Section 6.1. By investigating the external NA's instead of the supply deviations, the actual impact of the causes on the online customers is validated.

The analysis to determine impact is conducted based on a developed decision tree. This tree is designed based on the causes identified in the premier data analysis, an explorative impact analysis in weeks 15 and 16 (2018) to determine decision sequence and by validation on an in-house data analyst. The development of the analysis tree and the result can be found in Appendix 0.

Sample selection
The extent of the research required for a single product is time consuming and the weekly lists of products with externally caused NA's includes around 2000 products. Therefore, it is not within scope of the research to provide a cause analysis for all NA's and, hence, the concept of the Pareto Principle is applied. This principle states that 80% of the consequences can be explained by 20% of the causes (Dunford, 2014). It indicates that by resolving the causes for 20% of the products, 80% of all NA's will be solved. Since the total NA's are caused by a relative high number of products, a large percentage of products has low impact on the consequences. For this reason and due to the time required for a thorough analysis per product, the research focuses on 5% of the products with largest NA's per week, which sums 100 products per week. As can be seen in the Appendix 10.4.3, these products are directly responsible for 40% of the weekly consequences and resolving those causes will have even more

impact due to the Pareto Principle. The analysis is performed over three weeks, week 17, 18 and 19 in 2018, to increase reliability of the impact investigation. Note that the registered internally caused NA's are already excluded from the data selection. In total, the cause of 300 data points/products are investigated responsible for 19.379 NA's.

Although the decision tree systematically structures the analysis of the causes of the NA's, drawing conclusions based on data is not inclusive for several reasons. First, due to the dynamic environment, where most flows arrive twice a day and volumes are high, traceability on product level is difficult. Secondly, data does not uncover all possible reasons for deviations. Third, inaccuracies in picking or loading operations cannot be affirmed, only by crossing out all other possibilities. Therefore, the analysis will not conclude on those causes and it is expected that a severe share of the undefined causes of NA's will remain unconcluded.

Results of impact sample analysis

The cause distribution concluded from the sample is given in Figure 24. From all externally caused NA's in the sample, 80% is caused by *acknowledged supply problems*: 56% by KSP and 24% by TOS. Most NA's are caused by KSP as these are unexpected. TOS causes long-term unavailability; therefore, the customer reservations can be closed in advance resulting in fewer NA's. 97% of the known supply problems is communicated because of insufficient stock.

After the analysis using the NA decision tree, the conclusions show that 2% was caused by inaccurate store demand forecast (SDF) and product quality issues. These causes should have been communicated as KSP and are therefore not considered as undefined causes.

The 20% of the NA's in the sample are caused by undefined supply deviations. 39% of these undefined causes are due to *insufficient database quality*. This share proves the need of deeper analysis into data quality in the network. In 20% of the undefined causes, a structural product shuffle was expected. A structural product shuffle would indicate *restocking inaccuracy* at the suppling DCs as the picking operation is based on product locations. One structural shuffle over the three weeks highly impacted online customers. As expected, a significant large amount of the undefined causes of NA's (31%) could not be detected. This proves the value of the following expert judgment analysis.

From the sample, conclusions concerning performances per DC could be cond
ucted. However, the sample is concluded too small to substantially allocate responsibilities.

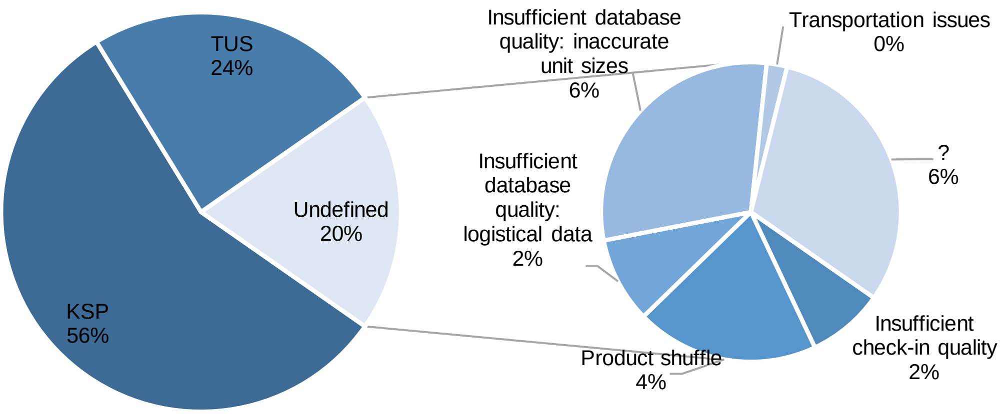

Figure 24 Cause distribution of sample including externally caused NA's

b) Expert judgement analysis

Human experts reduce uncertainty at both extremes: 1) when there is not enough good data, their informed estimates bridge gaps. 2) when there is too much data, they select the variables and models that are the most pertinent (Benini, 2017). The expert judgment method is chosen to qualitatively scope the problem to the most relevant causes of the supply deviations problem, whilst it also produces insights into the general knowledge of the problem by the holders. The process of expert judgment is visualized in Figure 25 and every step is elaborated on in Appendix 10.4.4. The experts are asked the following question:

> *Rank the discovered causes of supply deviations based on your opinion about their frequency and impact on order fulfillment performance at OR?*

The question mentions both frequency and impact to verify the complete impact of the cause. By verifying the impact on order fulfillment performance of OR both direct customer impact and indirect customer impact are taken into consideration. It is chosen to list the discovered causes with a short definition to be ranked. Since in the current process the causes are not tracked, the experts were asked about their opinion relying on their experience. As the scope of the problem exceeds some expert's view, the ranking is tailored to the expert group view.

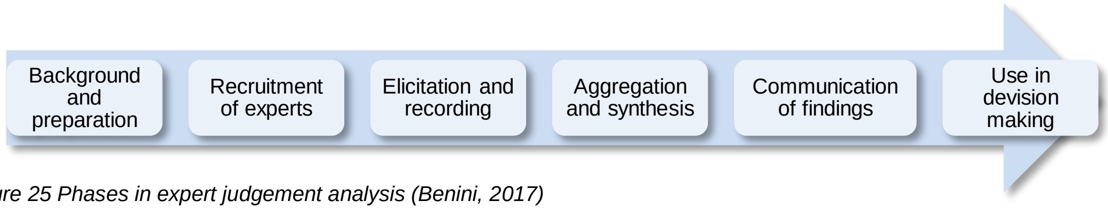

Figure 25 Phases in expert judgement analysis (Benini, 2017)

Results of expert judgment analysis

An overview of the results is given in Table 6. The complete results can be found in Appendix 10.4.5. The main conclusion is the high covariance of the ranking by OR. This indicates a high variation in the rankings proving the insufficient insight and knowledge about the supply deviations. Therefore, only about the expert perceptions can be concluded. *Transportation issues* are considered to have the least impact on the performance of OR as they are actively prevented due to the extreme impact in case of occurrence. Equal for *loading inaccuracy*, experts feel the occurrence is very low as they are aware of the high impact. What mainly can be concluded is the acknowledged *insufficient check-in quality*, as both OR departments point this cause as most occurring and impacting. The covariance of the network rankings was lower, which shows that the largest share of the deviations due to supplying DCs are caused in picking operations.

Deviation cause	OR problem holder		OR DCs		Network (MP)	
	RANK	SD	RANK	SD	RANK	SD
Insufficient database quality in PBD	3	0,98				
Partner inaccuracy: Restock inaccuracy	2	1,02	2	0,82	3	1,2
Partner inaccuracy: Picking inaccuracy	5	1,66	2	1,08	1	0,89
Partner inaccuracy: Loading inaccuracy	5	1,66	4	1,22	2	1,2
Transportation issues	4	1,56	5	0,43		
Insufficient check-in quality	1	1,63	1	1,73		

Table 6 Overview of results of expert judgment analysis

Conclusions on impact evaluation

The impact sample analysis and the expert judgement analysis gave insight into the occurrence and impact of the general causes of supply deviations on the performance of OR and were concluded to be highly complementary for two reasons:

1. Data is not inclusive
2. Experts ranked very variable indicating insufficient insight.

The following conclusions concerning the general root-causes of undefined supply deviations are drawn:

- According to the sample, *data quality* has proven to have a large impact on both perceived and actual supply deviations. Further root-cause analysis is required.
- The ranking by OR experts shows that they believe that the *insufficient check-in quality* highly impacts supply deviations data. Hence, the inbound process containing the check-in must be reviewed.
- Because the extent of picking inaccuracies at the partner DCs cannot be substantiated by the data analysis and because of the high ranking of the MP experts, a clearer view of the root-causes of *suppling DC inaccuracies* would give insight into the urgency and solvability of these problems. Next to that, the analysis showed a large amount of product shuffles which also requests further insight into MP's DC operations.
- As transportation is considered unimportant by the experts and has a low occurrence in the sample, therefore this cause is left out of scope in this thesis.

6.2.3 Detailed root-causes if undefined supply deviations

After the identification and evaluation of general root-causes causes, the following general root-causes are selected for detailed analysis

1. *Insufficient database quality*
2. *Insufficient check-in quality at OR*
3. *Supplying DC inaccuracy*

These root-causes are selected for the scope of this thesis research, because (1) the quantitative sample analysis showed that *insufficient database quality* has high impact on the deviations, (2) the ranking shows that experts have little believe in the *check-in quality at OR* and (3) the extent of *suppling DC inaccuracies* cannot be substantiated by the previous analyses and more insight into this intra-organizational process of the partner can be beneficial for the overall collaboration. Deeper analysis into the root-causes of these issues are discussed in this section.

1. Insufficient database quality

The evaluation has proven that *insufficient database quality* can cause actual and perceived supply deviations. The distributed system architecture diagram in the AS-IS analysis in Chapter 5 shows that the order fulfillment is highly dependent on the order flow between the intra-organizational systems. This means that all systems must be well aligned and require a high level of (product) data quality to avoid interruptions in the order flow. The SLR also concluded that data quality and business-IT alignment are critical issues for effective collaborative business processes, which strengthen the value of the investigation into these causes.

The data quality issues at OR and the network are investigated by a deeper root-cause analysis of data problems that resulted in supply deviations. Huner (2011) described a method-based process of identifying business critical data defects because “data defects and their business impact have rarely been investigated in scientific studies”. Inspired by the study of Huner (2011), this root-cause analysis consists of three phases which are described in detail in Appendix 10.4.6 An overview of the results is given in Table 7.

Data Attribute	Data defect	Result	Source Issues	NA's in sample	Root-cause
Logistical product data	Inaccurate PDB	Orders disappear in the supply chain resulting in supply deviations	D3, D7, D8, D9, D11, D14, D16, D17	+- 3400	**Insufficient data base quality in PBD**
	Last minute data modifications in PDB	Misalignment in the system landscape	B2	/	**Business-IT misalignment**
	Function in WMS of OR can incorrectly overrule product data base	Orders are blocked by DEDI resulting in supply deviations	I1	+- 100	
Unit sizes	Inaccurate unit sizes in WMS of OR in case of MP substitution	Inaccurate administrative stock levels resulting in incorrect future replenishment and impact on website availability	B3, D5, D6, D10, D12, D13	+- 2200	
Product relations	Inaccurate unit sizes at WMS of OR due unknown product relations		D1, D2, D15	+- 750	

Table 7 Concluded data defects including data attributes and root-cause

Conclusions

The Ishikawa diagram in Figure 26 contains the conclusions of the root-cause analysis.

All defects involving the logistical product data result in actual deviations. Either the product data base was incorrect, or the ISs allow modifications due to which the order flow is interrupted. The latter are clear examples of business-IT misalignments.

Incorrect unit sizes and missing product relations in the WMS of OR are not caused by insufficient database quality but are business-IT misalignments that result in check-in inaccuracy at OR. The data is accurate at MP but not well-processed to the systems of OR. These causes are taken into account in the following analysis into check-in accuracy and added to the Ishikawa diagram in Figure 27.

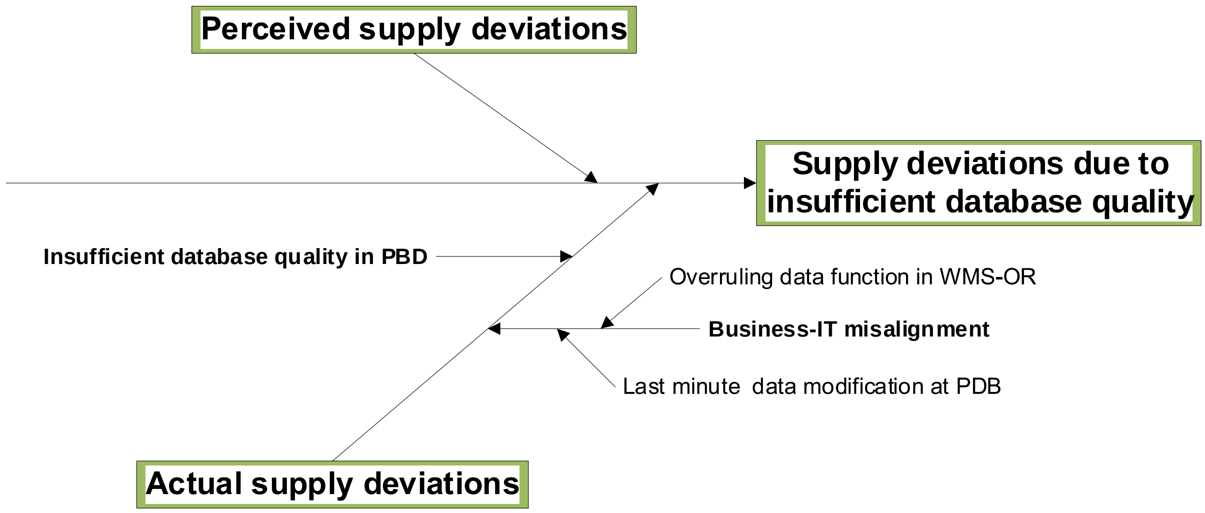

Figure 26 Ishikawa diagram of insufficient database quality

2. *Insufficient check-in quality at OR*

As there exists a high distrust among the experts in the expert analysis concerning the quality of the check-in data, the inbound process is further investigated. It is verified if, where and what risks in the inbound process cause errors in the check-in data.

First, the inbound process is modeled and validated by the existing work description and two problem holders. The inbound process is standardized for all DCs of OR. The process is scoped from the moment the trucks arrive until the supply is stored and checked. The BPMN diagram in Appendix 10.4.7 describes the inbound process. Silver's method is used to create the diagram following the phases in Figure 12. Second, by means of observations in the inbound process, the risks to check-in inaccuracy are discovered. The observations have been performed at three RDCs of OR. The observation set up, sourcing, coding and descriptions of the check-in inaccuracy risks can be found in Appendix 10.4.8.

Conclusions

Four main activities comprise the complete inbound process: unload truck, split supply, store supply and checking activities. At the start of the storing process, the replenishment operator scans the product per colli to register it in the WMS and to recover the exact storage destination of the product. At the end of a replenishment shift, a by the WMS derived list states the deviation between what is manually checked in and what was ordered. The list's accuracy is manually rechecked, and if deviations are discovered, the production leader adjusts the stock levels in the WMS. If the deviations found are large, the Preparation department is informed.

Currently, the supply checking activities during the inbound process only have one goal: ensuring stock level accuracy. This is explained by the master schedule modeled in the AS-IS analysis which showed that the window between receival and production is almost always too short to prevent the deviations found during check-in from impacting the online customer. The fact that there exists no supplier's evaluation process, confirms the sole goal of this process. This indicates that there is currently no focus on providing accurate data on which suppliers accuracy or suppliers evaluation can be based.

The observations have concluded on risks that result in *insufficient check-in quality* and perceived supply deviations. An overview is given in Figure 27. It mainly concludes that the inbound process involves a high proportion of error-prone manual processes.

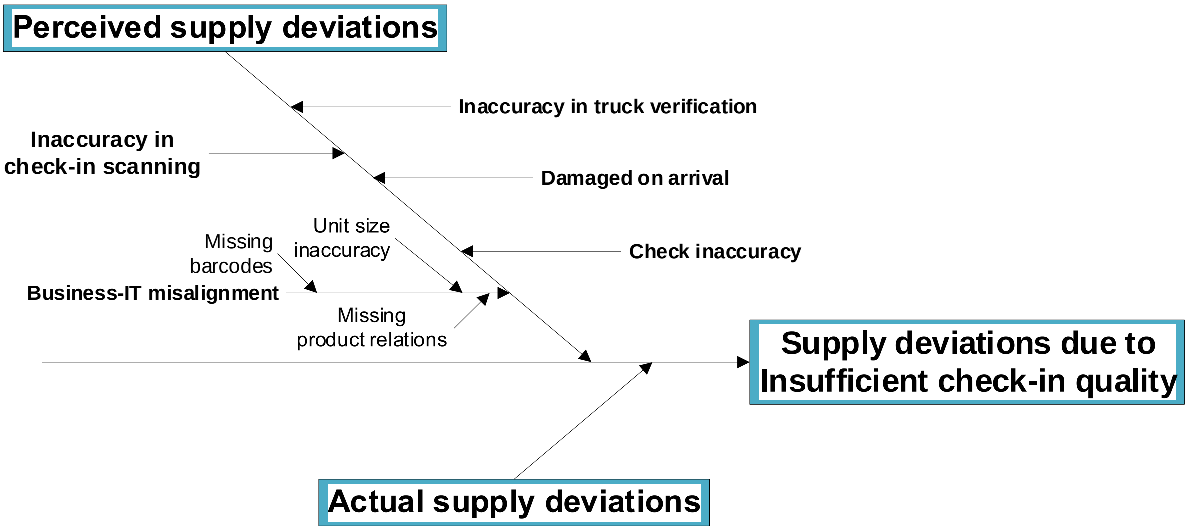

Figure 27 Ishikawa diagram of insufficient check-in quality

3. *Supplying DC inaccuracy*

OR has little knowledge of the processes and risks in operations at MP. However, this must be known to be able to perform a cause analysis and to evaluate the accuracy of the supply deviations. Therefore, deeper cause analysis at MP is performed.

The three processes identified in the premier root-cause analysis were chosen as the scope of analysis: restocking, picking and loading. To structure the analysis, these processes were first modelled and validated by the interviewees. The process models are added to Appendix 10.4.9. The root causes of deviations due to operational inaccuracy at the supplying DCs are identified based on observations and interviews. These are listed and the methods are described in Appendix 10.4.10. The observations have been performed in a RDC, a NDC and an ODC of MP, as they vary in product groups and ownership.

Conclusions

The Ishikawa diagram in Figure 28 shows the root-causes discovered. The identified root-causes, descriptions, sources and coding concluded from the interviews and observations are given in Appendix 10.4.10.

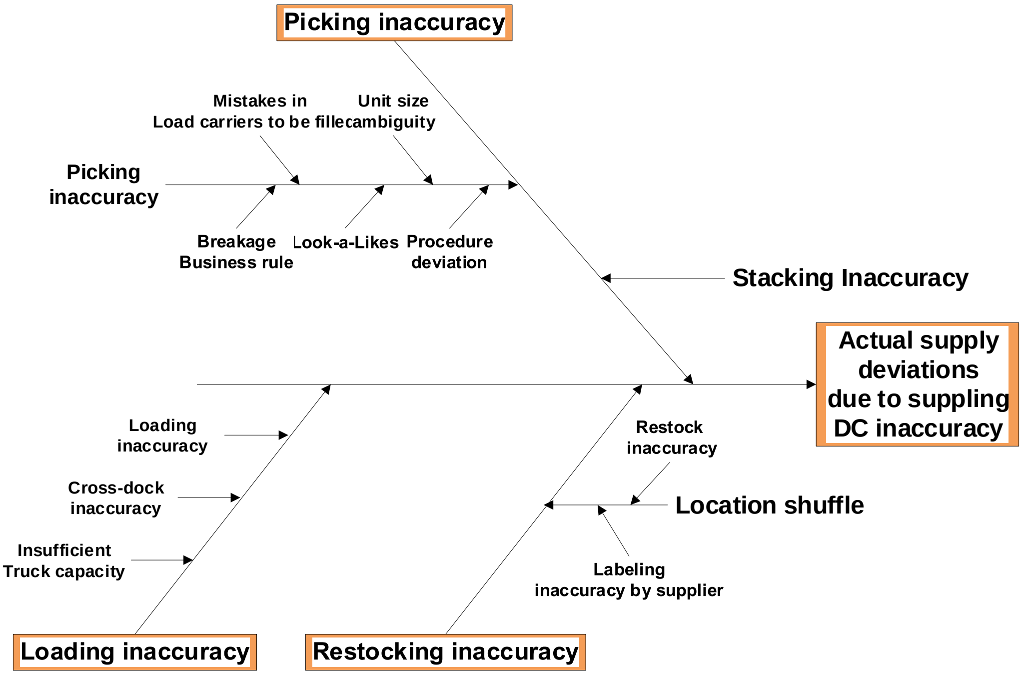

Figure 28 Ishikawa diagram including all identified causes

Based on the root-cause analysis into the supplying DC inaccuracy, the following conclusions about the supplying DC operations can be drawn:

- A variety of causes, mainly due to human operations, result in actual deviations. The process diagrams are helpful during cause investigations at OR.
- A location shuffle results in structural deviations which could be avoided by discovery at OR.
- Cross docking increases the risks of deviations.
- Accuracy of picking operations is measured at the end of every shift in the DCs by means of a sample and validation by an independent party. The current sample results are added to Appendix 10.4.11.
  - The current maximum inaccuracy norm stated by MP is 0.18% of total DC production.
  - No differentiation is made between accuracy performance norm of supply designated for physical stores or OR. However, although supply inaccuracies are inconvenient for stores causing buffers or empty shelves, at OR it directly impacts the online customer.
  - The current sample size reflects 0.002% of the total production and the average inaccuracy result is 0.16%, which is almost 3000 colli of the complete supply per week.

- Although OR is structurally financially compensated for possible deviations due to DC inaccuracy, this does not solve customer impact. There exists unambiguity between the interviewees concerning whether it is allowed to correct mistakes found in OR supply during the sample verification due to the structural financial compensation.
- Accuracy is not a determined KPI of DC operations. The KPI's are productivity, loading timeliness, unloading timeliness and process disruptions. However, the sampling results function as a KPI.

6.2.4 Conclusion on root-causes supply deviations

The Ishikawa diagram in Figure 29 concludes on all root-causes of supply deviations discovered in the root-cause analysis. Color coding is added to visually merge all Ishikawa diagrams concluded above. Supply deviations are concluded to be either perceived or actual deviations. Perceived deviations are concluded when there is a system stock deviation, but there is no physical supply deviation. As the order fulfillment process is highly dependent the stock levels, the causes were considered of equal importance. The diagram is not complete as more causes could exist. However, due to the use of qualitative and quantitative research methods, the current most important causes are considered discovered.

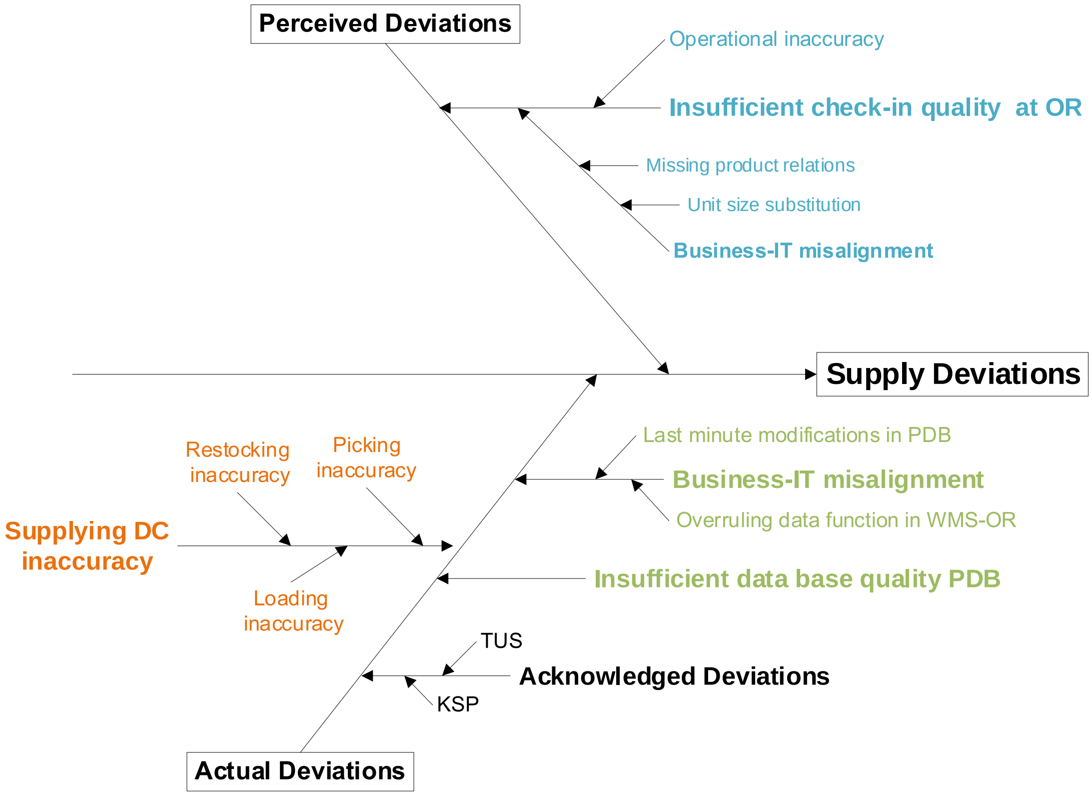

Figure 29 Final Ishikawa diagram

The discovered root-causes can be reflected on the network challenges framework in Figure 6. The root-causes of this problem confirm data quality challenges due to the *insufficient database quality* and the insufficient supply deviations data due to *insufficient check-in quality at OR. Supplying DC inaccuracy* is both a challenge of performance measurement, as this was concluded misaligned between the partners, and risk management, as inaccuracies in manual processes are inevitable. Acknowledged problems are a combination of knowledge sharing challenges, i.e. knowledge on forecasts and product availability sharing, and risk management. Business-IT misalignment resulted in data issues and confirm the business-IT alignment challenge in the framework.

6.3 Conclusions

This section concludes on the investigated problem at OR. A data analysis and a root-cause analysis were performed to uncover the root-causes of supply deviations.

The data analysis showed that supply deviations significantly impact the order fulfillment of online customers. Almost 40% of the supply deviations has an undefined cause. The remaining deviations have an acknowledged cause, which are known and communicated in the network. It is acknowledged that the data on which these conclusions are based upon has several limitations. To improve this data quality, the causes of the insufficient data quality have to be discovered. For this reason, and to identify other possible causes, the root-cause analysis was scoped to the undefined causes.

The general causes based on expert brainstorms concluded to be *transportation issues*, *supplying DC inaccuracy*, *insufficient database quality* and *check-in inaccuracy*. These root-causes were evaluated by means of an impact sample analysis and an expert judgement analysis. It mainly showed that the cause analysis of undefined causes based on current data on product level is not conclusive due to low data quality. Furthermore, it concluded a high variability in the expert ranking results, which shows the little insight into the problem. However, the analyses did clearly show the direction for the detailed root-cause analysis. The impact sample analysis showed that *insufficient database quality* has a high impact on the NA's. The expert ranking clearly showed that experts have little believe in the *check-in accuracy* at OR. The extent of the *supplying DC inaccuracies* could not be substantiated, hence, more insight into this intra-organizational process of MP is beneficial for the overall collaboration. These causes were investigated in more detail.

Based on the root-cause analysis into the undefined causes, the following is concluded:

- Undefined supply deviations consist of actual deviations and perceived deviations.
- Perceived deviations highly impact the quality of the supply deviations data and therefore complicates any root-cause analysis. Perceived deviations are caused by *check-in inaccuracy* in the inbound process of OR. They not only impact the data quality, they also result in new replenishment decisions based on incorrect stock levels. Inaccurate check-in into the WMS of OR is caused by:
  - *Business-IT misalignment*: the by MP substituted unit sizes are not known in the WMS of OR
  - *Operational inaccuracy* possible due to insufficient process design: the error-prone manual activities during the inbound process result in inaccuracy. This is an intra-organizational issue of OR.
- Actual deviations result in short and excessive supply that either impact online customers or the efficiency in the process. Actual deviations are caused by:
  - *Insufficient database quality*: inaccurate data disrupts the order flow. This risk was already identified in the AS-IS analysis as two databases with different owners increase the risks of errors.
  - *Supplying DC inaccuracy*: inaccuracies occur at the suppling DC due to manual processes. This cause can almost never be substantiated by OR's data as long as it includes perceived deviations. Cross-docking activities increase the risk of deviations. At MP, the supply accuracy is sampled but there is no differentiation between the accuracy norm for the physical stores or for OR.

The problem of supply deviations is recognized by OR, but no actions are taken to reduce the problem, or it's causes. This is explained by (1) the low local insight into the inter-organizational processes and the root-causes and (2) due to the lack of confidence in supply deviations data quality by all network partners. As impact and extent of the problem is proven, solutions must be designed to improve the coping with supply deviations and to prevent the root-causes.

7 Solution design

This chapter describes solution directions for the supply deviations problem which are supported by literature. As production at OR is rising following the growth of e-commerce, the replenishment volumes are rising. Therefore, as proven in the data analysis, the extent of supply deviations will grow equivalent. A solution to the supply deviations is therefore required, as more and more customers are impacted by neglection of these issues. The solution design does not aim to give a complete list of solutions to all root-causes but focuses on solutions to cope with supply deviations and network solution concepts to improve the collaboration and decrease the risk of supply deviations.

Following the conclusions of the previous problem analysis, the next questions will be explored in this solution design:

1. How to reactively cope with supply deviations?
    a. Operational solution design
2. How to preventively hedge against supply deviations?
    a. Tactical solution directions
    b. Strategic solution directions

To answer these questions, several solutions directions are proposed. The solution designs are structured based on the three management levels: operational, tactical and strategic. As the depth of collaboration can be established at these management levels, these different management perspectives for solutions of the problem are discovered (Verdecho, 2009). In this thesis research, the operational level concerns decisions in the day-to-day operations. In the tactical management level involves decisions that concerning the design of inter-organizational processes. The strategic level incorporates the intra- and inter-organizational strategies. As the problem surfaces in the operational level of the network, tactical and strategic solutions are not considered reactive. Operational preventive solution directions for the identified root-causes are out of scope in this solution design because more insight is needed into the IS architecture, into database management processes and suppling DC replenishment and operation processes to prevent business-IT misalignment, insufficient data base quality and the supplying DC inaccuracy root-causes respectively.

The reactive solution design proposes process improvements due to which the problem holder, OR, can better cope with or react to the supply deviations. It is therefore scoped to the intra-organizational processes at OR. The reactive solution design is described in Section 7.1.

It was acknowledged that a network-wide approach results in a more effective and more integrated results. Therefore, preventive solutions directions to hedge against the root-causes of supply deviations and challenges of network collaborations are proposed on the tactical and strategical management level. These solution directions will improve the collaboration between networked organizations and therefore mitigate the risk of supply deviations. They are presented in Section 7.2. Due to the scope of the thesis analysis on the operational order fulfillment process, the network wide solutions directions remain highly conceptual.

An initial evaluation of the solution designs is performed with three experts representing OR and MP. The goal of the evaluation is to validate the ideas of the solution design and improve the solution designs based on expert recommendations.

7.1 Reactive solution design

In the reactive solution design, solutions for OR to better cope with the supply deviations are proposed. The reactive solution design assumes that some extent of deviations will always exists in a buyer-supplier process, like in the operational level between OR and MP.

The AS-IS analysis and the root-cause analysis have shown that currently no process or activities are performed to reduce the registered deviations because there is a lack of confidence in supply deviations data quality by all network partners. Therefore, OR first has to improve the supply deviations data to enable a reliable view of the problem. The root-cause analysis concluded that perceived supply deviations pollute the data and that these are caused due to the manual check-in in the inbound process at OR. Therefore, it is concluded that the measurement of supply deviations must be improved, in order to resolve the perceived deviations and improve the data quality. Once this measuring function and the data quality is considered reliable by all partners, the data must be processed to valuable information used as feedback to the network. A network performance evaluation process will guide network improvements. As the network is an extended enterprise and shares benefits and risks, an evaluation process aligns and prioritizes network improvement projects. An evaluation with three experts is required to validate the completeness, efficiency and the practical implementation issues of the ideas in the solution design. For these reasons, the reactive solution design includes three phases:

1. Improve the supply accuracy measurement at OR to improve supply deviations data quality
2. Design an evaluation process to communicate supply performance information
3. Evaluate solution designs with network partners

7.1.1 Improve supply accuracy measurement

The improvement of the supply accuracy measurement is the first essential step to agreed network performance evaluation process. The inbound process, described in the detailed root-cause analysis in section 6.2.3, is the scope of measurement function for the following reasons:

- The inbound process is the first physical moment for OR to be able to verify the supply accuracy
- Improving the process will result in a decrease of the *check-in inaccuracy* risk, which was concluded an intra-organizational issue. It will improve the data accuracy quality.
- Sufficient accuracy data quality is needed to track deviations and substantiate preventive actions.

The following figure indicates the inbound process in a compressed duplicate of Figure 13 by a red circle. It aims to clarify the concluded scope.

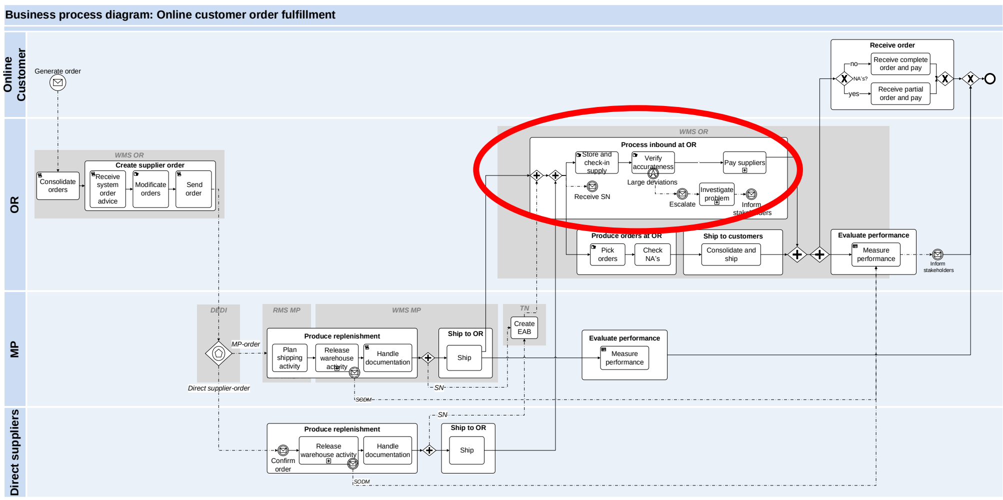

Figure 30 Compressed business process diagram to indicate scope

Redesign of inbound process

The inbound process is redesigned with the purpose to eliminate the *check-in inaccuracy* root-cause and thereby eliminate perceived supply deviations and improve the measurement of supply accuracy.

A systematic approach is required to ensure parts of the spectrum of potential redesign options are not missed (Dumas, 2013). The RePro procedure is chosen to guide the redesign, which is argued in the in Section 2.4. The application procedure is shown in Figure 31. This procedure supports practitioners in applying the set of RePro principles, which structures redesigning the operational inbound process. Nominal group technique and the multi-level design approach are the basic ingredients of the approach (Vanwersch, 2014).

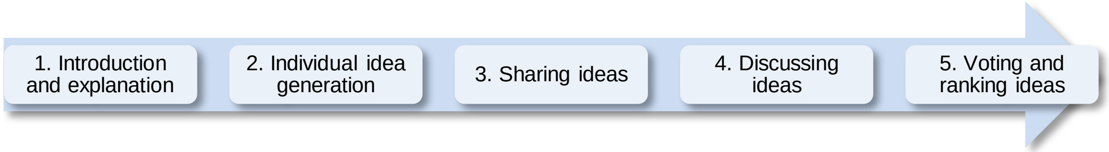

Figure 31 Phases of RePro procedure (Vanwersch, 2014)

During redesign, the Devil's Quadrangle is an important concept to consider (Dumas, 2013). It expresses that improving a process in one dimension may have a weakening effect on another and is therefore a trade-off. The dimensions are time (T), flexibility (F), cost (C) and quality (Q). Awareness of these trade-offs is utterly important for effective process redesign. A dimension has a positive relation (+), a negative relation (-), an unknown relation (?) or no relation (/) with the redesign.

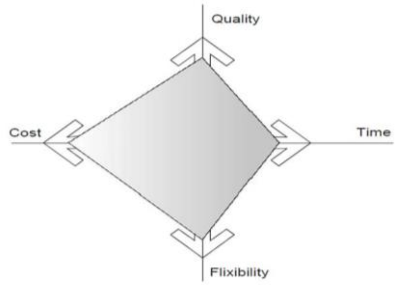

Figure 32 Devil's Quadrangle (Dumas, 2013)

Execution of RePro procedure

Three co-students with business process management knowledge are selected to execute the nominal group technique in the application procedure. The execution of the first three phases is described in Appendix 10.5.1.

In the discussion phase of the RePro procedure, the feasibility, the quadrangle tradeoffs and the position in the inbound process per listed idea are discussed with all participants. The conclusions of the discussion per principle are described in Appendix 10.5.1 and summarized in Table 8. The discussion concluded on an important limitation of two redesigns. It is essential that the entire network trusts the measurement of the accuracy to substantiate interventions and network improvements based on this data. Therefore, any measurement function that involves manual internal activities does not meet this requirement. Improving the measurement process by *Split storing and check-in activity* or by *Addition of control activity*, will therefore not accomplish a reliable measurement function. Therefore, these were excluded from the ranking in the next phase.

Redesign Ideas	*Repro principle*	Short description	Conclusions of Devil's quadrangle	Conclusions on ranking (phase 5)
Measuring supply accuracy by sampling by a third party	Trusted party	Sample incoming supply just after arrival at OR by a thrusted party	C+, F -, T +, Q +	2
Measuring supply accuracy by weight control	Integral technology	Implement weight scale technology to check supply just after arrival and check manual when a deviation is detected	C +, F -, T +, Q ?	3
Split storing and check-in activity	Triage	Divide the storing and check-in activity in two tasks to gain operator focus on quality of execution.	C /, F -, T +, Q ?	/
Eliminating the check-in activity	Task elimination	Eliminate manual check-in because the activity is concluded too unreliable. Import supplier's data (SN) into WMS to update stock-levels	C /, F /, T -, Q ?	1
Addition of control activity	Control addition	Add a manual control on unit size or number of colli to be stored during the manual storing activity	C /, F -, T +, Q ?	/

Table 8 Conclusions of Re-Pro procedure discussion and ranking phase

Lastly, the remaining ideas are ranked. It is acknowledged that systematic voting and ranking processes exists like described in Delbecq et all. (1975). However, due to the relatively small number of participants (n=4), it was chosen to rank the redesigns by concluding on a mutually agreed ranking. The participants concluded on the ranking in Table 8.

The RePro procedure concludes that *eliminating the check-in activity* in combination with a measurement activity is the most efficient redesign that will result in reliable supply accuracy data.

Description of concluded inbound process redesign

The current and the proposed redesign of the inbound process are shown in the business process flows in Figure 33. The main differences are indicated in red.

“A common way of regarding an activity as unnecessary is when it adds no value from a customer’s point of view” (Dumas, 2013). The redesign *eliminates the check-in activity* because of three reasons: (1) the current check-in activity has proven to be unreliable; (2) an internal and manual verification is concluded to never deliver substantial results; (3) no process redesign solutions are identified in the scope that improve the check-in activity. Products still need to enter the WMS of OR, but OR can import the supplier’s notifications (SN) send by MP before the picking activities start. When this manual process is eliminated, all discovered root-causes that resulted in perceived deviations become irrelevant. Evaluated by the devil’s quadrangle, it is concluded that time is positively impacted but the impact on quality is unknown. The operator does not have to scan every colli and the check-in does not have to be checked (“validate deviations due to check-in inaccuracy”). The impact on quality is unknown due to the unknown quality of the shipping notifications. This is a risk of the redesign that must be further researched and mitigated.

At OR, this risk can be mitigated by adding supply accuracy measurement activities:

- *Sampling by a third party:* A third party samples the accuracy to verify supplier performance. This activity must be performed as soon as possible after the supply arrives at OR to avoid the supplier performance to be influenced by internal activities of OR. To avoid high impact on transportation schedules, this redesign is therefore positioned after the truck unloading. To limit the time required for the sampling, a system should be developed that updates sampling parameters, like frequency, depending on previous results of streams or supplying DCs.
- *Weight control:* As volumes, weights per products and products per roll cage are known in the network, a weight scale can verify the completeness of the supply per roll cage. When weight deviates by for example a determined percentage, the supply must be manually verified. To ensure reliability, the manual verification should be performed by a third party. This measurement verifies accuracy on product level. The weight control must be implemented as soon after supply arrives on the dock to prevent internal processes at OR to impact the results. In case a deviation is found, the manual check is performed after the roll cage have been removed from the dock and before it is distributed over the aisles. Several limitations must be addressed before implementation of this measurement:
    - Reliability of the scale measurement and of the data is essential. Therefore, a scale with a certificate of conformance is recommended. The current weight data quality in the network requires a thorough investigation. Thereby, the quality of data must be continuously guaranteed which will require a network wide data quality management approach (Schaffer, 2017).
    - Further research into the implementation restrictions of the weight scale technology is needed

As in the current situation, stock levels must be continuously verified to ensure actual supply deviations do not impact stock levels accuracy and future replenishment. However, the results of the accuracy measurement will indicate the extent of the stock level verification necessary.

The redesign will improve the data quality of supply deviations and improve the coping with supply deviations of OR. It must be noted that the supply accuracy measurement redesigns are designed within the scope of OR. However, it is recommended to evaluate the possibilities of measuring supply accuracy before it is shipped to OR. In that way, the window of time to rectify possible deviations is larger. This option is out of scope of this solution design but recommended for further research.

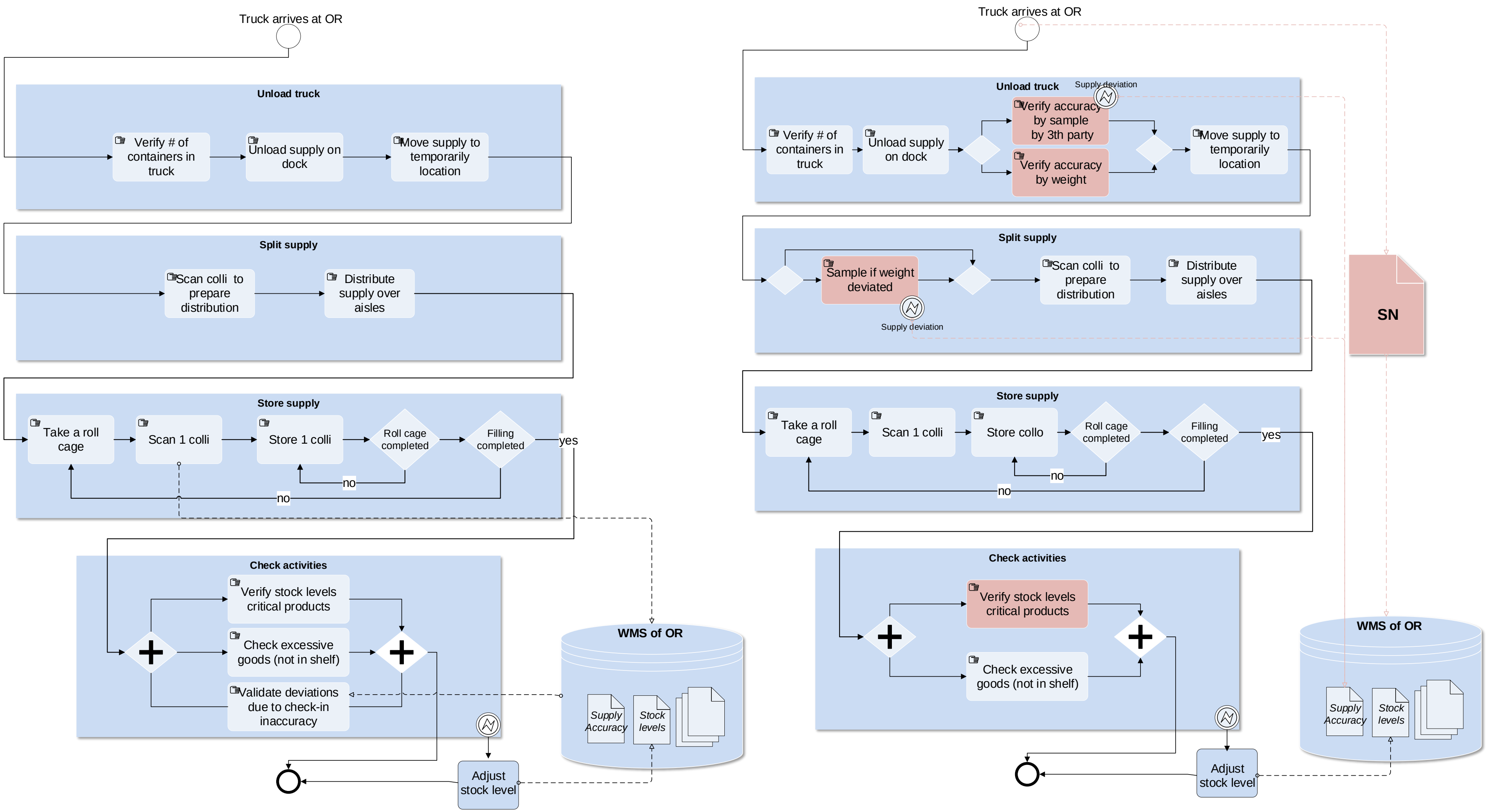

Figure 33 Current inbound process vs Redesign of inbound process

7.1.2 Design a network performance evaluation process

When the supply accuracy measurement is improved, it is important that the data gathered from this activity is transformed into information and shared with the network. Only then, the network has substantial prove and directions for improvements. Therefore, a network performance evaluation process is designed in this section and focuses on the supply accuracy and quality of the suppliers of OR.

Process control in a steady-state model is used to design an evaluation process. The advantage of the steady-state model approach is that it is a universal model, not dependent on the transformation process or on the input (‘t Veld, 2011). Therefore, it can be used as a template to design a general evaluation process which does not dependent on the detailed design of the storing and picking activity at OR or fluctuations in order volumes. Hence, the design is resistant to changes in the dynamic online retailing business. Process control ensures the process meets the required standards (‘t Veld, 2011). The main constructs are the comparison function and the intervention function. A comparison function compares the input or throughput with the determined norm, and the intervention function intervenes when the norm is exceeded to structurally improve the process. There are three fundamentally different methods for realizing this arrangement:

1. Forward link: cause determines intervention
2. Feedback link: result determines intervention
3. Adding the missing: repair mistake

A conceptual design of the network performance evaluation in the order fulfillment process from the perspective of OR is designed based on the template and the methods from ‘t Veld (2011). It assumes that the improved accuracy measurement redesign is implemented at OR. During the evaluation, it was recommended to add a supply quality evaluation to evaluate supplier performance more completely. Product quality is currently evaluated, tracked and photographed during other processes in the inbound process. The following conceptual design is shown in Figure 34. The component descriptions and process decision parameters are explained below.

The scope of the performance evaluation design focusses on the design of the comparison function, the measurement and norm comparison. It is chosen due to time limitations to leave the detailed design of the intervention functions, norm determination and a responsibility and stakeholder analysis out of scope in this solution design. In case the supply accuracy measurement is performed outside the borders of OR, the conceptual design needs little reshaping, but the essence remains equal.

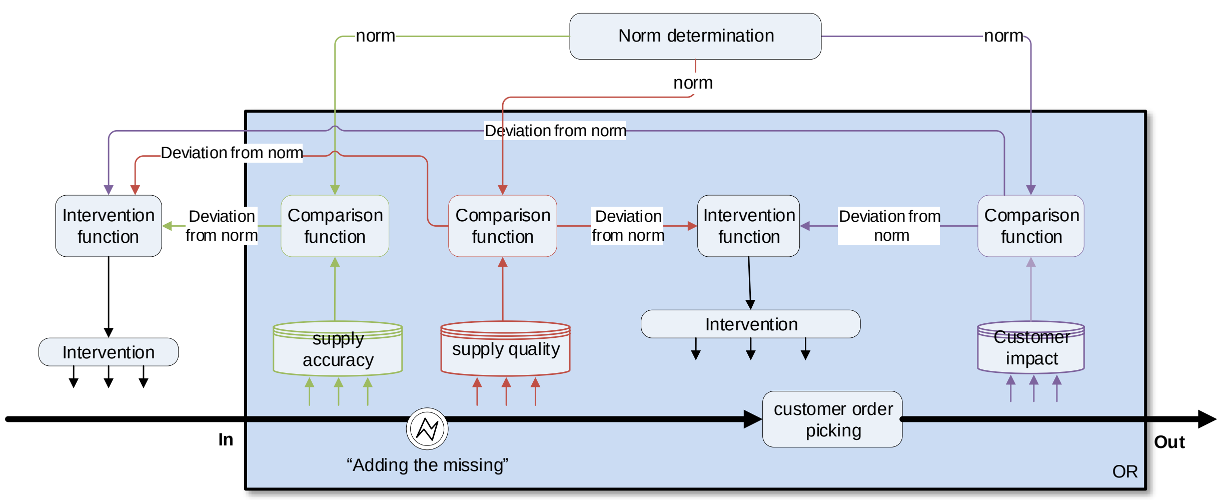

Figure 34 Conceptual design of network performance evaluation process

Description of conceptual design

The components added to the conceptual design are described below. For every method a decision tree is developed that guides the detailed evaluation. All decision tree's in this chapter are designed based on the development of the NA analysis decision tree in Chapter 6. The decision trees contain the data analysis steps and intervention directions in case of norm exceedance. As data is not always conclusive, it is specially mentioned to discuss (the need for) interventions with the potential cause holder. The data and conclusions are tracked to guide future norm determination. The norm exceedance functions as an alert for more detailed cause analysis. The network must jointly accept this network performance evaluation process and the intervention directions to be affectively implemented (Lehtinen, 2010).

- *Supply accuracy evaluation*

The feedback link indicated in green in Figure 34 evaluates the supply accuracy data. The root-causes of actual deviations identified in the thesis research will be uncovered from this data. When a norm is exceeded, the intervention function is triggered. A decision tree, in Figure 35, is developed for the execution of this feedback link. The identified causes in the root-cause analysis are discovered and guide the further interventions. It must be noted that the root-cause analysis did not include supply deviations by direct suppliers, and is must be verified whether the same causes apply.

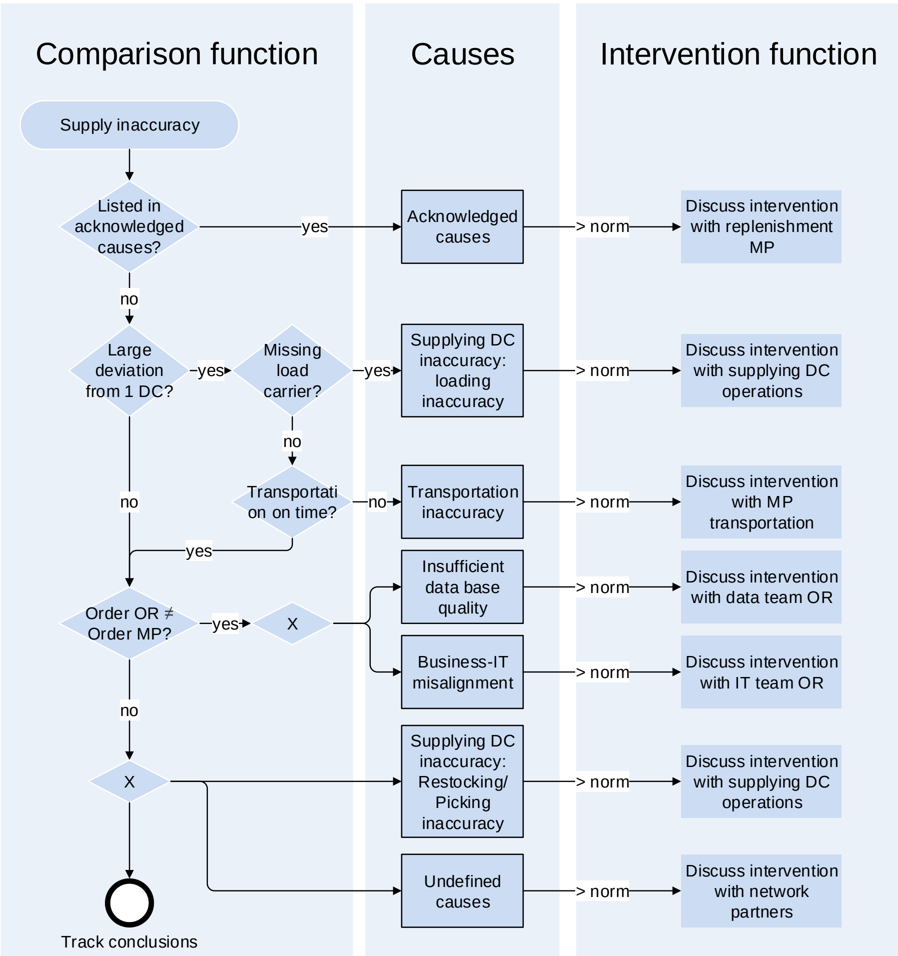

Figure 35 Detailed evaluation method of supply accuracy evaluation

- *Last-minute solutions*

An "adding the missing"-method is positioned just after the measurement of the supply accuracy. When a large deviation is detected during supply verification, OR can attempt to solve this problem by last minute deliveries to avoid large online customers impact. However, it has been shown that available time windows in the OR operations are very short which highly complicates the reactive action and demands flexible resources. Hence, this is not a structural method and no decision tree is developed.

- *Customer impact evaluation*

A feedback link indicated in purple in Figure 34 measures the impact of supplier performance on the online customers via the NA's. Currently, an unreliable distinction between internally caused NA's or the externally caused NA's is made. However, the network partners cannot rely on the internal tracking of the internal causes. It therefore depends on the level of detail in the supply accuracy data what the evaluation enfolds:

- When *measuring supply accuracy by sampling by a third party* is implemented, the causes of the NA's per product cannot be substantiated as the sample is limited. When NA's exceed the determined norms, the network must evaluate (1) whether the current ongoing interventions based on the supply accuracy evaluation can be accelerated; (2) whether the sampling activity must be enlarged to find more root-causes; (3) whether the determined norms of the supply accuracy evaluation must be stricter; (4) or whether a (internal) process can be improved to prevent further NA's.
- When *measuring supply accuracy by weight control* is implemented, the extent of which supply accuracy is tracked on product level depends on the level of detail of the weight control. When detailed, a distinction between internally caused NA's and externally caused NA's can be made. In case the NA's exceed determined norms, the intervention directions can be scoped more precisely

The decision tree in Figure 36 contains both scenarios. For both methods, the data of supply accuracy is essential.

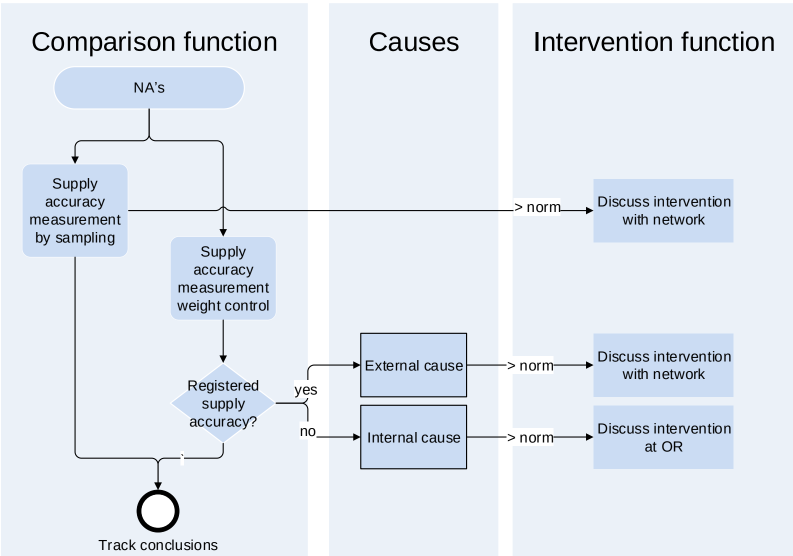

Figure 36 Detailed evaluation method of NA evaluation

- *Supply quality evaluation*

The forward link indicated in red in Figure 34 evaluates the quality of supply that is evaluated during the inbound process. In case product quality in incoming supply is insufficient, an intervention is performed by excluding these products from the process. When the product quality issues occur more than the determined norm, an intervention at the supplier is requested. The decision tree in Figure 37 is developed. It is assumed that insufficient product quality is caused during transportation, at the supplying DC or due to insufficient product package quality, although further research is necessary to substantiate these causes.

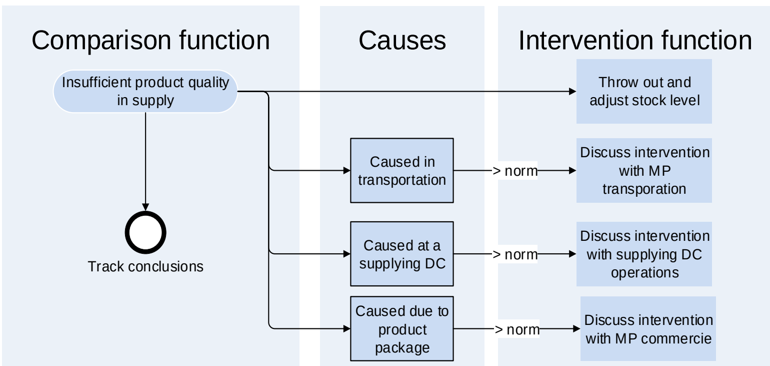

Figure 37 Detailed evaluation method of product quality evaluation

Decision parameters of network performance evaluation process

Several decision parameters of the conceptual evaluation process remain to be decided on by the collaborative network:

- Norm determination
  In inter-organizational collaborations, joint norm determination with all network partners is required for the control process to be accepted (Babiak, 2009). Therefore, norm determination is considered the most important aspect of the evaluation process. Simple SLA's like in supply chain theory are of no value as the following consequences in a network collaboration are different (Lethinen, 2010). Unified measures should be used across the enterprise to ensure the alignment of goals, at least in the scope of the extended enterprise (Lethinen, 2010). To determine these mutual performance indicators, the network strategy must be reviewed to ensure alignment of goals.
- Intervention actions
  In case norms are exceeded, the need for an intervention must be discussed by the network partners. If a need it identified, an intervention is designed to improve the process and the collaboration. The following preventive solution design could inspire possible interventions. Other example of an intervention could be additional controls or measurement activities earlier in the process, for example at the suppliers.
- Use of tracked evaluation data
  The tracked data can guide norm determination or uncover trends. It is highly recommended to track the evaluation data over time to avoid the impact of occasional issues on the norm determination.
- Frequency of norm determination
  As the supply accuracy of the network partners will change and improve over time, it is recommended to review the determined norms with the network regularly.
- Frequency of comparison function
  The comparison function could be performed per shift, per day or in any other time frame. The higher the frequency, the easier cause recovery becomes as the analyses has shown that data is less accessible over time. In case of high frequency, a data tool is recommended to simplify the analysis.

7.1.3 Evaluation of reactive solution design

The recommended redesign of the inbound process and the conceptual performance evaluation process are reviewed and evaluated by three experts in the network. The goal of the evaluation is to validate the ideas in the reactive solution design using the following topics:

- Effectiveness of solution: Do you think the solution will lead to improved tacking of supply deviations?
- Ease of implementation: What kind of implementation issues do you foresee?
- Operational feasibility: Once implemented, what problems do you foresee in the use of the solution?
- Stakeholders involved: In case of further design or implementation, who are the stakeholders involved?
- Completeness of conceptual design: Do you have ideas on how to improve the solution design?

Semi-structured interviews are used to be able to narrow down to important areas or topics. The protocol of the semi-structured interviews is added to Appendix 10.5.2. The reactive design as presented already contained some improvement suggestions concluded in the evaluation. This section states the conclusions based on semi-structured interviews.

<u>Expert evaluation of the inbound process redesign evaluation</u>

All experts agree on the *effectiveness* of eliminating the check-in activity. The MP expert states that an automatic check-in would strongly increase the quality of data. The experts of OR agree on the inadequacy of the current manual check-in. They conclude that saved time and improved stock level reliability are benefits of automatic check-in. The conclusions of this research confirm their current pilot.

The OR expert expects no issues in *implementation*, as the system infrastructure is already validated in the current pilot. However, the OR experts mention a couple of limitations in the *operational feasibility* when eliminating manual check-in: (1) the start of the picking process is dependent on a timely arrival of the SN into the WMS of OR; (2) there is no insight in internally caused versus externally caused stock level deviations; (3) actual supply deviations are no longer tracked due to which the stock levels in WMS are incorrect. The first limitation is added to the redesign. The last two limitations are encountered by the design of the supply accuracy measurement.

The MP expert states that MP believes that supply deviations are not a big problem and that any initiative to improve the supply deviations problem must be done by OR. The OR experts believe in the *effectiveness* of measuring supply accuracy, especially in combination with the automatic check-in. It will protect stock level accuracy and determine the causes of NA's. However, the OR experts both mention the need of the network's cooperation to act on the results of the measurement.

The experts believe in the *effectiveness* of sampling and agree on the positioning in the redesign. The introduction of a third party is not seen as a problem in the *implementation*. However, issues are concerned with the time required for sampling between truck arrival and the storing activity. For the *operational feasibility*, OR experts are concerned that since sampling does not verify every product, no distinction could be made between externally caused and internally caused NA's. For the exact implementation of sampling, the expert at MP recommends process insights from the current sampling in the inbound of the MP DCs. Weight control is considered a fast, and rough control of the accuracy and an original solution. A large limitation of the o*perational feasibility* was acknowledged by both OR experts: the measurement must be based on reliable weight data. Frustrations increase and time is wasted when the weight indicates deviations based on inaccurate weight data, which are then concluded to be non-existing after the manual check. Therefore, testing on data quality and scale reliability is essential. No other solutions to supply accuracies were concluded in the interviews.

<u>Expert evaluation of the network performance evaluation process</u>
All experts agree with the *effectiveness* of the essence of the conceptual performance evaluation process. Although the conceptual design was considered complicated at first sight, the structure became clear for all experts after a quick explanation. In terms of *effectiveness* per component, the supply accuracy feedback link, the adding-the-missing component and the NA feedback link are all concluded to add value to the evaluation process according to both OR experts. One OR expert strongly emphases the need of the customer impact evaluation, as reducing customer impact is the most important goal of the network performance evaluation process.

In terms of *operational feasibility*, the OR experts noted the importance of joint network intervention designs instead of a simple score communication to ensure interventions are performed. An OR expert also mentioned that the measurement method must be reliable for the evaluation process to be effective.

The *implementation* of norm determination was mentioned by all experts as essential and challenging, because: (1) The MP expert mentions that MP is currently not extremely interested in investing a lot of time in the evaluation of supplier performance (2) The OR expert warns that general norms per order (in colli) do not reflect the absolute customer impact. A missing colli with multiple customer unit sizes has more customer impact than a colli with a small number of customer unit sizes; (3) the norms will have to be based on previous data as snapshots are less informative.

Concerning *completeness,* an OR expert recommended to add product quality to the network evaluation process. This is currently already evaluated in the inbound process. Therefore, this is taken into account in the design of the conceptual evaluation process. However, it was noted by the expert that cause analysis needs further development, as it is difficult to conclude the root-causes of insufficient quality. The MP expert cannot think of missing components in the conceptual design process.

7.2 Preventive solution design

Independent of what reactive solution design is implemented, preventively hedging against risks of supply deviations is beneficial to the network performance. As the check-in quality risk has been mitigated in the reactive solution design, literature is explored to opt for preventive solutions for the remaining root-causes and challenges concluded in the thesis research. As it was acknowledged that a network-wide approach results in a more effective and more integrated results, preventive solutions are discovered on the tactical and strategical management level. The concluded conceptual solution directions were briefly evaluated with experts of the network.

In the conclusions of the root-cause analysis in Section 6.2, the identified root-causes were classified in the challenge framework concluded from literature in Figure 6. The literature was explored for solution directions for these concluded challenges. The Table 9 summarizes these conclusions. Challenges and root-causes that are considered mitigated by the solution directions are marked with an X. The relations are explained below. A distinction is made between solutions on the tactical and the strategic management level. The difference between the two management levels is that the tactical level focuses on the inter-organizational process design and IT architecture. The strategic level focusses on the strategic direction and organization of the network. Each solution direction is further explained in the following sections. When further investigated and implemented, these solution directions will prevent root-causes of supply deviations and they will lead to an improved network collaboration.

			Tactical solution directions		**Strategic solution directions**		
Identified network challenges in AS-IS analysis		**Identified root-causes of supply deviations**	Increasing safety stock	implementing network wide data quality management	Implement network wide performance management	integrating network activities	integrating network information system landscape
IT management	Business-IT alignment	Business-IT misalignment	X				X
Knowledge management	Data quality	Insufficient database quality	X	X			X
	Knowledge sharing	Acknowledged problems (TUS, KSP)	X			X	
Performance and risk management	Measuring performance	Supplying DC inaccuracy	X		X		
	Mitigating risk	Supplying DC inaccuracy	X		X		
		Acknowledged problems (TUS, KSP)	X			X	

Table 9 Combining network challenges, supply deviation root-causes and solution directions

7.2.1 Tactical solution directions

On the tactical level, the following preventive solution directions to mitigate against the risk of supply deviations and improve network collaboration are suggested:

- Increasing safety stock
- implementing network wide data quality management

Increasing safety stock

This proposed solution direction minimizes the impact of deviations on customers discussed in the problem analysis in Chapter 6. When customer retention is the greatest good, one can reach this goal by decreasing the dependency on the accurateness of supply. By structurally increasing the safety stock the probability of a stock out is reduced (Ghiani et al, 2013). The impact of all identified root-causes and other challenges is mitigated. Although it increases the flexibility of the process, it requires physical capacity. It's is a trade-off between flexibility and cost. This solution direction might become of a strategic nature when warehouse capacity is insufficient. In case additional physical capacity is required but impossible, the network can also decide to adjust their strategy and decrease the variability of the assortment.

Implementing network wide data quality management

The thesis analyses have shown that data quality is an essential and critical factor in the collaborative network, especially when structured inter-organizational data messages and EDI are used. The order flow is the foundation of the inter-organizational order fulfillment process. However, two databases managed by different owners with different objectives provide this foundation. According to various literature, data quality can be continuously and preventively management by implementing a network wide data quality management system (Schaffer, 2017). This will positively impact all process that depend on data and prevent the *insufficient database quality* root-causes identified.

Although the great importance of inter-organizational master data quality and its management has been acknowledged by many, researchers still conclude on the lack of research dealing with the quality of data between organizations (Dalmolen, 2015; Legner, 2008; Otto, 2011), appropriate solutions (Schäffer et all., 2017) or comprehensive frameworks (Otto, 2011). However, the literature analysis of Otto (2011) concluded on four concepts from the intra-organizational perspective of information and data quality that can be transferred to collaborative business processes.

1. Dimensions and metrics must be introduced in order to appropriately analyze, improve and ensure information and data quality.
2. Responsibilities must be identified and assigned regarding information and data quality. In an intra-organizational context this is often described as data governance (Otto, 2011). The elements of effective data governance (IBM, 2007), added to Appendix 10.5.3, must be evaluated for network wide data governance. Especially, the management of the two databases require very strict data governance to align responsibilities and functions.
3. The lifecycle of information and data from creation to archiving or deletion must be managed across the boundaries of the business partner.
4. The management process must entail a continuous cycle of defining, measuring, analyzing and improving data quality

By starting with these four concepts to develop a network wide data quality management process, the network will be able to manage the quality of the databases.

7.2.2 Strategic solution directions

On the strategic level, the following preventive solution directions to mitigate against the risk of supply deviations and improve network collaboration are suggested:
- Implement network wide performance management
- integrating network activities
- integrating network information system landscape

Implement network wide performance management

By aligning and sharing performance information with the network partners, the network can identify bottlenecks and 'weak links' in its processes, and act accordingly to improve the overall performance of a single organization and the entire collaborative network (Kulmala, 2006; Parung et al., 2008). Sharing mutually agreed supplier's accuracy performance information is a clear example in the operational order fulfillment process. It will mitigate against the risk of *supplying DC inaccuracies.* However, it will benefit all inter-organizational processes as especially due to the aligning of performance measurement, both organizations aim for the same objectives.

The AS-IS analysis showed a discrepancy between the operational KPI's of the supplying and the receiving organizations, which indicates that the network partners have implemented intra-organizational performance management methods. Lethinen (2010), Bitici (2012), and Folan (2005) argue that direct application of dominant performance measurement models or frameworks into the context of an extended enterprise can lead to suboptimal or even disastrous results. Local perspectives and misaligned incentives result in phenomena as externalities, spill-over, or neighborhood effects (Simatupang, 2002). To eliminate local perspectives, a network-wide performance system is required.

Although literature acknowledges the need of a framework for the design of a performance measurement system for a collaborative network (Pekola, 2013a), work in this area is still limited (Bitici, 2012). However, the relatively conceptual process design of Folan (2005), visualized in Figure 38 is recommended as a guideline for the development and implementation of a network wide performance management system. The stages are further elaborated on in the Appendix 10.5.4. In the review stage, the maturity framework of Pekola (2013b) is recommended to evaluate the state of the performance management system in the network of OR and to focus on goals to (further) develop the system.

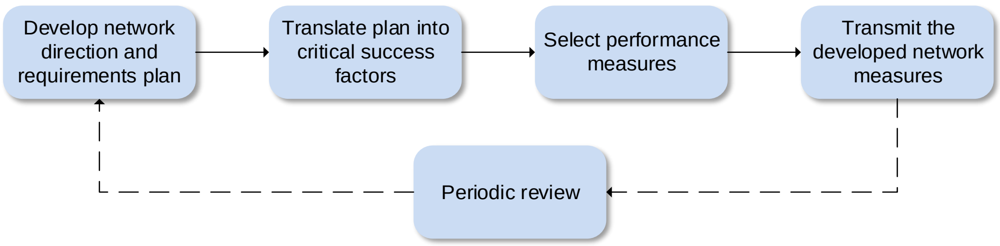

Figure 38 Inter-organizational performance management development framework (Folan, 2005)

Integrating network activities

MP is a large, well-established organization with knowledge concerning physical supply chains and OR is the expert in retail operations in the dynamic e-commerce. In the intra-organizational set up, this knowledge must intensively flow between the organizations to optimize the whole process containing both the physical supply chain and e-commerce. Knowledge sharing can be strongly improved by the integration of multiple processes or activities.

In general, integrated business processes should render a more efficient execution, both from a time and cost perspective (Dumas, 2013). By integration of the replenishment activity, one department can share amongst others forecast knowledge, product availability knowledge and contact with providers of both organizations, which could result in a synergy effect and improve product availability for customers. This will result in a decrease in the *acknowledged supply deviations*. The mutual dependence increases strongly due to which the flexibility of both companies decreases. It must be noted that when the dependency between companies increases, they become more exposed to the risks of other companies and these must be understood and managed (Hallikas, 2004). As several inter- and intra-organizational processes will need redesign, the network must note that (1) the current IT-landscape will need revision and the network was identified to be receptive for IT implementation challenges (2) organizational transformation strongly impacts the current way of working. Therefore, integration of activities is of a strategic nature.

Integrating network information system landscape
The AS-IS analysis shows a highly distributed network IS landscape with multiple databases. To decrease the risk of IS misalignment, (parts of) the IS landscape should be integrated. Moreover, Swafford (2008) indicated that IS integration enables a firm to tap its supply chain flexibility which in turn results in higher supply chain agility and ultimately higher competitive business performance. This will mitigate *business-IT misalignments.* The existing IS landscape could be integrated using technologies found in literature:

- At the OR network, the databases could be merged using electronic catalogues. These are repositories of product information that allow to exchange messages containing product information using open standards and the internet (Christiaanse, 2004). The database is shared by companies in a central hub. Two forms of electronic catalogues are acknowledged: data pools and product information management (Rowe et al., 2009). Data pools are external electronic catalogues outside of the information system landscape and product information management is an internal electronic catalogue. Rowe's (2009) study concluded that from project managers' point of view, electronic catalogues use induces data centralization, automation of flows, data standardization, additional controls, and processes standardization. The user-friendly interface, the low costs of access, the real-time information and connecting downstream demand flows with upstream capacity, has in some industries already led to massive restructuring of the coordination structures among adjacent members of supply chains.
- New inter-organizational data exchange technologies have lower dependency on data quality or higher exchange accuracy. Radio-Frequency Identification technology (RFID) is an automated identification application that highly improves the data accuracy as it can establish item-level tracking. RFID is advantageous because it does not require barcode scanning, it acts to reduce labor levels, enhances visibility, and improves inventory management (Micheal, 2005). Hence, supply deviations can easily be tracked. However, RFID is a big investment and requires a complete revision of the IS landscape. Other disadvantages Michael (2005) mentions are that RFID lacks standardization, it has a small number of suppliers developing end-to-end solutions, it suffers from some adverse deployment issues, and that it is clouded by privacy concerns. Nevertheless, RFID in supply chain management is seen as a revolutionary practice of which especially collaborative networks could value due to the shared risks and goals (Peppa, 2013; Shin, 2015) Alternative tracking technologies to RFID are regularly investigated, but none is found that has been widely embraced.

7.2.3 Evaluation of preventive solution directions

The preventive solution directions for the network are briefly evaluated with three experts to validate the potential of the conceptual ideas. The three experts collaborating in the reactive solution designs are asked the following question per preventive solution directions: *Do you recognize potential in this preventive solution direction? Why? Why not?* The following conclusions are stated:

- The benefit of increasing safety stock is clear for all experts and OR experts are going to evaluate to what extent the current capacity will allow an increase in the safety stock
- The experts have no insight into the current data quality management but confirm the need for high quality data. They indicate management challenges in the volume of product information.
- The experts confirm that the KPI's at OR are currently difficult to manage due to misaligned objectives in the network. The MP expert states that the network has started to better align performance starting 2019. Insights into how to implement network wide performance management are therefore considered useful.
- The OR expert mention that OR is becoming too large to operate with an intra-organizational focus next to MP. Integration in network activities and information systems is required to improve the quality and the efficiency of all processes to cope with the rising replenishment volumes.

8 Conclusions

This chapter provides the conclusion of the thesis research. First, the conclusions per research question are described in Section 8.1. The answers to the research questions include the contribution to literature. In Section 8.2, the limitations of the research are elaborated on. The chapter ends with the practical recommendations for the network in Section 8.3.

8.1 Conclusions

The practical objective of this thesis focuses on the discovery of the inter-organizational order fulfillment process and the investigation into a network problem at OR. The main research question inquests to investigate the causes of supply deviations at OR and a coping strategy for the network. The research questions are discussed to describe the conclusions, recommendations to the network and the contribution to literature:

What are the challenges of inter-organizational collaboration? The “state of the art” literature on the topic was explored to find acknowledged challenges of inter-organizational business collaboration, which are used to reflect on OR’s network. The concluded framework describes that network challenges are located in the following five domains: IT management, relationship management, knowledge management, performance and risk management and sustainability management.

What are the root-causes of the network problem of OR?
OR and MP are a strongly linked inter-organizational collaboration due to the mutual representation of one brand and the identical holding company. They cannot be defined as a general supply chain, as they share risks and benefits (Parung et all (2006). The problem experienced at OR is defined as deviations in the replenishment of OR, that include both excessive supply and short supply. These deviations either have acknowledged causes or undefined causes.

The AS-IS analysis of the inter-organizational order fulfillment process was very beneficial, as inter-organizational know-how concluded to be limited. The AS-IS analysis concluded on the challenge domains found in literature that appose risks in the current network. Especially IT management challenges, knowledge management challenges and performance measurement challenges were found in the AS-IS analysis. In the current network these domains showed to be highly intra-organizational focused. Due to the rapidity of the order fulfillment process required for competitive online e-commerce, these challenges pose risks to customer impact.

In the current process the supply deviations are solely registered. No process is defined for a cause analysis, the impact on performance or attempts to solve the supply deviations. An analysis of the supply deviations data proved significant impact on order fulfillment KPI of OR. The detailed problem definition concluded that deviations have either an acknowledged cause, defined and communicated by the network, or an unknown and undefined cause. The data analysis showed that almost 40% of the supply deviations has an undefined cause.

After a detailed root-cause analysis in the undefined supply deviations, they concluded to either consist of perceived supply deviations and actual supply deviations.

- The perceived supply deviations strongly impact the quality of the supply deviations data and system stock level quality. They are concluded to be caused by *inaccurate manual check-in* into the WMS system of OR.
- Actual deviations are concluded to be caused by *supplying DC inaccuracy*, *business-IT misalignment* and *insufficient quality of data bases*.

Cause investigation was considered complicated due to (1) limited inter-organizational process knowledge and insight into the causes (2) the low data quality of the supply deviations caused by perceived supply deviations.

How should the network cope with the problem? The solution design proposed a reactive operational solution design specified for OR and preventive solution directions for the network.

In the reactive solution design, it was concluded that OR could better cope with supply deviations when they would improve the measurement of supplier performance in the inbound process. When the performance measurement is improved and reliable, (1) it eliminates the perceived root-causes impacting stock level accuracy at OR; (2) it substantiates network improvement interventions based on data thrusted by the network. A redesign of the inbound process is recommended to improve this measurement. The redesign eliminates the manual check-in activity in the current process and recommends a new supplier performance measurement activity at OR by a sampling activity by a third party or a weight control activity. For both measurement functions, a tradeoff must be made with between the extent of the measurement and the level of detail in the performance data.

For the performance measurement to substantiate network wide improvement interventions, the data must be processed into information and communicated with the stakeholders. A conceptual performance evaluation framework is designed which evaluates the supplier performance at OR. It evaluates supply accuracy, supply quality and the impact on online customers by the NA's. The essence of the evaluation framework is that network interventions are requested when jointly determined norms are exceeded. The data measured on operational level can be processed by detailed evaluation methods, shaped as decision trees. Based on the conclusions, it indicates directions for improvement interventions.

The preventive solution directions hedge against the risks of supply deviations and improve network performance on a tactical and a strategic management level. Network improvement opportunities are concluded to be in network data quality management, network wide performance management, integration of network activities, and integration of ISs by new technologies. Especially network performance management, including aligned goals and performance measurement, eliminates local perspectives which will strengthen the benefits of inter-organizational collaboration and hedge against problems like supply deviations.

How does the network evaluate the proposed solution design? The expert panel representing both MP and OR have evaluated the solution designs. They confirm the effectiveness of the improved supplier performance measurement and the network performance evaluation process to solve the supply deviations problem. However, the expert at MP mentions that there is currently not enough foundation at MP to actively cooperate in improving the supply accuracy and resolving the supply deviations. This shows that objective of OR an MP must first be better aligned before a structured network-wide process can be effectively implemented. Network-wide performance management was also evaluated as an important network improvement by the expert panel.

Overall it is concluded that although OR and MP are mutually dependent and strongly linked, they do not exploit the full benefit of the collaboration by an inter-organizational perspective on the order fulfillment process. The intra-organizational focus of the organizations results in a general supply chain collaboration Problems like supply deviations can easily be resolved when the network has aligned objectives and performance measurement. Benefits of strongly linked inter-organizational collaboration can mostly be exploited when objectives and performance measurement are aligned within the collaboration.

What can be concluded about or added to the current theoretical foundation? The thesis concluded on a conceptual network performance evaluation process on the operational management level based on the steady-state approach. It is based on mutually accepted performance measurement and norm determination. Further research and evaluation are needed to validate the practical and scientific value of the conceptual design.

Furthermore, this thesis concluded on a systematically obtained challenges framework of inter-organizational process management in collaborative networks. This thesis empirically tested the framework in an inter-organizational order fulfillment process of a strongly linked collaboration in the e-retailing business. Business-IT alignment, data quality, knowledge sharing, measuring performance and managing risk are proved to be network challenges resulting in experienced business problems. Obviously, future research is needed to evaluate the challenge framework in other, more complex, types of collaborative networks and in other businesses.

Finally, the thesis shows the demand for research dealing with appropriate solutions or comprehensive frameworks for strongly-linked network collaborations. For network wide data quality management and network wide performance management solutions, basic concepts were found, but practical guidelines for implementation were missing in the theoretical foundation. The rising number of inter-organizational collaboration demands future research into inter-organizational process and system reference models.

8.2 Limitations of research

This research has some limitations that have to be taken into account, which are the following:

- The research investigates a practical and specific problem. Therefore, generalizability is a limitation of the research. The conceptual network performance evaluation process demands more evaluation in order to contribute to the literature.
- Validity of the research is an important limitation. For the literature review, it was chosen to approach the collaboration of OR and MP as a specific case of a collaborative network. However, following the definition of Camarinha-Matos (2008), the organizations are not autonomous and are therefore not a general collaborative network. This must be taken into account when addressing the conclusions of the network based on the literature search.
- The research was commissioned by OR and mainly executed at OR due to which the inter-organizational process and the supply deviations problem were mainly seen from the perspective of OR. As a network-wide approach was argued in the thesis methodology, this is a limitation of the research. This limited the research because at OR there is a large foundation to investigate and solve the supply deviations problem, but this foundation was not seen at OR.
- The AS-IS analysis was chosen to be performed first due to the lack of an inter-organizational overview. Therefore, an AS-IS analysis scoped to the origins of the root-causes could not be performed within the boundaries of the master thesis project.
- The limited data quality of the data analysis must be taken into account when addressing the conclusions of the data analysis.
- In the reactive solution design, the performance measurement process is designed in scope of OR. However, it must be evaluated whether performance measurement more upstream in the replenishment process would achieve a more optimal integrated network solution. Furthermore, it was chosen due to time restrictions to not include the architecture dimension of the BOAT-framework in the reactive solution design.
- Due to time restrictions, the evaluation of the reactive and preventive solution design does not include experts from more network perspectives. Multiple expert opinions are of need to substantial evaluate the process redesign which represent all stakeholder perspectives like DC operations, DC replenishment, and data support. The concepts in the preventive solution design must be evaluated and further researched by network wide project teams including all management level.

8.3 Practical recommendations

To cope with the supply deviations, it is highly recommended to further evaluate and develop the reactive solution design. Therefore, the data quality must be improved in order to substantiate the problem of the supply deviations in the network. OR must further evaluate the effectiveness of the proposed inbound process redesign with multiple expert opinions from various business perspectives. As the automatic check-in is currently piloted, it is recommended to decrease the dependency of the currently unknown quality of the SN as soon as possible. Instead of reactively hedging by manually verifying all stock levels, OR should start with the supplier performance measurement activity. This will indicate whether the quality of the SN is sufficient. As measuring supply accuracy by weight control has currently more restrictions in terms of weight data quality, testing and technology purchase, it is recommended to start evaluating the effectiveness and implementation issues of measuring the supply accuracy by sampling by a third party. Furthermore, it is also beneficial to already hedge against the actual root-causes of the undefined deviations found in this research. It results in an improved quality of the SN.

Once a redesign at OR is implemented with the objective to improve supply deviations data quality, it will show the impact of supply deviations on online customers. In case impact is proven to be significant, there will be a foundation at MP and at other departments of OR to implement the conceptual evaluation process and start detailed cause analysis. At this time, MP and OR must also evaluate whether the supplier performance measurement in the inbound process of OR is the most integrated and effective solution. It should be considered to measure supplier performance more up-stream in the process.

Based on the conclusion of this thesis, OR and MP could better exploit their collaboration by aligning objectives and performance measurements. This is not only the solution to the operational supply deviations problem but will be beneficial for all inter-organizational processes.

As the AS-IS and root-cause analyses showed limited inter-organizational knowledge on inter-organizational processes, it is recommended to increase this inter-organizational know-how in the network. This will lead to more opportunities for a more effective collaboration.

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- Zachman, J.A. (1987) “A Framework for Information Systems Architecture.” IBM Systems Journal. 26, 3.

10 Appendix

Contents of Appendix

10.1 Literature Analysis

10.1.1 SLR: Search Protocol

Research question

The goal of this literature review is to give insight into the network-related challenges of collaborative networks, especially into the business process challenges and knowledge management challenges. The review will focus on business networks, leaving for example governmental and health services out of scope. Therefore, this systematic literature review will conclude on the most important aspects of cross-organizational process management in collaborative business networks.

Research question: What are the challenges of cross-organizational process management in collaborative business networks?

Search strategy

In the search strategy, the search query is constructed, and the sources are selected. After the search strategy is determined and executed, the next sub-chapter constructs a two-phased selection strategy with help of selection criteria. These selection criteria are used to refine the results yielded from the search query. These two steps, defining and executing a search strategy and selection strategy, will ultimately lead to a final pool of articles.

- Search term

The search terms are primarily based on the goal of the literature search and divided in 4 elements. As described above, the main goal is to discover challenges of cross-organizational processes in collaborative networks. A comprehensive search term was defined incorporating all keywords by which the relevant literature could be tagged.

Index	Keyword	Synonyms and varians	Source
1	Collaborative Network	Network*, extended enterprise, collaborative (supply) chain	Parung 2008
2	Challenge	Pitfall, threat, risk, difficult*	Thesaurus 2018
3	Cross-organizational	inter-organization*, cross-organization*	Thesaurus 2018
4	Process Management	Business process management, process (re)design	n.a.

The first, second and third terms (1,2,3) directly reflect the goal of the research. The third term is added to ensure the articles focus on processes between organizations, rather than internal or external challenges. The term Process Management (4) functions the aim to find articles that have an information systems approach, rather than a social or IT network approach. All these elements must be present in the article hits and are therefore connected with an AND-operator.

The corresponding search term: ("collaborative network" OR network* OR ("supply chain" AND collaborat*)) AND (Challenge OR Pitfall OR Threat OR Risk OR difficult*) AND ((cross-organization* OR inter-organization*) AND (business process OR process*) AND (management OR *design))

Given the exploratory goal of this literature review, it doesn't specifically focus the search on one concrete aspect. Therefore, it can be expected that the search term will result in a longer first article list than other systematic reviews might have imposing more accountability on the selection strategy.

- Sources

The TU/e Library list of relevant search engines for the topic of Industrial Engineering and Management Sciences is used to select search engines. In addition, some of the existing literature reviews on the topic of cross-organizational management are evaluated to verify the completeness of the sources. Diirr (2018) used Compendex, IEEEXplore, Web of Knowledge and Scope. Gimenez (2012) performed a SLR in the same research area and used among others Emerald Journals, Web of Knowledge and JSTOR business. So, by evaluation of the existing material and university input, the following databases are selected: Web Science, Science Direct and Scopus.

<u>Selection strategy</u>

Selection criteria are intended to identify those studies that provide direct evidence about the research question. (Kitchenham, 2007) The criteria decide on the inclusion or exclusion of literature for this review and cover both accessibility and content aspects.

First, a long list is created by the determined search term and by the use of the initial selection criteria that can directly be applied to the filters in the chosen databases.

Initial selection criteria

1. Written in English
2. Recent article; publication in 2008 or later
3. Subject Area/research area: business value chains

To avoid language problems and given the fact that most scientific literature is written in English, the first criteria states inclusion of sole English written literature (1). (Brutt-Griffler, 2006) Due to the fast-changing business environment, collaborations in networks have developed continuously over the years. (Grefen, 2013) To ensure the search concludes on current challenges, the search is framed to the last 10 years. (2). To further scope the search, the subject area filter in Scopus and Web of Knowledge is used to focus on the studies that provide insight in business value chains, like the research environment of the main thesis. Subjects like medicine, art, environment, earth, and public are organizations are hereby excluded from the results. (3) During the search, this turned out to have a large impact in the number of results. Since ScienceDirect doesn't provide a subject filter, the results of this database are manually filtered by evaluating title and keywords. From the 80 results, 55 papers were concluded to be out of scope for this review. These excluded articles by manual. Most hits focused on clinical or health networks, but also into governmental networks and scientific research networks.

To validate the search terms and initial selection criteria, 2 articles (Bukhsh, 2012 & Krenz, 2014) that were found in a preliminary exploratory search in the scientific literature were used as benchmark for the quality of the search. Eight articles showed in two search engines. The long list is now created and consists of exactly 100 unique articles. These are too many to evaluate in depth, therefore the abstract and keywords are evaluated manually by more in-depth selection criteria.

Secondary selection criteria

1. Access to full texts
2. Included when
    a. Focus on cross-organizational business process or data flow challenges
    b. Focus on operational challenges
    c. Focus on research area: business value chains
3. Excluded when
    a. primarily focused on dynamic networks
    b. primarily focused on strategic level, i.e. partner selection
    c. primarily focused on a conceptual approach
    d. Primarily focused on a mapping method

Articles are excluded if there is no access to the full text. (1) As it turns out, Scopus also shows conference exceedings, consisting of multiple published articles. Assuming the singular articles also surface in the search if relevant, the whole conference exceedings are excluded from the results.

During a more thorough exploration of the long list, an overview of the main topics in the list is mapped. Based on the exploration of the topics and the goal of the literature review, more content-specific selection criteria were defined. Literature is included when the author focuses on cross-organizational process and data flow challenges on an operational or slightly tactical level in business value chains. (2) Articles are excluded if the content is primarily focused on dynamic networks. This topic has gotten a lot of attention due to the extra challenges arising when partnering dynamically. Due to the static network structure of the retailer where the master study in conducted, the literature excludes dynamic networks. (3a) The literature study also excludes articles that delineate network challenges on strategic level, where is it is mainly the goal to framework partner selection. Again, due to the static structure of the researched retailer, this is left out of scope. (3b) Literature describing collaborative networks from a highly conceptual view are excluded from the shortlist, since it doesn't comply with the practical intension of the literature study and it is not focused on challenges. (3c.) Lastly, literature containing methods to map, or model cross-organizational processes are not selected for this literature review, since it does not contribute to operational challenges. (3d.) However, this literature can provide important input for the master thesis, in which several processes need to be modeled.

The second selection applied to the long-list yielded from the primary selection, results in a short list of 23 containing the final selection. In the following table, the number of rejected articles per criteria is listed.

Selection criteria	**Number of articles rejected**
1. No access to full texts	14
2a. No focus on cross-organizational business process or data flow challenges	20
2b. No focus on operational challenges	0
2c. No focus on business value chains	13
3a. Focus on dynamic networks	5
3b. Focus on strategic level	11
3c. Focus on conceptual approach	7
3d. Focus on mapping method	7

10.1.2 SLR: List of selected article pool

1. Ambos T.C., Schlegelmilch B.B., Ambos B. (2009) Evolution of Organisational Structure and Capabilities in Internationalising Banks. The CEE Operations of UniCredit's Vienna Office, Long Range Planning, 42(5-6). 633-653
2. Babiak K.M. (2009) Criteria of effectiveness in multiple cross-sectoral interorganizational relationships. Evaluation and Program Planning. 32(1). 1-12
3. Boström M., Jönsson A.M., Lockie S. (2015) Sustainable and responsible supply chain governance: challenges and opportunities. Journal of Cleaner Production. 107. 1-7
4. Bukhsh F.A., Daneva M., Weigand H. (2012) Understanding maturity of collaborative network organizations by using B-ITa processes. Lecture Notes in Business Information Processing 112 LNBIP. 580-591
5. Chan F.T.S., Yee-Loong Chong A., Zhou L. (2012) An empirical investigation of factors affecting e-collaboration diffusion in SMEs. International Journal of Production Economics. 138(2). 329-344
6. Cheng, J., Chen, S., & Chen, F. (2013). Exploring how inter-organizational relational benefits affect information sharing in supply chains. Information Technology and Management. 14(4). 283-294.
7. Chituc C.M. (2017). XML interoperability standards for seamless communication: An analysis of industry-neutral and domain-specific initiatives. Computers in Industry. 92–93. 118-136
8. Dunford, R. (2014) The Pareto Principle. The Plymouth Student Scientist, 7(1), 140-148
9. Franqueira V.N.L., Van Cleeff A., Van Eck P., Wieringa R.J. (2013) Engineering security agreements against external insider threat. Information Resources Management Journal 26(4). 66-91
10. Gogoulos F.I., Antonakopoulou A., Lioudakis G.V., Mousas A.S., Kaklamani D.I., Venieris I.S. (2014) On the design of a privacy aware authorization engine for collaborative environments. Electronic Markets. 24(2). 101-112
11. Hahn R., Gold S. (2014) Resources and governance in "base of the pyramid"-partnerships: Assessing collaborations between businesses and non-business actors. Journal of Business Research. 67(7). 1321-1333
12. Hinkka V., Främling, K., & Tätilä, J. (2013). Supply chain tracking: Aligning buyer and supplier incentives. Industrial Management & Data Systems. 113(8). 1133-1148
13. Hoellrigl T., Dinger J., Hartenstein H. (2010) FedWare: Middleware services to cope with information consistency in federated identity management. ARES 2010 - 5th International Conference on Availability, Reliability, and Security. 228-235
14. Karvonen I., Conte M. (2016) Supporting and facilitating the Enterprise Collaboration (EC) & Enterprise Interoperability (EI) solution take-up. 2010 IEEE International Technology Management Conference
15. Krenz P., Basmer S., Buxbaum-Conradi S., Redlich T., Wulfsberg J.-P. (2014) Knowledge management in value creation networks: Establishing a new business model through the role of a knowledge-intermediary. Procedia CIRP 16. 38-43
16. Lehtinen J., Ahola T. (2010). Is performance measurement suitable for an extended enterprise? International Journal of Operations & Production Management. 30(2). 181-204.
17. Li Q., Zhou J., Peng Q., Li C., Wang C., Wu J. (2010) Business processes oriented heterogeneous systems integration platform for networked enterprises. Computers in Industry. 61(2). 127-144
18. Lo Nigro G., Abbate L. (2011) Risk assessment and profit sharing in business networks. International Journal of Production Economics. 131(1). 234-241
19. Mau M., Mau N. (2008) Requirements of knowledge management systems according to performance and risk related issues in global supply chains. Innovation and Knowledge Management in Business Globalization: Theory and Practice - Proceedings of the 10th International Business Information Management Association Conference 1-2. 1372-1377
20. Piercy N.F. (2009) Strategic relationships between boundary-spanning functions: Aligning customer relationship management with supplier relationship management.
21. Preuveneers D., Joosen W., Ilie-Zudor E., (2017) Trustworthy data-driven networked production for customer-centric plants. Industrial Management and Data Systems 117(10). 2305-2324
22. Schäffer T., Leyh C. (2017) Master data quality in the era of digitization - toward inter-organizational master data quality in value networks: A problem identification. Lecture Notes in Business Information Processing 285. 99-113
23. Ylitalo J., Immonen S., Ziegler K., Mäki E. (2006) Building and nurturing partner relationship in collaborative product development. 2005 IEEE International Technology Management Conference
24. Zhang J., Sun Y., Jara A.J. (2015) Towards semantically linked multilingual corpus. International Journal of Information Management. 35(3). 387-395

10.1.3 SLR: Execution of Coding Strategy

	Coding phase 1: Identify keywords	Coding phase 2: Identify management domain	Coding phase 3: Generalize management domains	Coding phase 4: Identify detailed domain
Ambos (2009)	Managing cross-border integration, banking, Aligning organizational structures	Integration management	Relationship Management	Relationship Management
Babiak (2009)	Evaluate effectiveness, performance measurement, IOR effectiveness criteria	Performance management	Performance And Risk Management	Measuring performance
Boström (2015)	Sustainable supply chain governance, responsible global supply chain, economic globalization	Sustainability management	Sustainability Management	Sustainability Management
Bukhsh (2012)	Business and IT alignment, Maturity model,	B-IT alignment management	IT management	IT Alignment
Chan (2012)	E-collaboration diffusion, EDI, EDI implementation, TOE model,	IT management	IT management	IT Implementation
Cheng (2013)	Information sharing behavior, relational benefits, information flow	Information sharing management	Relationship Management	Knowledge Sharing/Mitigating Risk
Chituc (2017)	Real time information exchange, information interoperability, semantic interoperability.	Information sharing management	Knowledge management	Knowledge Sharing/IT Alignment
Franqueira (2013)	Data security, outsourcing IT resources, external insider trheat, security agreements	Data security management	IT management	System Security
Gogoulos (2014)	Privacy and sensitive information confidentiality, privacy-aware decision	identity management	IT management	System Security
Hahn (2014)	Base of Pyramid partnerships, resource distribution, informal self-enforcing governance mechanism	Partnership management	Relationship Management	Relationship Management
Hinkka (2014)	IOS implementation projects, interorganizational tracking, implementation barriers, IT adoption	IT management	IT management	IT Implementation
Hoelrigl (2010)	Information consistency, identity management, authorized access	Identity management	IT management	System Security
Karvonen (2016)	Enterprise collaboration & enterprise interoperability solution, IT take-up, IT adoption, IT tool utilization	IT management	IT management	IT Implementation
Krenz (2014)	Knowledge management, knowledge complexity, knowledge objectives conflicts	Knowlegde management	Knowledge management	Knowledge Sharing
Lehtinen (2010)	Performance management, Extended enterprise performance measurement	Performance management	Performance And Risk Management	Measuring performance
Li (2010)	Cross-system interoperability, systems integration platform, service access agent, SOA	IT management	IT management	IT Alignment
Lo Nigro (2011)	Risk assessement, risk management, measure risk	Risk management	Performance And Risk Management	Mitigating Risk
Mau (2008)	Process transparency, information readiness, knowledge management systems, information requiremen	Knowledge management	Knowledge management	Knowledge transparency
Piercy (2009)	Strategic relationships, boundary spanning functions, aligning organizational groups	Relationship management	Relationship Management	Relationship Management
Preuveneers (2017)	Cyber-security threats, information security challenges, unauthorized access, espionage, Industry 4.0	Security management	IT management	System Security
Schäffer (2017)	Master data quality	Data quality management	Knowledge management	Data Quality
Ylitalo (2006)	Partner relationship, relationship building, relationship nurturing	Relationship management	Relationship Management	Relationship Management
Zhang (2015)	Multilingual information processing, multilinguel corpus, information analysis, information processing	Relationship management	Relationship Management	Relationship Management

Knowledge management
IT management
Relationship management
Performance and Risk management
Sustainability Management

10.1.4 SLR: Challenges Framework

	Knowledge management			IT management			Relationship Management	Performance And Risk Management		Sustainability Management
Authors	Knowledge transparency	Data Quality	Knowledge Sharing	System Security	IT Implementation	IT Alignment		Measuring performance	Mitigating Risk	
Ambos (2009)							X			
Babiak (2009)								X		
Boström (2015)										#
Bukhsh (2012)						X				
Chan (2012)					X#					
Cheng (2013)			(O)				O		(O)	
Chituc (2017)			#			(#)				
Franqueira (2013)				X						
Gogoulos (2014)				X						
Hahn (2014)							X			
Hinkka (2014)					X					
Hoelrigl (2010)				#						
Karvonen (2016)					#					
Krenz (2014)			X							
Lehtinen (2010)								#		
Li (2010)						X#				
Lo Nigro (2011)									#	
Mau (2008)	#									
Piercy (2009)							#			
Preuveneers (2017)				#						
Schäffer (2017)		X								
Ylitalo (2006)							X			
Zhang (2015)							X			

Casestudy	X
Literature review	#
Statistical data analysis	O

10.2 AS-IS Analysis

10.2.1 Problem definition: KSP cause code description

Causes KSP	Description
Timing of processing in DC (“doorhaling”)	Stock is in the DC, but not yet at the designated location. It is a deviation between physical stock and system stock.
Quality issues	Quality issues cease supply.
No pick zone	The product has no designated place in the DC. This can be caused by data errors, faulty delivery or products that are going out of assortment.
Insufficient stock	Unexpected insufficient stock at the DC. Insufficient stock could be caused by stock level inaccuracy, inaccurate warehouse demand forecast due to an unexpected rise in demand or internal issues like breakage or product shelf lives.

10.2.2 AS-IS Analysis: Interview Protocol

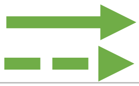
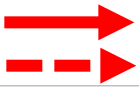
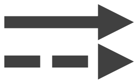
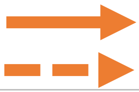
The following protocol is used to evaluate the reactive solution designs:

- Interview goal: *The goal of the interviews is to discover processes, activities, data flows and information systems within boundaries of the scope and to validate the modelled diagrams*
- Interview approach: A semi-structured interview is chosen to be able to narrow done to important areas or topics.
- Interviewer approach: objectivist approach (Angrosino, 2005).
- Expert selection: The experts were chosen to represent the entire network from the different BOAT-perspectives. As more insight was gathered by observations at OR, as the research was mainly performed on sight at OR, the interviews were especially focused on experts at MP. The following table concludes the expert selection

#	Expert interview	Organization
1	Replenishment expert (multiple interviews)	OR
2	Replenishment expert (multiple interviews)	OR
3	Operations expert	OR
4	Replenishment expert	MP
5	Data expert	OR
6	Data expert	MP
7	Data expert	MP
8	IT expert	OR
9	IT replenishment expert	MP
10	IT Transportation expert	MP
11	Commercial expert	MP
12	Replenishment expert	Direct supplier

- Interview preparation
  - Eliciting situation: One-on-one interviews and follow up validation
  - Mode of communication: To discover the models: face-to-face. To validate the models in the follow up: email contact.
  - Interview structure:
    - Introduction of participants (Approximately 10 min)
    - Introduction of thesis research (Approximately 5 min)
      - Goal of context analysis
    - Discovery of process/IS architecture (Approximately 45 min)
      - What are the main activities [in interview scope]
      - What are the support activities [in interview scope]
      - How are the processes linked to the ISs [in interview scope]
      - Who in responsible for the activities [in interview scope]
  - Follow up question:
    - Can you read the diagram created based on your input?
    - Is the diagram correct? / Does the diagram reflect the actual situation?

10.2.3 Business logistical system: Product streams including color coding of Figure 11

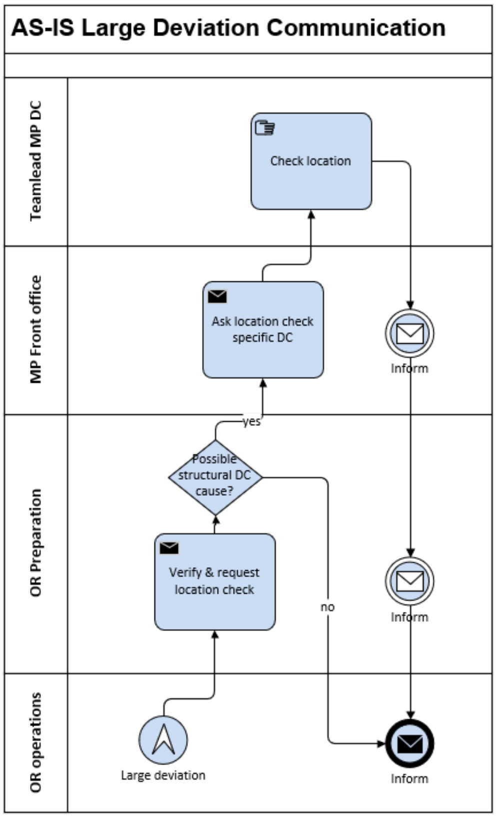
Color code	Stream	Description
	X1	fast-running non-perishables
	X2	fast-running perishables
	X10	non-food products
	X83	Belgium market intended products
	X9	slow-running non-perishables
	X4	deep frozen products
	X96	slow-running perishables
	X11	Cheese products
	X10	Non-food products
	OR streams	
	Direct supplier streams	For example: fresh bread, magazines, toilet articles, vegetables, fruits wines and flowers.
	Physical store streams	

10.2.4 Business process model: Detailed description of business process model

The online customer generates orders via the website. The WMS of OR collects all customer reservations for the morning or afternoon production and calculates the order for the suppliers based on reservations, the current stock, the current pipeline, the forecast for the time window between the order moment and the cut-off for the customer and commercial lift factors. The order is manually revised and modified by the preparation department. At the determined order moment, the order is sent into the supply network. At MP, first a transportation planning and the volumes per truck is determined, after which the order is released at the warehouse. Only then, the actual inventory is verified. All orders that could not be produced, are summarized in the store order deviation message (SODM). For the direct suppliers, an order confirmation is inserted to ensure the order has successfully arrived. After production, the suppliers create an (advanced) shipping notification for the shipment, which is converted by MP to an EAB per location per order containing all products supplied according to the supplier.

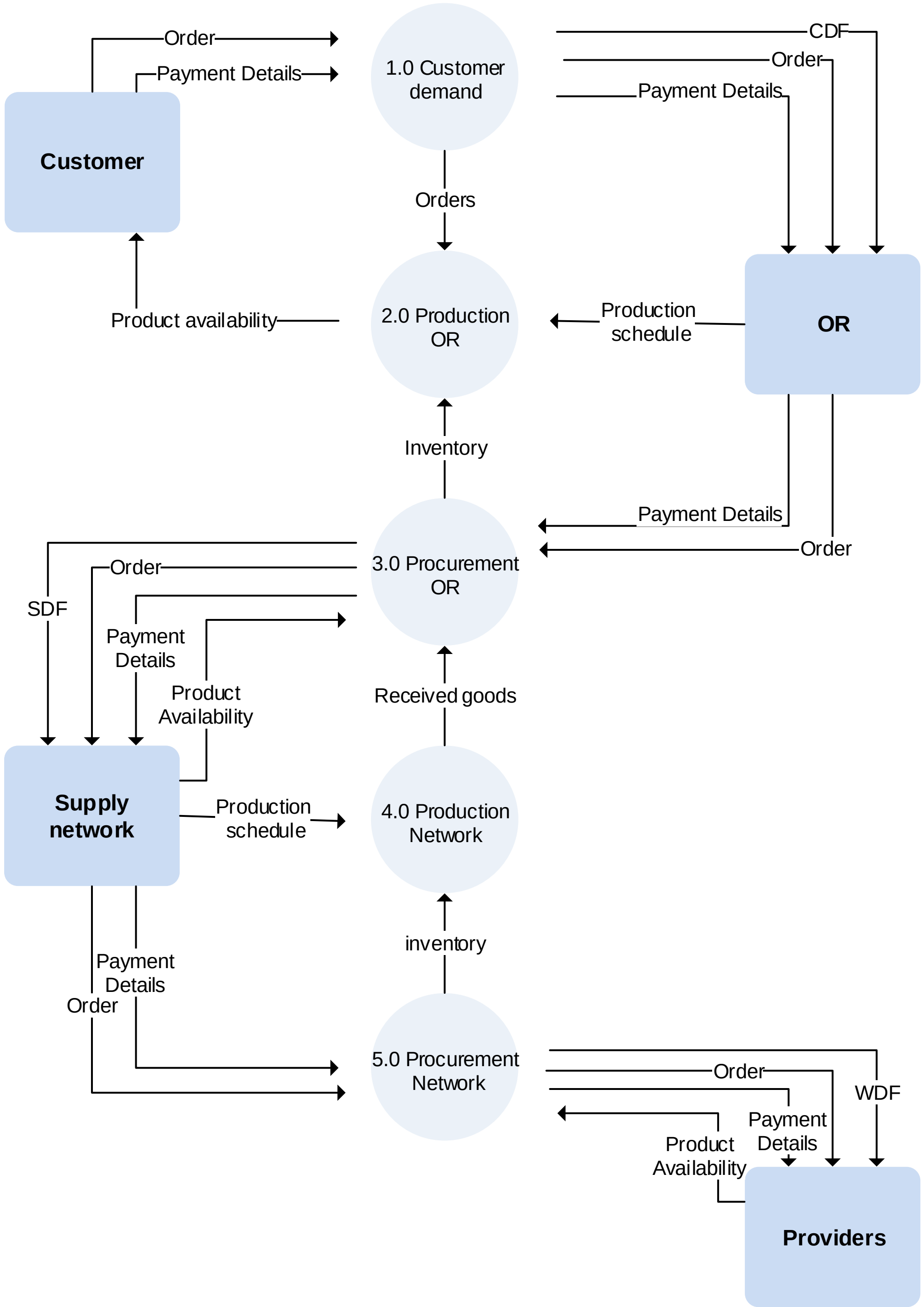
The orders are shipped to OR and are manually or automatically checked into the BOFF, depending on an ongoing test and implementation. Normally, to update the system stock level, all products are manually checked-in during the storing activity. This data is used to verify the completeness of the supply. However, this process has proven to be error-prone. A by BOFF derived list, named received goods, states the deviation between what is manually checked in and what is ordered. The list's accuracy is rechecked, and then large deviations are discovered, the production leader escalates to Preparation department. Due to the ongoing pilot of omitting the check-in procedure and trusting the network supplies what they register as supplied, a possible deviation is not registered in the deviations list and only discovered during counting activities at OR. During the storing activity at OR, the picking activity of the previous shift is performed at the same time.

When production discovers high deviations in supply during the counting activities or during the received goods check, the preparation department is responsible for the investigation of causes, impact and they determine the follow up. When the preparation department suspects a structural problem, they contact MP's front office to mention the deviations and to avoid future issues with the product. A detailed view of this communication process is visualized in figure on the left.



After customer order picking, a NA check is performed. A product in the order of the online customer that cannot be delivered to the online customer is called a NA. The NA check verifies that the products stated to be unavailable for order fulfillment during picking activities, are valid. Then, all shipments are consolidated from OR's DCs and shipped to the customer. In case the customer orders suffered from NA's, the order could not be completely delivered. The online customer is delivered at the door and pays for the delivered products at the driver.

10.2.5 Conceptual data flow diagram: Level 0



10.2.6 Distributed systems architecture: Grefen's three-dimensional design cube dimensions

The following table describes the dimensions and the according levels (Tummers, 2017).

Dimension	Definition
Aggregation Dimension	Within the aggregation dimension, the number of components identified determines the level of detail. The four aggregation levels: • **Level 1: a black-box;** • Level 2: the black-box is opened and main architectural style visible; • Level 3: within the main architectural style components are visible; Level 4: the components from level 3 are opened up to subcomponents.
Abstraction Dimension	Within the abstraction dimension, the level of concretization of the IS architecture determines its position (i.e. the number of specific choices made). Three abstraction levels: • **Level 1: class type components specifying their functionality, i.e. general software systems**; • Level 2: system type components specifying company-specific software systems; • Level 3: vendor specific components
Realization Dimension	The realization dimension defines the orientation of the architecture from very business-oriented to very technology-oriented. The realization levels are: • Level 1 (B): business, i.e. business goals of IS; • Level 2 (O): organization, i.e. structure to achieve business goals; • **Level 3 (A): architecture, i.e. conceptual software structure;** • Level 4 (T): technology, i.e. technological realization.
Aspect Dimension	The aspect dimension is held implicit and provides different perspectives or viewpoints on the IS architecture positioned within one specific cell. • The data aspect describes the organization of data within an IS; • **The process aspect describes the business processes managed in an information system;** • The software aspect describes the organization of software or modules of an IS; • The platform aspect describes the organization of software and hardware; • The organization aspect describes how the IS is embedded into an organization.

10.2.7 Distributed systems architecture: detailed diagram

All databases and information systems are summarized in the below. The detailed architecture is visualized and explained in the diagram below.

PDB contains the product master data of all MP products. It directly communicates logistical data, including the supplying DC, the product stream and product availability, to the WMS-OR by an overnight transaction. In A-PDB, the data team of OR enriches the product data of PDB by adding a website name, photo and other data necessary for the website. The A-PDB contains all master data of OR, since it also manually adds all product and logistical data of the assortment of two other network partners. The A-PDB has a near real time connection with the WMS-OR, with an automatic overnight transaction as a safety net. Every 5 minutes the WMS-OR checks whether information is ready to be send to the demand distributer of MP via a standard message.

The WMSOR sends the replenishment order of OR to DEDI containing the orders per receiving DC, product stream and supply moment. Depending on the capacity of DEDI, it takes several minutes for the order to be received. As the DCs work with collo numbers, which are identification numbers for a unique product, OR orders products via these numbers. One product can have multiple collo numbers, as the suppliers might stock multiple unit sizes for a product. Therefore, a preference for OR is indicated in the A-PDB. The preference collo number is not always leading, because in case of promotions the promotional collo number overrules. When the preference collo number is communicated TOS, A-PDB automatically switches to the next favorable collo number available.

DEDI verifies order quality, ensuring products are ordered on the correct product stream, and then distributes all orders to the right distribution centers. If DEDI cannot match an order line the data from PDB, the order lines will be rejected. This automatically leads to supply deviations at OR, as the order will never reach the supplying DCs. DEDI verifies whether the delivery moment for the collo number in the order matches with the delivery moments known in PDC. This indirectly means that it verifies the right stream for the collo number. DEDI can automatically assign a different stream when the specific collo number can be matched to the delivery moment of a different stream. If this is not the case, the order line is blocked. When an order line is blocked or when DEDI derives a new stream for the collo number, the product is logged, and a message is sent to OR IT support. OR IT support has confirmed to occasionally verify the reason for ordering on an incorrect stream, but no further actions are taken.

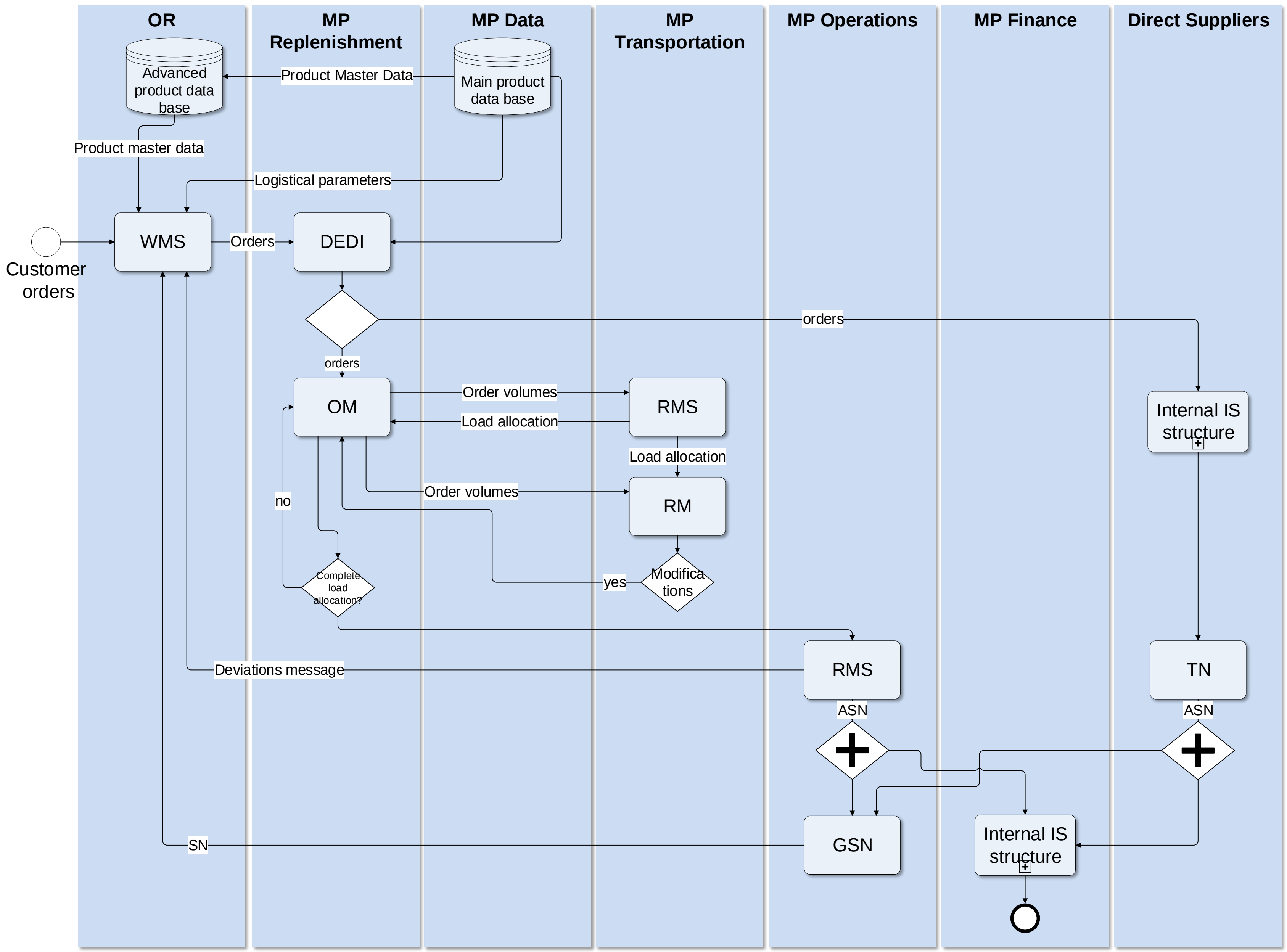
DEDI also manages all data for direct suppliers using electronic data interaction standards (EDI), like forecasts and actual orders. An EDI is an automatic electronic data interchange between computers of different organizations, resulting in structured communication and all MP systems are fully geared to communicate with suppliers through EDI.

The orders destined for MP are send to OM. This system collects all orders for the specific DC and is connected with the transportation systems. In OM, the orders can be manually adapted, for example when a maximum capacity control on a product is set for which OR is excepted or other situations in which orders need to be manipulated. RMS, route management system, allocates orders to transportation regardless of capacity and lead carriers per orders. In RM, an estimation of the number of load carriers per truck is determined. In case the maximum capacity of a truck is reached, the orders must be manually distributed over more trucks. When the load is completely allocated, it is sent to the warehouse management system of MP (WMS-MP). After the release in the warehouse, the actual stock at the DC is verified and products that are not administratively in stock are communicated via store order deviations messages. This is directly communicated to WMS-OR and processed automatically. With use of voice picking, WMS pilots pickers through the warehouse ending on a specific dock. When the last truck of the order is loaded, the WMS sends the supply per order to the GSN. The GSN creates a shipping notification (SN) per truck. This means that trucks can arrive at OR, before the standard shipping notification has been received when an order is transported by multiple trucks. There is no business rule for exact communication of the delivery notification, apart from 'at most half an hour before the check-in'.

For direct suppliers, the order is again communicated via EDI communication structure and the supplier communicates an advanced shipping notification (ASN) to the TN system of MP. This system manages all EDI-traffic between MP and their suppliers and sends the ASN's to the GSN and to the financial systems. It must be noted that not all direct suppliers follow this process, but this is left out of scope.

The GSN collects all shipping notifications per order and ensures the right systems, WMS-OR for AH OR and another system for physical stores, receive an SN-message. The SN's's are also the input for financial aspects of the supply chain.

Abbreviations descriptions	
Product databases	
Product database (PDB)	This main product database contains the product master data of MP and all corresponding logistical parameters. Ownership at MP.
Advanced product data base (A-PDB)	This product data base enriches the data for OR operations and the OR assortment. It adds the website naming, a photo, a preference BE and other data necessary for the website. It also adds product and logistical parameters of the assortment of two other network suppliers sold by OR. Ownership at OR.
Intra-organizational information systems	
Warehouse management system of OR (WMS-OR)	The WMS-OR has the following functions in scope: - tracking stock levels of OR DCs, - managing picking and filling operations at OR - capturing all customer data - managing customer orders, - generating the replenishment orders of OR. Ownership at OR.
Demand distributor (DEDI)	This system receives standard order messages, merges all orders and forwards the orders to the specific supplying DCs and to the direct suppliers. Ownership at MP.
Order manipulator (OM)	This system collects all orders for the specific DC and is connected with the transportation management systems. In OM, the orders can be manipulated. Ownership at MP.
Route management system (RMS)	This system allocates orders to transportation. Ownership at MP.
Route manipulator (RM)	This system verifies whether the order allocation by the RMS exceeds truck capacity. If so, a manual adjustment into the allocation is performed.
Warehouse management of MP (WMS-MP)	The WMS-MP has the following functions in scope: - tracking stock levels of MP DCs ' - managing picking and filling operations at MP DCs.
GSN	This system manages shipping notifications per truck.
TN	The system that manages all EDI traffic between MP and the direct suppliers


OR
MP Replenishment
MP Data
MP Transportation
MP Operations
MP Finance
Direct Suppliers
Advanced product data base
Product Master Data
Main product data base
Product master data
Logistical parameters
Customer orders
WMS
Orders
DEDI
orders
orders
OM
Order volumes
Load allocation
RMS
Load allocation
Order volumes
RM
no
Complete load allocation?
yes
Modifications
Internal IS structure
RMS
Deviations message
TN
ASN
ASN
GSN
SN
Internal IS structure

10.3 Data Analysis

This appendix describes the data analysis. First, the methodology is described in Section 10.3.1, followed by the data collection in Section 10.3.2. Then, the analysis results are elaborated on in Section 10.3.3. The details of the results are added to Section 10.3.4.

10.3.1 Data analysis methodology

The three goals of the data analysis have been described in the introduction of Chapter 6. Based on these goals, the following research questions are stated:

1. What is the impact of supply deviations on the KPI's of OR
2. What is the impact of supply deviations on NA's

3. What are the absolute and relative deviations?
4. Is there a variation in relative deviation?
    a. over weeks?
    b. over weekdays?

5. What is the share of acknowledged causes and undefined causes?

The impact of supply deviations on the network is measured the relation between short supply and the KPI's; order completeness and website availability. The second KPI is impacted because when reservations exceed the stock level, the product is infinite unavailable on the website for new customer reservations until the OR DC is restocked. Simple linear regression is a statistical method that allows to summarize and study relationships between two continuous (quantitative) variables. Short supply is denoted as the predictor or the independent variable and the KPI's are the responses or dependent variables. OR's data shows the NA's due to external reasons and internal reasons. This is automatically generated by the WMS. It assumes internal causes when stock levels have been mutated within a specific time frame, assumedly 24 hours, of the supply arrival. The short supply data, KPI data and the list of NA's of OR of the first 36 weeks in 2018 is used to ensure relevance in the fast-changing e-commerce.

The absolute deviations and the deviations relative to the order volumes give insight in the extent of the problem. By measuring the variation in relative deviation over weeks, a substantiated conclusion can be drawn concerning the variability of the problem. The variability of the absolute deviations is not considered, as those are highly affected by the variability of the order volumes. In case variability is small, the causes could have a structural nature, whereas large variability implies high uncertainty or trends. The coefficient of variation (COV) is used as measure as it indicates the extent of variability in relation to the mean. Single factor analysis of variance (ANOVA) determines whether there are any statistically significant differences between the means of three or more independent (unrelated) groups. This measure is used to find possible trends over the months, verifying seasonality. To calculate the absolute deviations, relative deviations, and the variation of weeks, all deviations and order volumes of weeks 1 to 36 of 2018 are used and compared with the data of 2017. To ensure relevance, the focus will primarily be on the data of 2018 due to the fast-paced business of the online retailing, the constant evolving replenishment strategy and the high growth factor per year.

ANOVA is also used to find possible trends of deviations over weekdays. Weekdays are independent as the deviation on Monday does not depend on the deviation of Tuesday. Relative deviations are verified to again avoid impact of order volumes or initial supply at the start of promotions. For the calculation, only the data of 2018 is used as the order data per day of 2017 was unavailable.

Lastly, the extent of acknowledged causes is calculated. The acknowledged causes identified were:
- TOS
- Known supply problems

If these causes are not indicated, the deviation is considered to have an undefined cause. Excessive supply is always considered as undefined cause and is probably related to the undefined short supply. All conclusions concerning the causes are based on the communication from MP. Twelve weeks are investigated, weeks 20-23 and 26-33 in 2018 as the data is on order line level and becomes inaccessible over time. However, again to the highly changing and growing business, by analyzing the latest weeks insight into the present situation is generated.

To discover trends, the research questions are examined from different perspectives: in total, per stream, per supplying DC and per receiving DC. As described in the process analysis, products are grouped per stream and every stream is of responsibility of a procurement team. Differences in deviations between the MP DCs and OR DCs are evaluated.

10.3.2 Data analysis data collection

Due to availability of data, the extent of data study will only cover the supply by MP and not by the direct suppliers. This will however give valuable insights into the supply deviations because, based on the registered supply deviations at OR, 87% of the weekly deviations in 2018 are of the responsibility of MP and MP is with 85% by far the largest supplier of OR. In 2017, the MP's supply caused 89% of the deviations.

The data used to conduct the analysis are:
- The results of the KPI's of OR
  - Data points of week 1-36 in 2018
  - A data point is the KPI percentage per week of order completeness or website availability
- the supply deviations registered by OR
  - Data points of 2017 and of week 1-36 in 2018
  - A data point is a deviation per article, per delivery moment, per OR DC, per stream
  - Supply deviations by direct suppliers excluded
  - On average 15.000 data points per week
  - One outlier in in week 22 in 2018 is neglected. The outlier can be explained by a miscommunication in unit sizes during a large change in the soda assortment. Physically the replenishment was accurate, but due to incorrect data the system stock was extremely inaccurate
  - Data reliability is notable for two reasons:
    - The manually checked-in using a barcode scanner at the arrival of supply at OR is error prone. The check-in inaccuracy is further investigated in the research in Section 6.2.
    - Due to an ongoing pilot of omitting the check-in, deviations are not registered and only rectified after discovery during counting activities in the OR DCs
- the order volumes as registered by OR
  - Data points of 2017 and of week 1-36 in 2018
  - Order volumes per delivery moment, per OR DC, per stream.
  - Orders to direct suppliers excluded

  - On average 14.500 data points per week
  - The order volumes stated by OR are assumed to be equal to the order volumes received by the supply network. Possible data issues in the order flow are therefore neglected.
- the products not delivered due to TOS and KSP according to MP
  - Data points in week 20-23 and 26-33 in 2018
  - A data point is a deviation per product, per delivery moment, per OR DC, per stream and with deviation cause code.
  - Around 15.000 data points per week

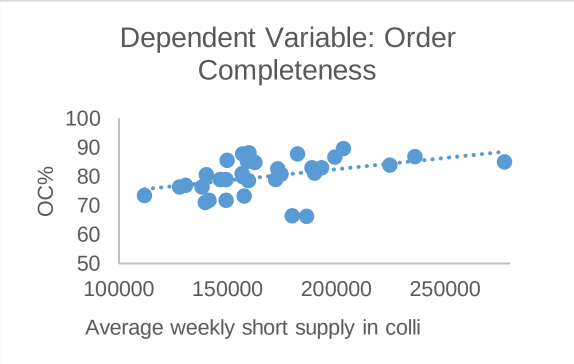
To conclude, all input data is structured (Batini, 2009). Although the reliability of the data is not completely reputable, analysis is still valuable to verify the impact and extent of the problem as to see whether further investigation is of need.

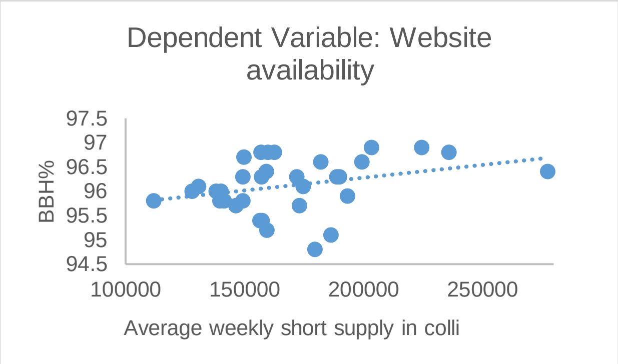
10.3.3 Data analysis results

The research questions are answered in this section. First the impact of supply deviations is described. Then the remaining research questions are described from the different perspectives: in total, per stream, per supplying DC and per receiving DC.

10.3.3.1 Impact analysis

Simple linear regression is used to statistically validate the expected relation between supply deviations and KPI's order completeness and website availability. The scatterplots in following figures visually show the relation between the KPI's and short supply in colli. For order completeness, a significant positive relationship is concluded at α=0.05 (r (32) = 0.41, p<0.05). For website availability, the Pearson's R, which measures the strength of the linear relationship between two variables (Zou, 2003), is 0,31 and therefore indicates a positive relationship. However, the p-value states the relation is insignificant at α=0.05 (r (32) = 0,31, p > 0.05). By decreasing the supply deviations, the order completeness will be significantly impacted, and the website availability is impacted, but not significantly. Exact results for the simple linear regression are added to Data Details 1.



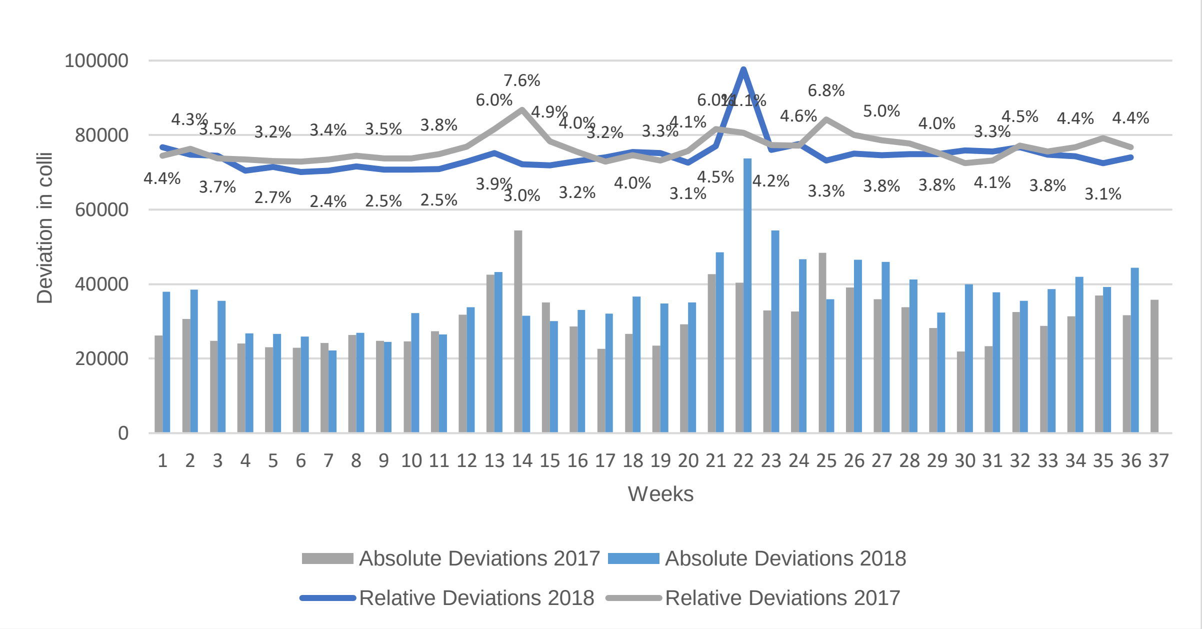


As mentioned in the AS-IS analysis in Section 5.2, a product that is ordered by an online customer but cannot be delivered is called one NA's. These NA's naturally have extreme impact on the order completeness performance. NA's can also be internally caused due to for example breakage or shelf live expiration but based on the NA list of 2018, 67% of the weekly 15.000 NA's are caused due to external reasons which are supply deviations. This concludes that on average per week around 10.000 products cannot be delivered to customer due to supply deviations.

10.3.3.2 Supply deviations in total

1. <u>Absolute and relative deviations</u>

The following diagram shows the absolute and relative deviations per week in 2017 and 2018. It is concluded that 3.5% of the replenishment deviated from what was ordered in 2018 neglecting the outlier in week 22. This includes excessive supply and short supply. On average the deviation is 36.000 colli per week in the replenishment of all OR DCs in 2018, containing around 200.000 customer unit sizes. 15% of the total deviation in 2018 was excessive supply that wasn't ordered. The deviation percentage indicates the deviation relative to what was ordered. The deviation percentage in 2018 is higher than in 2017, which implies that the higher the replenishment volume, the higher the chances on deviations.



2. <u>Variation in relative deviations</u>

There is a variation in the relative deviation varying from 2.4% to 4.5% over the weeks of 2018. The coefficient of variation is 21% (μ= 36.106, σ= 7434) compared to 26% in 2017. The average weekly variability of 7500 colli proves that the problem is influenced by multiple factors and incidental issues.

The ANOVA-analysis was used to detect seasonality in relative deviations. The results are shown in Data Details 2. It concluded on no statistically significant evidence at α =0,05 for a difference in the relative deviations over the first 9 periods (F(1.65)<Fcrit(3.22)). This implies no seasonality in the supply deviations.

ANOVA is again used to statistically determine whether total relative deviations vary over weekdays. Sunday is excluded as the average clearly shows a lower deviation percentage of 1.2% explained by the lower replenishment volumes. It can be concluded that there is statistically significant evidence at α=0.05 to show that there is a difference in relative deviations over the days of the week in 2018 (F(2.44)>Fcrit(2.26)). The detailed test results can be found in the Data Details 3. Tuesday, Wednesday and Saturday have the highest relative deviation per week.

Weekday	Deviation %
Monday	3.2%
Tuesday	3.7%
Wednesday	3.9%
Thursday	3.3%
Friday	3.2%
Saturday	3.5%
Sunday	1.2%

3. <u>Cause distribution</u>

The cause distribution showed that 37,6% per week of all deviations has an undefined cause. This means that for almost 38% of all deviations per week there is no generally acknowledged explanation for the unavailability**.** Considering only the short supply, leaving the excessive supply which always has an undefined cause out of scope, 31% per week has an undefined cause. Performance indicators will clearly benefit from a reduction of these undefined deviations.

10.3.3.3 Supply Deviations per stream

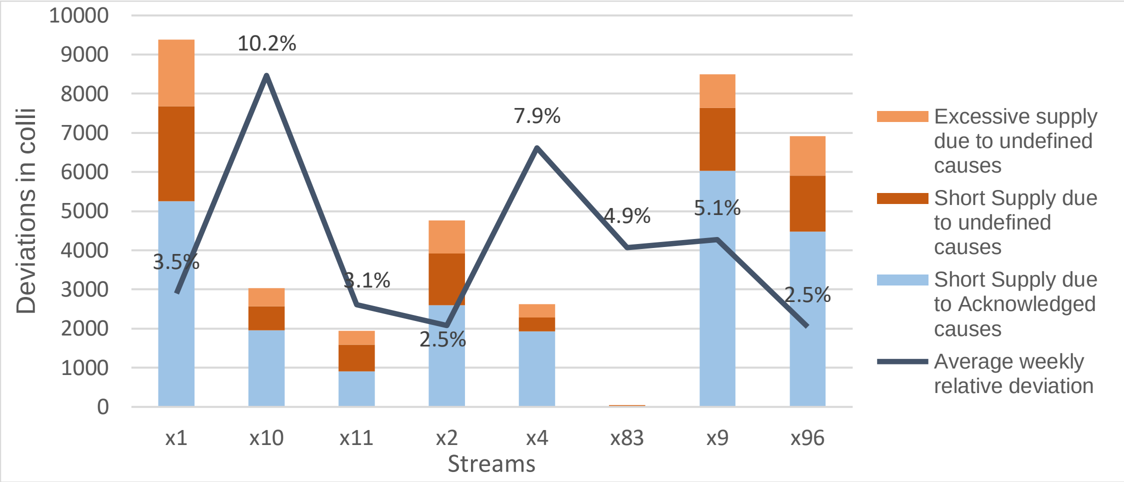
In the Data Details 4, all deviation data in 2017 and 2018 per stream used in the analysis is summarized. The following Figure gives a quick overview containing the absolute and relative deviations and the share of acknowledged and undefined causes. Again, all research questions have been investigated, during which the following conclusions are found:

1. <u>Absolute and relative deviations</u>
- 3 out of the 8 streams are responsible for 67% of the total absolute deviations in 2018 (x1, x9, x96). However, these streams have the largest replenishment volumes and relatively do not supply the most deviations. This confirms the logic that the larger the replenishment volume, the more deviations occur.
- Two streams have the highest relative deviations in 2018 (x10,8% and x4,10%)

2. <u>Variation in relative deviations</u>
- Based on the conclusions of the ANOVA-analysis in Data Details 5, the two streams with the highest relative deviation in both 2017 and 2018 (x10, x4) appear to have structural causes as no seasonality is detected. Looking at the type of products, possible causes are suggested:
  - x4 supplies deep frozen products which have a longer production lead time stressing the importance of safety stock
  - x10 consists of non-food products which are subject to many promotions of which inventory and timings must be evaluated.

  Although these possible explanations can be argued, these products impact online customers most.
- Although in total there exists a significant difference in relative deviations over weekdays, the conclusions of the ANOVA-analysis in Data Details 6 show that there is no statistically significant evidence at $\alpha=0.05$ to show differences in weekdays per stream.

3. <u>Cause distribution</u>
- Most striking is that almost 50% of the high absolute supply deviations in x1, responsible for 25% of the total deviations in 2018, has no acknowledged cause. Per week on average 2.400 colli is not supplied for an undefined cause, impacting numerous online customers. Equal for x96, of which 35% of the short supply in 2018 has an unknown cause.
- The streams with the highest relative deviations have the highest shares of acknowledged causes, which implies that high relative deviations are primarily caused by acknowledged causes.



10.3.3.4 Supply Deviations per supplying DC

In the Data Details 7, all deviation data in 2017 and 2018 per MP DC used in the analysis is summarized. As most streams are directly related to one DC of MP, the focus is on RDC 1, RDC 2, RDC 3 as they are the only DCs supplying the same streams. All research questions have been investigated, during which the following conclusions are found:

1. Absolute and relative deviations
   - ODC 3 and ODC 4 have the highest relative deviations compared to the other DCs of MP, which is remarkable as these are outsourced DCs.

2. Variation in relative deviations
   - The coefficient of variation of RDC 2 is higher than of RDC 1 and RDC 3. Especially in 2017, but since RDC2 only started supplying late 2017 this is neglected.
   - Again, no statistically significant evidence at a=0.05 is found for variation in relative deviations over weekdays per DC based on the ANOVA-analysis results added to Data Details 8.

3. Cause distribution
   - MP DCs have no influence on deviations in supply due to TOS.
   - Although, it must also be noted that not all undefined causes are of the responsibility of the DCs, it is remarkable that RDC2 has lower absolute and relative deviations due to undefined causes compared to RDC1 and RDC3. This could imply that the newer DCs suffer less from undefined causes and therefore the nature of the undefined causes seems decentralized.

10.3.3.5 Supply Deviations per receiving DC

In Data Details 9, all deviation data in 2017 and 2018 per OR DC used in the analysis is summarized. All research questions have been investigated, during which the following conclusions are found:

1. <u>Absolute and relative deviations</u>
   - It can be concluded that the supply of the RDCs of OR have an average deviation percentage of 3.0% per week, where 2.5% is short supply and 0.5% is supplied too much.
   - The highest relative deviation percentage of RDC 4, 3.4%, could be explained due to the highest production rate and that during the weeks in scope only this DC received x4, which was the stream with the highest deviation percentage.
   - NDC 2 produces slow-running products and has a high deviation percentage (7.2%). This indicates that the probability of mistakes increases with the number of different products to be supplied.

2. <u>Variation in relative deviations</u>
   - For all DCs apart from NDC 2, no statistically significant evidence at a=0.05 is concluded that shows that there is a difference in the relative deviations over the weekdays in 2018. The ANOVA conclusions are added to Data Details 10. For NDC 2, the ANOVA analysis found statistically significant evidence at a=0.05 for a difference in relative deviations over weekdays F(3.44)>Fcrit(2.26). The results show that the average weekly relative deviation on Monday and Wednesday is higher than on the other weekdays.

3. <u>Cause distribution</u>
   - OR DCs have no impact on deviations due to KSP and TOS, but can cause undefined deviations
   - RDC 3 has the highest undefined deviations, on average 2000 colli per week. However, as these causes are undefined the responsibility of the DC cannot be substantiated.

10.3.4 Data analysis details

1. Results of simple linear regression

SUMMARY OUTPUT Order completeness

Regression Statistics	
Multiple R	0,419135903
R Square	0,175674905
Adjusted R Square	0,149083773
Standard Error	5,729325721
Observations	33

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	216,8602364	216,8602	6,606522	0,01518696
Residual	31	1017,58037	32,82517		
Total	32	1234,440606			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	66,91030234	5,205582784	12,85357	5,84E-14	56,29344626	77,52715843	56,29344626	77,52715843
Short Supply	7,77425E-05	3,02463E-05	2,570316	0,015187	1,60548E-05	0,00013943	1,60548E-05	0,00013943

SUMMARY OUTPUT Website Availability

Regression Statistics	
Multiple R	0,3194368
R Square	0,102039869
Adjusted R Square	0,073073413
Standard Error	0,530136627
Observations	33

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,990034102	0,990034	3,522691	0,069974164
Residual	31	8,712390141	0,281045		
Total	32	9,702424242			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	95,22785246	0,481674499	197,7017	1,22E-49	94,24547084	96,21023408	94,24547084	96,21023408
Short Supply	5,25284E-06	2,7987E-06	1,876883	0,069974	-4,55153E-07	1,09608E-05	-4,55153E-07	1,09608E-05

2. Results of ANOVA analysis testing seasonal trends

H0: μ(Period 1) = μ(Period 2) = μ(Period 3) = μ(Period 4) = μ(Period 5) = μ(Period 6) = μ(Period 7) = μ(Period 8) = μ(Period 9)
H1: The means are not all equal.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
period 1	2	6.6%	3.3%	1.25154E-05
period 2	2	5.2%	2.6%	1.76783E-07
period 3	2	5.5%	2.8%	1.39266E-06
period 4	2	7.3%	3.7%	3.42867E-05
period 5	2	6.4%	3.2%	3.75651E-05
period 6	2	7.5%	3.8%	0.000101437
period 7	2	7.6%	3.8%	2.62459E-06
period 8	2	7.5%	3.8%	2.34151E-05
period 9	2	6.8%	3.4%	2.62182E-06

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000316527	8	3.95659E-05	1.648312074	0.235847767	3.229582613
Within Groups	0.000216035	9	2.40039E-05			
Total	0.000532562	17				

3. Results of ANOVA analysis testing weekday trend in 2018

H0: μ(Monday) = μ(Tuesday) = μ(Wednesday) = μ(Thursday) = μ(Friday) = μ(Saturday)
H1: The means are not all equal.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Monday	33	1.072396	0.032497	0.000173614
Tuesday	33	1.223133	0.037065	0.000127483
Wednesday	33	1.292373	0.039163	9.57718E-05
Thursday	33	1.08558	0.032896	0.000158845
Friday	33	1.052366	0.03189	4.49329E-05
Saturday	33	1.165294	0.035312	7.53535E-05

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00138	5	0.000276	2.449919037	0.035247	2.261137581
Within Groups	0.021632	192	0.000113			
Total	0.023012	197				

4. Detailed Deviation Data per stream

		X1	X10	X11	X2	X4	X83	X9	X96
2018	Average absolute weekly deviation in colli	9387	3037	1944	4762	2622	37	8496	6918
	% of total	25.2%	8.2%	5.2%	12.8%	7.0%	0.1%	22.8%	18.6%
	% short	82%	85%	81%	82%	87%	92%	90%	85%
	% excessive	18%	15%	19%	18%	13%	8%	10%	15%
	COV	48%	44%	38%	30%	57%	77%	29%	38%
	Average weekly relative deviation	**3.5%**	**10.2%**	**3.1%**	**2.5%**	**7.9%**	**4.9%**	**5.1%**	**2.5%**
	Causes: KSP%	29%	46%	47%	46%	44%	48%	26%	56%
	Causes: TOS%	27%	30%	10%	21%	41%	19%	53%	20%
	Causes: UNDEFINED%	44%	35%	54%	45%	26%	39%	29%	35%
2017	Average absolute weekly deviation	7430	2773	1982	3569	1655	48	8548	6196
	% short	75%	82%	80%	82%	88%	95%	92%	83%
	% excessive	25%	18%	20%	18%	12%	5%	8%	17%
	COV	53%	56%	62%	50%	52%	51%	34%	56%
	Average weekly relative deviation	3.4%	11.9%	3.7%	2.4%	6.6%	6.8%	6.3%	3.1%

5. Results of ANOVA analysis testing seasonal trends per stream

H0: μ(Period 1) = μ(Period 2) = μ(Period 3) = μ(Period 4) = μ(Period 5) = μ(Period 6) = μ(Period 7) = μ(Period 8) = μ(Period 9)
H1: The means are not all equal.

Results x4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
period 1	2	0.0937488	0.0468744	1.517E-05
period 2	2	0.096098	0.048049	0.0002103
period 3	2	0.1672989	0.0836495	0.0006449
period 4	2	0.153417	0.0767085	0.0016281
period 5	2	0.0959732	0.0479866	6.07E-07
period 6	2	0.2345532	0.1172766	0.0019294
period 7	2	0.1732535	0.0866267	3.367E-05
period 8	2	0.1705293	0.0852647	0.0029078
period 9	2	0.1048038	0.0524019	0.0001152

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.0095	8	0.0011906	1.431533	0.3011651	3.2295826
Within Groups	0.0075	9	0.0008317			
Total	0.017	17				

Result x10

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
period 1	2	0.24461273	12.2%	2.2486E-08
period 2	2	0.21374222	10.7%	2.4568E-05
period 3	2	0.1810439	9.1%	7.4622E-07
period 4	2	0.16342341	8.2%	7.5805E-05
period 5	2	0.18005678	9.0%	5.4161E-07
period 6	2	0.2504788	12.5%	5.6934E-05
period 7	2	0.33941363	17.0%	0.005959
period 8	2	0.23628673	11.8%	0.00382779
period 9	2	0.18150135	9.1%	1.9746E-05

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0119	8	0.00149266	1.3480875	0.33134527	3.22958261
Within Groups	0.01	9	0.00110724			
Total	0.0219	17				

6. Results of ANOVA analysis over weekdays per stream

H0: μ(Monday) = μ(Tuesday) = μ(Wednesday) = μ(Thursday) = μ(Friday) = μ(Saturday)

H1: The means are not all equal.

Stream	SS	df	F	P-Value	F crit
X2	0.031	197	1.069	0.378	2.261
X96	0.033	196	1.575	0.168	2.261
X10	1.306	195	1.076	0.374	2.261
X83	0.339	120	0.326	0.896	2.293
X1	0.054	197	1.058	0.384	2.261
X4	11.11	193	1.203	0.309	2.261
X11	0.207	197	1.284	0.272	2.261
X9	0.117	197	1.469	0.201	2.261

7. Detailed Deviation Data per supplying DC

		RDC1	RDC2	RDC3	NDC	ODC1	ODC2	ODC3	ODC4
2018	Average absolute weekly deviation in colli	4779	2371	7036	8496	6918	1944	2622	3037
	% of total	12.8%	6.4%	18.9%	22.8%	18.6%	5.2%	7.0%	8.2%
	% short	81%	82%	83%	90%	85%	81%	87%	85%
	% excessive	19%	18%	17%	10%	15%	19%	13%	15%
	COV	36%	56%	32%	29%	38%	38%	57%	44%
	Average weekly relative deviation	3.2%	3.0%	3.0%	5.1%	2.5%	3.2%	7.9%	10.2%
	Causes: KSP%	30%	36%	31%	23%	48%	38%	38%	39%
	Causes: TOS%	23%	28%	23%	48%	17%	8%	36%	25%
	Causes: UNDEFINED%	46%	36%	46%	29%	35%	54%	26%	35%
2017	Average absolute weekly deviation	4139	541	6597	8548	6196	1982	1655	2773
	% short	80%	74%	76%	92%	83%	80%	88%	82%
	% excessive	20%	26%	24%	8%	17%	20%	12%	18%
	COV	26%	152%	57%	34%	56%	62%	52%	56%
	Average weekly relative deviation	3.0%	3.4%	2.9%	6.3%	3.1%	4.7%	6.6%	11.9%

8. Results of ANOVA analysis over weekdays per supplying DC

H0: μ(Monday) = μ(Tuesday) = μ(Wednesday) = μ(Thursday) = μ(Friday) = μ(Saturday)
H1: The means are not all equal.

RDC	SS	df	F	P-Value	F crit
RDC1	0.026	197	1.029	0.401	2.261
RDC2	0.106	197	1.202	0.309	2.261
RDC3	0.026	197	1.579	0.167	2.261

9. Detailed Deviation Data per receiving DC

		RDC 1	RDC 2	RDC 3	NDC 1	NDC 2	RDC 4
2018	Average absolute weekly deviation in colli	5352	5953	6734	3103	7787	12675
	% of total						
	% short	84%	84%	83%	87%	86%	83%
	% excessive	16%	16%	17%	13%	14%	17%
	COV	41%	26%	26%	35%	23%	30%
	Average weekly relative deviation	3.0%	2.6%	2.9%	2.9%	7.2%	3.4%
	Causes: KSP%	29%	30%	24%	16%	42%	26%
	Causes: TOS%	36%	34%	30%	50%	26%	35%
	Causes: UNDEFINED%	35%	37%	46%	34%	33%	39%
2017	Average absolute weekly deviation		6067	6545	4411	7605	10773
	% short		85%	78%	87%	81%	82%
	% excessive		15%	22%	13%	19%	18%
	COV		27%	53%	56%	30%	27%
	Average weekly relative deviation		2.9%	3.1%	4.0%	8.3%	3.3%

10. Results of ANOVA analysis over weekdays per receiving DC

H0: μ(Monday) = μ(Tuesday) = μ(Wednesday) = μ(Thursday) = μ(Friday) = μ(Saturday)
H1: The means are not all equal.

RDC	SS	df	F	P-Value	F crit
RDC1	0.927	197	1.486	0.195	2.261
RDC2	0.020	197	1.494	0.193	2.261
RDC3	0.026	197	2.238	0.052	2.261
RDC4	0.033	197	1.904	0.095	2.261
NDC1	0.094	197	0.600	0.699	2.261
NDC2	0.363	196	3.448	0.005	2.261

10.4 Root-Cause Analysis

10.4.1 General root-cause analysis: brainstorm protocol

- Research question: What are causes of registered undefined supply deviations?
- Research approach: participant in the brainstorms
- Scope: Registered supply deviations in the supply of MP.
- Expert selection: Problem holders of different seniority added to the table below.
- Mode of communication: face-to-face
- Methods of data collection:
    - Unstructured brainstorms
    - Structured brainstorm following the AS-IS diagrams
- Response modes: list with possible root-causes

Structured and unstructured brainstorms conduced		
Brainstorm 1	B1	Manager at OR & Senior Preparation at OR
Brainstorm 2	B2	Senior Preparation at OR
Brainstorm 3	B3	Replenishment employee at MP
Brainstorm 4	B4	Preparation employee at OR
Brainstorm 5	B5	Preparation employee at OR
Brainstorm 6	B6	Replenishment employee at MP
Brainstorm 7	B7	Replenishment employee at MP

10.4.2 Root-cause evaluation: NA cause analysis decision tree

A decision tree is developed to support the NA analysis. The tree is developed based on the causes identified in the premier data analysis, an explorative impact analysis in weeks 15 and 16 (2018) to determine decision sequence and by validation on an in-house data analyst. The decision tree is described and showed in figure below.

First it is verified whether the product with the NA had an acknowledged cause or an acknowledged internal cause. An internal cause can be concluded when administrative stock levels were mutated due to for example breakage or shelf lives.

If multiple products are missing from the same DC and of the same flow, a load carrier could have been gone missing. If even more deviations from one DC were missing, this could also be caused by delay in transportation.

Then, it must be verified whether a supply deviation had occurred one or two days prior of the NA. If this was not the case and everything was supposedly supplied, it must be verified whether the order was sufficient. If the order was too small, a forecast inaccuracy can be concluded.

Due to the ongoing pilot with automated check-in, a possible deviation is not registered in the deviations list. If there was a deviation, this mistake surfaced during counting activities and administrative stock level would have been adjusted. If the deviation was discovered too late, this is considered an internal problem. The new order is based on inaccurate stock levels and falsely low which enlarges the problem.

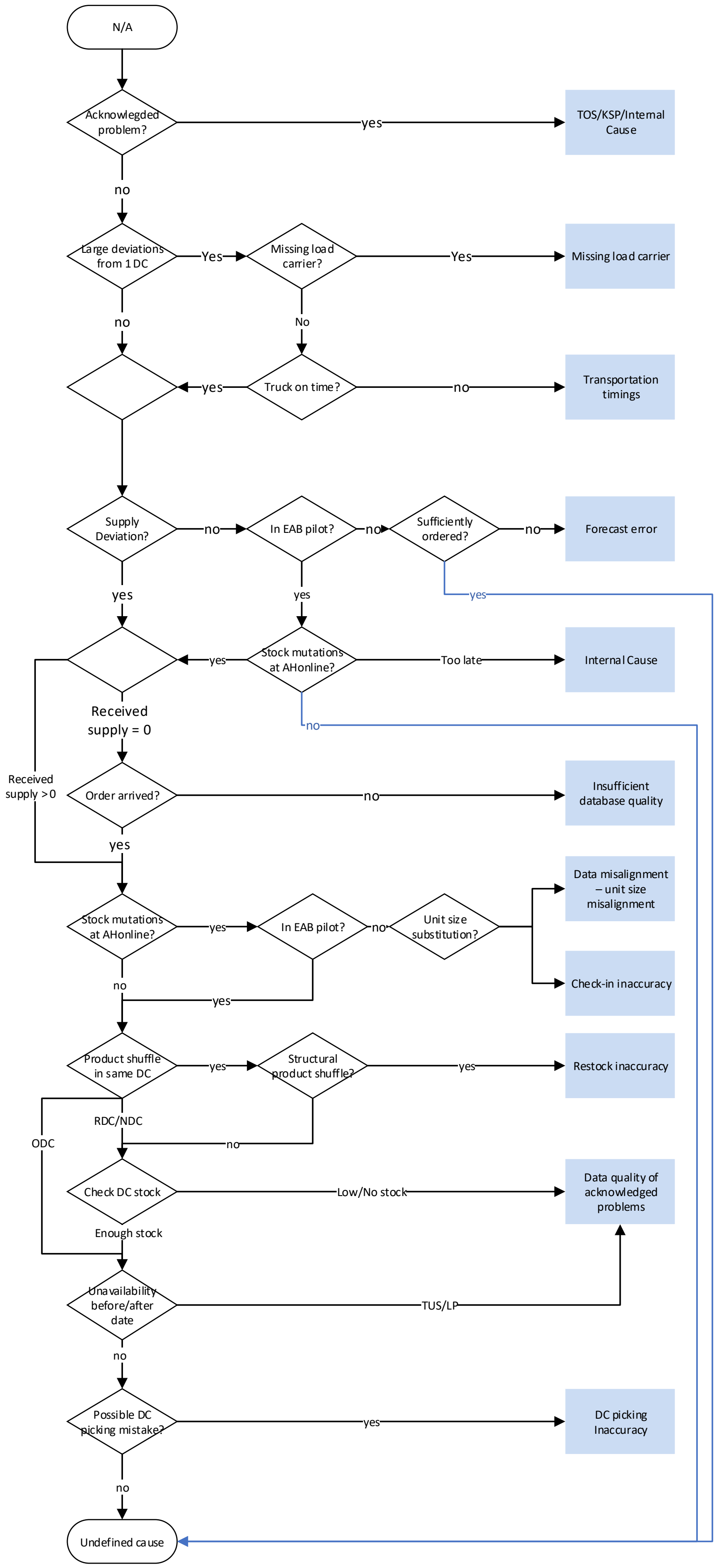
In case there was a supply deviation and none of the products in the order was supplied, it must be verified if the order had arrived at MP. It could have been blocked by DEDI due to logistical data misalignment. If the order was partly supplied, this cannot be the cause.

Then, the check-in accuracy is verified for products that are not in the automatic check-in pilot.
If large stock level mutations were made, it must be verified whether they were checked-in incorrectly due to inaccuracy or because a different unit size was supplied. Unit size misalignment is assumed when there is a consistent deviation per colli. If it is random, manual inaccuracy is assumed. Unit size misalignment can also be verified be comparison of the unit size on the EAB and the unit size registered in BOFF.

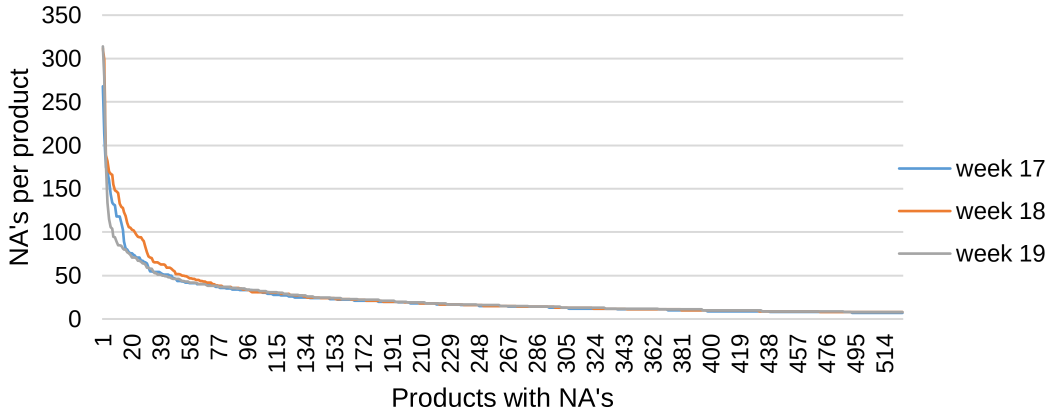
Next, the probability of a product shuffle is verified. If a product is in excess supplied with the exact amount of colli of the missing product and from the same DC, a product shuffle is expected.

If this is not the case, the stock levels at MP can be verified to check stock levels. If there was no stock, or the product was coupled TOS or KSP just before or after the production date at MP, it is assumed the NA was missing in the TOS/KSP problem reports.

If all of these causes cannot be concluded, the probability of picking inaccuracy must be considered or else the N/A has an undefined cause.


N/A
Acknowledged problem?
yes
TOS/KSP/Internal Cause
no
Large deviations from 1 DC
Yes
Missing load carrier?
Yes
Missing load carrier
no
No
yes
Truck on time?
no
Transportation timings
Supply Deviation?
no
In EAB pilot?
no
Sufficiently ordered?
no
Forecast error
yes
yes
yes
yes
Stock mutations at AHonline?
Too late
Internal Cause
no
Received supply = 0
Received supply > 0
Order arrived?
no
Insufficient database quality
yes
Stock mutations at AHonline?
yes
In EAB pilot?
no
Unit size substitution?
Data misalignment – unit size misalignment
Check-in inaccuracy
no
yes
Product shuffle in same DC
yes
Structural product shuffle?
yes
Restock inaccuracy
RDC/NDC
ODC
no
Check DC stock
Low/No stock
Data quality of acknowledged problems
Enough stock
Unavailability before/after date
TUS/LP
no
Possible DC picking mistake?
yes
DC picking Inaccuracy
no
Undefined cause

10.4.3 Root-cause evaluation: NA distribution



10.4.4 Root-cause evaluation: detailed expert judgement analysis

Process of expert judgment (Benini, 2017)	
Background and preparation	Goal: Clarifying priorities. What causes impact most and benefit most from further investigation according to the problem stakeholders?
Recruitment of experts	As the problem crosses organizational boundaries, selecting experts is challenging as none oversee the complete process. For that reason, the recruitment of experts crosses organizational borders. The expert panel must embody the following concluded restrictions: • Experts from both network partners • Both operational and managerial experts • Focus on problem owner as they have the broadest overview (preparation department) • 5-9 experts as recommended by Benini (2017) It must be noted that the scope of the problem must be considered for every expert as they cannot rank causes of which they have no knowledge off. Therefore the ranking is personalized to the expert groups. • The problem holder at OR is considered to have the most insight of the complete impact of the problem and of all causes, because OR's DCs communicate their suspicions to be verified to the problem holder. • As operations of OR need to cope with the effect of the problem, shift leaders and team leaders are questioned. It also obtains their valuable insight into their view on check-in accuracy. DC operations have no knowledge about data misalignment, as they do not investigate these causes. • DCs of network partners have no insight into the impact or occurrence of data misalignment, transportation delays and check-in accuracy at OR.
Elicitation and recording	A ranking is used to match time requirements with the yield of analysis, and since it is proven to be reliable for less than seven topics/causes (Benini, 2017). The question formulated is individually asked to a selected group of experts. The one-on-one interview is the best method for obtaining data on the problem-solving processes experts use to obtain the results and it avoids potential bias from group dynamics (Benini, 2017) It might result in too much detail, but it is the most practical option and simplified by focusing on only one question. Conclusions: - Elicitation situation: One-on-one interview between interviewer (data collector) and expert. - Mode of communication: face-to-face - Elicitation technique: Verbal probe - Response modes: Ranks or ratings - Aggregation of experts' answers: Mathematical
Aggregation and synthesis	Quantitative rankings

Communication of findings	By means of this report
Use in decision-making	Analysis of problem knowledge and direction for research

10.4.5 Root-cause evaluation: expert judgement results

Expert Group	**OR Preparation**					
Deviation cause/Expert	Employee	Employee	(ex-) Senior	Senior	Senior	Employee
Insufficient data quality	4	3	3	3	1	4
Partner DC inaccuracy: Restock inaccuracy	2	4	2	4	2	1
Partner DC inaccuracy: Picking inaccuracy	5	6	1	5	5	3
Partner DC inaccuracy: Loading inaccuracy	6	5	5	1	3	6
Transportation issues	3	2	6	6	4	5
Check-in inaccuracy	1	1	4	2	6	2
Expert Group	OR DCs					
Deviation cause/Expert	Team Lead RDC	Team Lead RDC	Team Lead RDC	Team Lead LDC	Team Lead RDC	
Insufficient data quality						
Partner DC inaccuracy: **Restock inaccuracy**	1	3	4	2	2	
Partner DC inaccuracy: **Picking inaccuracy**	3	4	3	3	1	
Partner DC inaccuracy: **Loading inaccuracy**	2	2	2	5	3	
Transportation issues	4	5	5	4	5	
Check-in inaccuracy	5	1	1	1	5	
Expert Group	Network (MP)					
Deviation cause/Expert	Manager RDC	Shiftleader LDC	Team lead RDC	Team Lead LDC (outsourced)	Replenishment trainee MP	
Insufficient data quality					4	
Partner DC inaccuracy: **Restock inaccuracy**	2	3	1	2	3	
Partner DC inaccuracy: **Picking inaccuracy**	3	1	2	1	6	
Partner DC inaccuracy: **Loading inaccuracy**	1	2	3	3	5	
Transportation issues					2	
Check-in inaccuracy					1	

10.4.6 Insufficient database quality analysis

The analysis and results are described of the analysis into supply deviations due to database quality analysis.

Analysis description

Inspired by the study of Huner (2011), this root-cause analysis consists of three phases:

Phase 1: List data issues resulting in supply deviations
Phase 2: Discover data defects of the data issues
Phase 3: Identify data attribute and root-cause

<u>Phase 1</u>

First all deviations due to data issues were listed. This was done by an in-depth desk analysis in the documents in the following table

DATA COLLECTION		
Source	**Description**	
Results from impact sample analysis on product level	Week 17,18,19 2018 Structured data	Explained in Section 6.2.2
Top 20 NA documentation	week 1-33 2018 Structured data	Structural weekly list with the 20 products with the most NA's including their suspected cause.
DEDI Log	week 29,32,33 2018 unstructured data	In case DEDI rejects order lines, these are communicated to IT support per email.
BE issues log Preparation department	2018 Unstructured data	Preparation department logged issues for a period to get insight into cause types

Only deviations due to data problems of 2018 were listed to scope the study and the ensure relevance in practice. The desk analysis found 17 situations where the online customer was impacted due to data issues. Each data issue discovered in the desk analysis is listed in table below including their source and impact in NA's. Clearly more business problems due to data in order fulfillment can occur, but this analysis will direct the stakeholders to the most current and most vulnerable aspects of data alignment.

<u>Phase 2</u>

To understand the data issues, each issue is investigated with help of deeper document and system review and interviews with the problem holder and IT experts of both OR and MP. During the interviews, one other data defect was recognized, which was not found in the desk study: the supplier deviation function in in the WMS of OR overrules the product data base (I1). Data defects were concluded from the investigation into the issues. For one product issue (D4), the defect could not be identified, and this issue is suggested for further research. The descriptions and the concluded data defect per data issue are added to the table below.

<u>Phase 3</u>

For each data defects, the data attributes were concluded. Incorrect unit sizes and product relations are challenges of the business-IT alignment, as the data is accurate at MP but not well-processed to the systems of OR. All defects involving the logistical product data result in actual deviations. Either the product data base was incorrect, or the information system architecture was not sufficiently aligned.

Analysis Results

<table>
<tr><th>CODE</th><th>SOURCE</th><th>PRODUCT</th><th>IMPACT IN NA'S</th><th>DESCRIPTION</th><th>DATA DEFECT</th></tr>
<tr><td>B1</td><td>BE log</td><td></td><td></td><td>During counting activities at OR, the DC scanners use regular unit sizes of products instead of actual unit sizes, resulting in stock level confusion</td><td>Misaligned between scanner and WMS of OR</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>D1</td><td>NA impact analyis</td><td>Sinaasappel sap</td><td>33</td><td rowspan="3">When there is no digital relationship between multipacks and singles products in the WMS of OR, during the inbound process only multipacks are checked-in. It seems singles have not arrived, but they have been physically supplied in multipacks. When the system stock level of the single product is not corrected in time, the next replenishment is based on an inaccurate stock level and the problem becomes a vicious circle. If operations at OR don't notice that also the location of the singles have to be restocked by the multipacks, this shelf is empty, and customers are not supplied.

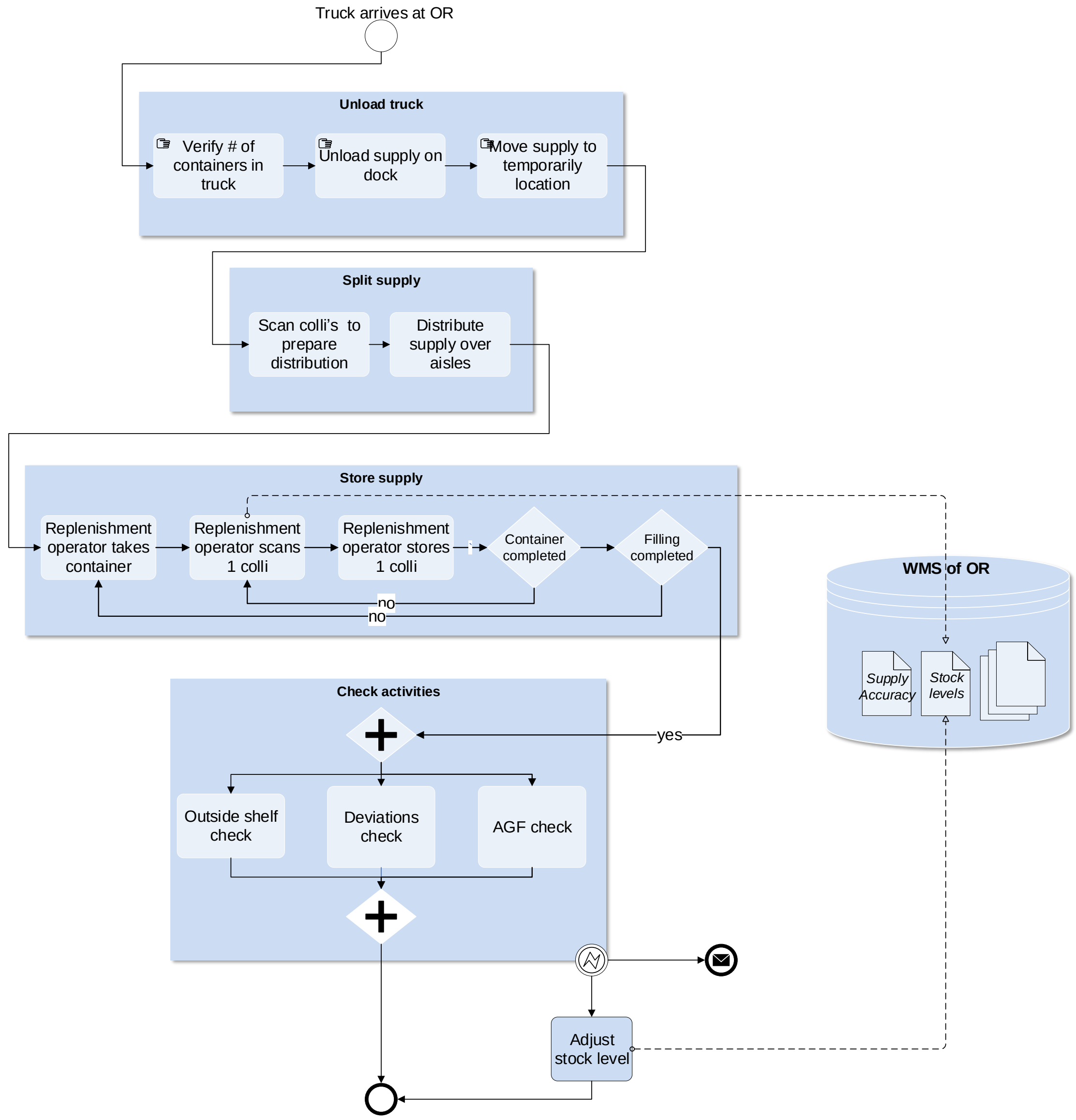
These product relations are communicated by the commercial department in the product data base but have not been processed by the ECDT to the WMS of OR. It is assumed that this is mainly caused by a lack of knowledge in the data support team of OR.</td><td rowspan="3">Product relations not processed from product data base to WMS of OR</td></tr>
<tr><td>D2</td><td>NA impact analyis</td><td>Appelsap</td><td>200</td></tr>
<tr><td>D15</td><td>NA RAPPORT & NA impact analysis</td><td>Spa Reine</td><td>518</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>B3</td><td>BE log</td><td></td><td></td><td rowspan="6">A unit size is substituted by the supplier, but the scanner used at the check-in during inbound process at OR always applies the regular data from the product data base. The substituted unit size is communicated via the EAB. Check-in operators at the OR are obliged to pay attention on incoming unit sizes, but reality shows this is not sufficient. The misalignment does not occur in the received goods check as what is checked-in is equal to what is ordered.
Products can be supplied by a different unit size when the DCs perform a substitute procedure. Reasons for suppliers to substitute are:
1. Substitution to avoid short supply: The problem is mostly impacted by fresh products as for example cauli flowers, cucumbers and eggplants vary in sizes over seasons. Therefore, the unit sizes per colli can deviate. OR can only place orders for a product on 1 collo number, which means the unit size is predetermined and not reactive to the actual stock in the DCs. To avoid short supply, the DCs substitute the ordered unit size for the unit size available.
2. Residual stock: D12 is an example where the DCs supplied substituted unit sizes as they were aiming to deterge residual stock, before starting the new unit size.
An example of the impact is shown in the table on the right. The system stock is 30 units lower than the actual stock, which means the order algorithm will order excess stock. If unit size substitute is lower, the system stock will be higher than the actual stock resulting in short stock impacting customers.

As this problem has been acknowledged for the "AGF" products, a list of around thirty varying fresh products ("top AGF") is created and must be checked after check-in in all locations. Inaccurate checks or products that are not included in the list can impact stock inaccuracy and practice has shown that this process is still error-prone.

<table><tr><th></th><th>colli</th><th>unit size</th><th>units</th></tr><tr><td>Order</td><td>10</td><td>6</td><td>60</td></tr><tr><td>Supply</td><td>5</td><td>12</td><td>60</td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>EAB data</td><td>5</td><td>12</td><td>60</td></tr><tr><td>Check-in data</td><td>5</td><td>6</td><td>30</td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>Physical stock</td><td></td><td></td><td>+60</td></tr><tr><td>System stock</td><td></td><td></td><td>+30</td></tr></table></td><td rowspan="6">Inaccurate unit sizes at check-in of OR in case of MP substitution, as OR uses regular unit sizes instead of substituted unit sizes</td></tr>
<tr><td>D5</td><td>NA RAPPORT</td><td>Pitloze rode druiven</td><td>599</td></tr>
<tr><td>D6</td><td>NA RAPPORT</td><td>Mango</td><td>226</td></tr>
<tr><td>D10</td><td>NA RAPPORT & NA impact analysis</td><td>Aardappelen iets kruimig voordeel</td><td>306</td></tr>
<tr><td>D12</td><td>NA RAPPORT & NA impact analysis</td><td>Courgette</td><td>767</td></tr>
<tr><td>D13</td><td>NA RAPPORT</td><td>Sable druif</td><td>291</td></tr>
</table>

CODE	SOURCE	PRODUCT	IMPACT IN NA'S	DESCRIPTION	DATA DEFECT
D3	NA RAPPORT & NA impact analysis	witte wijn	105	The database of a product in promotion contained a faulty stream sending the order to a DC where the product was not available resulting in a disappearance of the order line. An erroneous process for creating promotional data was the root-cause for these problems: The commercial department created the promotional data eight weeks before the start of the promotion with the logistical data based on the regular logistical data. However, in the time between the creation of promotional data and the start of the promotion, the regular logistical had been changed which was not incorporated when the promotion started. Since the information in DEDI was also based on the faulty information, the order was not rejected or logged. This problem has been recognized and a new process and tool were created. The new process flow ensures that commercial departments do not interfere with logistical information. This inaccurate data quality is therefore improved by an updated process design.	Inaccurate product data base during promotion ->Logistical data misalignment
D7	NA RAPPORT	Witte Reus	231		
D8	NA RAPPORT	Witte Reus	330		
D9	NA RAPPORT	Witte Reus	438		
D11	NA RAPPORT	Kiwi groen	971	Incorrect starting date of a promotion in the product data base resulted in orders for a DC, whilst these products were physically not yet available as the promotion has not yet started. OR relied on the inaccurate product data and opened customer reservations for the product, whilst these will not be fulfilled.	Inaccurate product database -> Logistical data misalignment
D14	NA RAPPORT	Zacht & sterk toiletpapier 3-laags	1303	The product data base was incorrect as a promotion was created for the whole network, whilst this was only valid for stores supplied from a specific DC, which does not supply OR. Due to the mistake in the data base, reservations were opened for online customers but were never to be fulfilled.	
D16	DEDI log & NA impact analysis	Yorkham	54	Due to an incorrect starting date in the product data base, OR started ordering products that were not yet available. The mistake was acknowledged and corrected in the product data base on the same day as the order which was in time for DEDI to track the issues, but too late to order based on accurate data.	
D17	DEDI log	Erdinger	49		
D4	NA RAPPORT	Spa Reine	229	The product was ordered by a faulty collonumber	Undefined
CODE	**SOURCE**	**DESCRIPTION**			**DATA DEFECT**
I1	Interviews	OR can modify streams via the 'deviant supplier' function in their WMS, which enables to force a different stream for a product than according to the product data base. The function is essential for products that are available in the MP DCs but are directly supplied from the supplier to OR. Therefore, deviant supplier functions for products that exists in MP streams but must be ordered on direct streams are crucial. However, there are also rules in the function that forces products with MP streams to other MP streams. This can be harmful as the product data base is then overwritten. This directly results in data misalignment between the inter-organizational systems. In the past, logistical data was not directly transferred from the product data base and this function necessary for a smooth ordering process. Although the procedure has been changed and all rules in the function has been checked and cleared last year, new deviation rules in the function seem to have been created even during the time of this research. As the rules can only be manually inserted in the function, not all users of WMS seem to be familiarized with the new procedure and consequences of the function. Threats occur when products are reactivated and are, following the deviate supplier function, ordered on a faulty stream. Stream 999 could be the most important threat for invalid new rules in the deviant supplier function. This stream is coupled when products do not have a regular stream in the product data base. This is the case for products that are temporarily in stock, for example only in the time window of the promotion. The regular stream is than aberrant and visible as 999 in the replenishment screens, but the products are temporarily part of an existing stream visible in the logistical screens. When the concept of supplier 999 is unclear, undesirable modifications can be made by the users. Only when the logistical screens show stream 999, a data errors can be assumed. This should be verified with the commercial teams of that product, as than the data in NASA needs revision.			'deviant-supplier' - function in WMS of OR can incorrectly overrule product data base

10.4.7 Inbound process analysis: process diagram



The previous process diagram describes the inbound process of OR. After unloading of the truck, the supply is distributed over the aisles of the circuit. Then, replenishment operator per aisle store the supply by scanning the barcode, which gives the exact location of the product. The scanning also functions as check-in in the WMS. After the entire replenishment activity, three checking activities are performed. Goods that do not fit in the shelf are checked, as this indicates excessive supply. Fresh products, AGF, that often vary in size, and therefore in BE per colli are also manually checked. This insures the right BE is used during the check-in in the WMS. A by the WMS derived list states the deviation between what is manually checked in and what was ordered. The list's accuracy is manually rechecked, and if deviations are discovered, the production leader adjusts the stock levels in the WMS. If the deviations found in the checking activities are large, the Preparation department is informed.

10.4.8 Inbound process analysis

Analysis design

The observation approach is semi-structured and involves the following observation template:

- Research question: What are risks in the DC's that could result in check-in errors?
- Research approach: objectivist approach (Angrosino, 2005).
- Research site: the inbound process in the warehouses of three different DC's of OR.
- Methods of data collection:
  - observation (approximately cir30 min per DC).
  - Informal conversations with warehouse operators
  - Follow up semi-structured interview to clarify findings form observations with a team leader.

Results

In observations, causes are not-identified or identified at the specific DC.

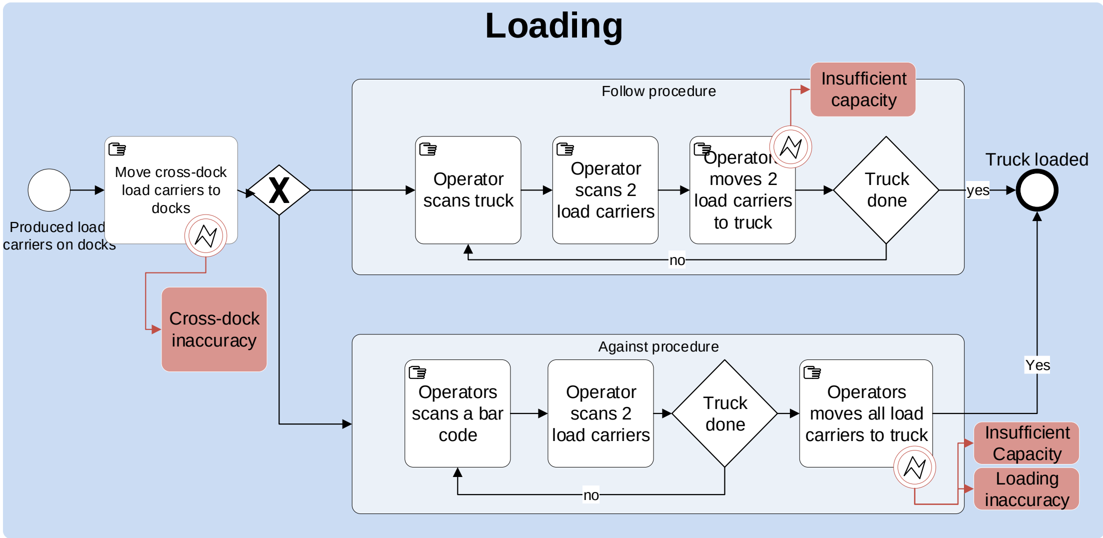
		Observation 1	**Observation 2**	**Observation 3**
DC type		**RDC1**	**RDC2**	**RDC3**
Data		Date	Date	Date
Cause	**Explanation**	Identification		
Inaccuracy during manual scan	As the operator has to scan all supply per BE before storing it, this is a clear risk of errors due to manual operations. Pushed by time restrictions, one can easily miss a BE or scan a product twice.	Identified	Identified	Identified
Trucks not fully offloaded	When a truck is not fully offloaded, supply seems to have not arrived. This can only occur when there is an inadequate verification of containers in trucks.	Identified	Identified	Identified
Data issues	Incorrect unit sizes (after for example substitution) or missing or incorrect barcodes in the WMS result in check-in errors.	Identified	Identified	Identified
Lost in DC	Supply has been lost during the transportation to and from temporal location.	Identified	Identified	Not-identified
Damaged on arrival	Supply has been damaged on arrival and is therefore not checked-in. Although the cause is clear, this will be registered as an undefined cause. Data quality is even more impacted when the damaged products are booked-off in the WMS, whilst they were not checked-in in the first place.	Identified	Identified	Not-Identified
Inaccurate checking	Checking activities are incorrect when storage buffers are forgotten during the check. Stock levels are incorrectly adapted.	Identified	Identified	Identified

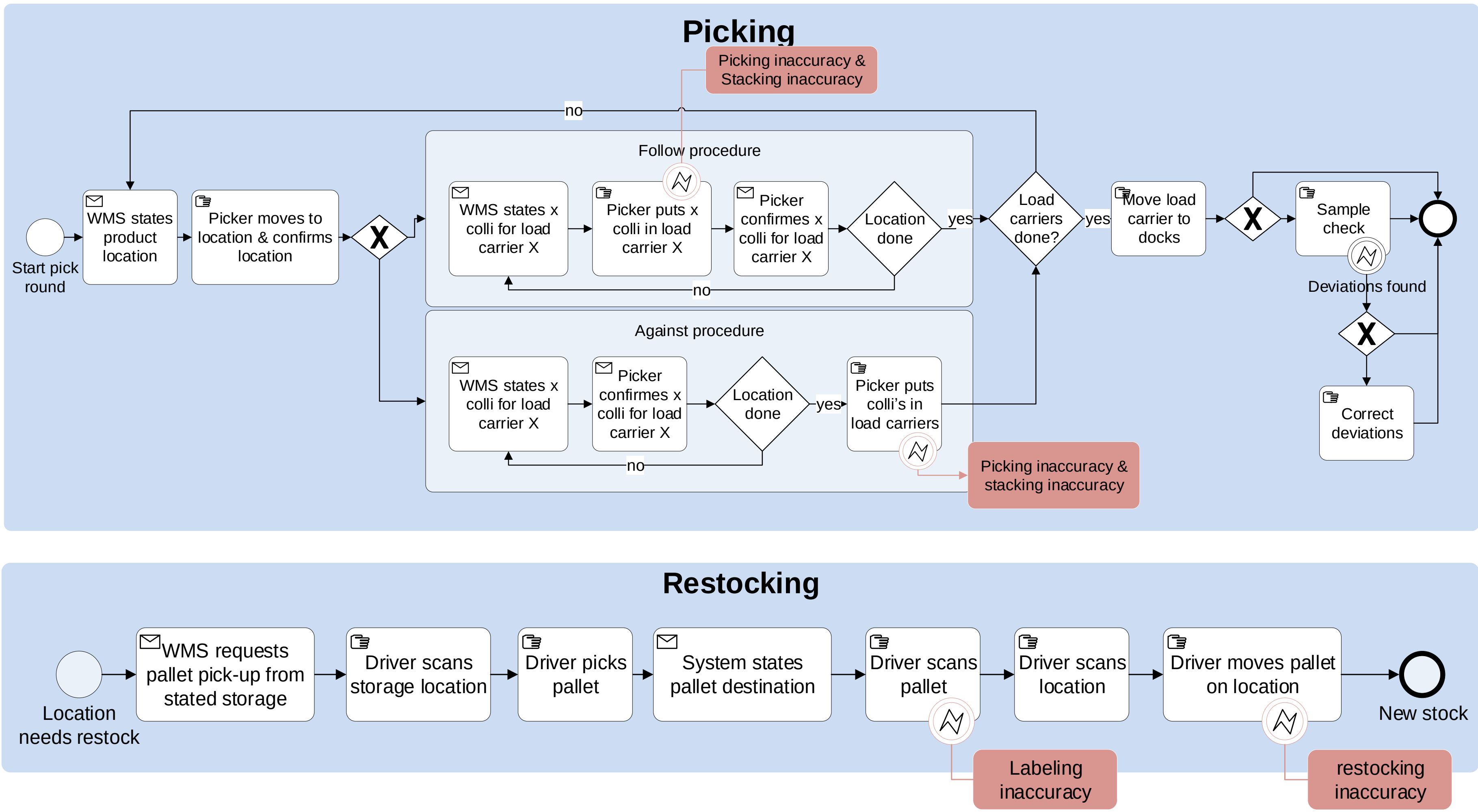
10.4.9 Supplying DC inaccuracy analysis: process diagrams

The following process diagrams, again conducted following the Silver method, model the loading, restocking and picking processes at the supplying DC's. A few differentiations must be noted between the three investigated DCs:

- At DC1, 1/3th of the picking production is produced mechanically.
- DC3 is an outsourced DC operating solely for the entire MP supply chain.
- DC2 and DC3 do not process cross-dock flows.
- At DC3, load carriers are stacked with crates. At DC1 and 2, load carriers are stocked by colli's.

In red, the causes identified in the following Appendix are depicted.





Picking
Picking inaccuracy & Stacking inaccuracy
no
Follow procedure
Start pick round
WMS states product location
Picker moves to location & confirms location
WMS states x colli for load carrier X
Picker puts x colli in load carrier X
Picker confirmes x colli for load carrier X
Location done
yes
Load carriers done?
yes
Move load carrier to docks
Sample check
Deviations found
Correct deviations
no
Against procedure
WMS states x colli for load carrier X
Picker confirmes x colli for load carrier X
Location done
yes
Picker puts colli's in load carriers
no
Picking inaccuracy & stacking inaccuracy
Restocking
Location needs restock
WMS requests pallet pick-up from stated storage
Driver scans storage location
Driver picks pallet
System states pallet destination
Driver scans pallet
Driver scans location
Driver moves pallet on location
New stock
Labeling inaccuracy
restocking inaccuracy

10.4.10 Supplying DC inaccuracy analysis

Analysis design

Both the observation and the interview approach are semi-structured conducted by the following template:

- Research question: What are risks in the DC's that could result in inaccuracy in supply?
- Research approach: objectivist approach (Angrosino, 2005).
- Research site: an RDC, a NDC and an ODC of MP, as they vary in product groups and ownership.
- Methods of data collection:
  - Semi-structured interview (approximately 45 min).
    - First a basic introduction including the main differences with other DC's
    - Second, the results from the premier-root-causes are discussed.
    - Last, by an integrated approach using the process models shown in 11.4.10, the risks to inaccuracy are discussed.
  - observation (approximately 30 min per DC).
  - Informal conversations with interviewees to clarify findings from observations.

Analysis results

The following table shows the results of the causes found. Interviewees have identified, confirmed or denied causes in the DC. In observations, causes are not-seen (not-identified), seen (identified of confirmed) or not applicable (NA) at the specific DC. In case no attention has been paid during the observations or a cause has not been discussed in the interview, the block is left blank.

Root- Causes		**Observation at NDC**	**Observation at RDC**	**Observation at ODC**	**Interview at NDC**	**Interview at RDC**	**Interview at ODC**
		8-8-2018 19.00-21.30	16-8-2018 15.00-16.30	11-9-2018 10.30-11-00	Shift Leader	Operation al manager	Customer Supply Service Manageme nt
Picking Inaccuracy	*Procedure deviation* When the picker is not following the procedure, take one colli and confirm one colli, picking errors can occur. Following procedure, the system calls the amount of colli for a load carrier, the order picker picks the assignment, loads the load carrier and confirms by voice. When a picker first confirms all assignments of one location and afterwards distributes them over de load carriers, there inaccuracy probability or mispicks increases. In this case, efficiency is chosen above accuracy.	Not-identified	Not-identified	Not-identified	Identified	Confirmed	Confirmed
	Mistakes in load carriers to be filled The picker loads the colli to the wrong load carrier, even though right load carrier is confirmed by naming the letter placed above the load carrier. As the picker is going to the circuit with 5 load carriers, possibly designated for 5 different locations, loading the wrong load carrier leads to excess supply at one destination and short supply at another destination. This is only a root-cause in the DCs of MP, as in the ODC the pickers only pick one load carrier at the time.	Not-identified	Not-identified	NA- Single load carrier pick	Identified	Confirmed	NA
	Unit size ambiguity From the interview at ODC is concluded that confusion about the unit size, both single products as crates with products, must be picked. Some products are supplied in both unit sizes, and they have separate locations. Still, pickers can be confused about whether to pick a single product of the complete package. Also from the observations in the RDC's and NDC's is concluded that there is uncertainty about the definition of a colli. Product locations with unpacked colli, for example an unpacked colli originally including 4 six-packs of beer, result in confusion for the next picker arriving at the location. ODC emphasis the dependency on the suppliers as it is impossible to verify the completeness of all inbound.	Identified	Confirmed	Not-identified	Confirmed , very low impact	Confirmed	Confirmed Especially as both singles or colli's could be picked
	Look-a-likes After the picker has confirmed the right product location, mistake probabilities can increase when products that are very similar are in a nearby location. As the location of a product only needs to be confirmed once, and not all DCs state to pay attention on look-a-likes during the slotting, this threats product shuffles.	Confirmed	Confirmed	Not-identified	Identified. "focus during slotting"	Confirmed "no focus during slotting"	Denied. "Process is location driven"
	Breakage business rule The breakage business rule, stating 75% of the colli must be complete for it to be admitted for production, also results in incomplete production. Both causes seem to have no large effect on the supply deviations, as it only incorporates several unit sizes. However, as a colli contains a large amount of unit sizes it could hit online customers as these products ordered at the DCs are already sold.	Identified	Not-identified		Confirmed . Low impact	Confirmed . Low impact	

Root- Causes		**Observation at NDC**	**Observation at RDC**	**Observation at ODC**	**Interview at NDC**	**Interview at RDC**	**Interview at ODC**
Stacking inaccuracy As multiple receivers can be consolidated in one truck, there are chances that products fall on other load carriers as a result of poor stacking of product in RDC and NDC. In the ODC, the load carriers are stacked with crates of different sizes, whereas when small crates are stacked low, the stability is impacted.		Confirmed	Confirmed	Confirmed	Identified	Confirmed	Confirmed
Location Shuffle During the restocking process, mistakes in restocking locations result in a misalignment between the products and the locations. The location physically contains different products than administratively. As during picking only the location is verified, and not the exact product, this can have large impact on picking accuracy. The interviewee at NDC states the changes of restock errors are very small, which the interviewees at RDC and ODC contradicts for the following reasons.	*Restock inaccuracy* The restocker can move products to faulty locations, even though they are scanned correctly.	Not-identified	Not-identified	Not-identified	Contradicted. Never happens	Confirmed	Confirmed, extra challenging due to buffer locations
	Labeling inaccuracy ODC and NDC emphasize the dependency of supplier labeling. Interviewee 2 mentions the meat supplier of RDC, which often supplies with inaccurate stickers.		Not-identified	Not-identified		Identified	Confirmed
Loading inaccuracy As around 50 load carriers must be loaded into one truck, missing load carriers can occur and impact supply quality. Operators at the RDC and NDC must confirm two load carriers and the truck before moving the load carriers into the truck. The WMS knows the amount of load carriers to be loaded, and the operator cannot finish the loading before the load is administratively complete. When operators don't follow the procedure and they forget to scan a load carrier the operator could look up the bar code of the missing load carrier and manually insert the load carrier. The probability on missing load carriers increases when operators choose to go against protocol and first scan all load carriers before physically loading as the barcode of the truck can be any barcode.		Not-identified	Not-identified	Not-identified	Identified	Confirmed in past. "Has been acknowledged and attacked in past"	Confirmed Inaccuracy results in load carriers in wrong truck or left behind.
Cross-dock inaccuracy As the RDCs also cope with cross-dock flow, extra threats to inaccuracies during supply exists. Cross-dock flows arrive and need to be transferred to the correct loading docks. In case the cross-dock flows are late, or timings deviate due to other reasons, the transportation department orchestrates the cross-dock processes and the cock-pit at the RDCs must ensure that the decisions by transport are rightfully processed. This process can be error prone and load carriers can be left behind or loaded incorrectly		NA	Not-identified	NA	NA	Identified	NA
Insufficient truck capacity When the capacity estimation is misjudged or a supply just exceeds the truck capacity, supply deviations could occur. Attempts are made to move to supply to another truck. Insufficient details during the interviews and observations were acquired. Therefore, this cause is a recommendation for further research.			Not-identified			Identified	

10.4.11 Supplying DC inaccuracy analysis: sampling results

Sample results (based on week 1-36 2018)	RDC	RDC	ODC	RDC
Average Production per week	3.500.000 colli	2.800.000 colli	44.182 rolli	2.400.000 colli
Sample per week	10.000 colli	4.700 colli	167 rolli	4.460 colli
Sample %	0,002%	0,002%	0,002%	0,002%
Current Inaccuracy result in %	0,15%	0,11%	0,22%	0,15%
Current Inaccuracy result per week	1.500 colli	517 colli	37 rolli	700 colli
Norm Inaccuracy Rate	0,18%	0,18%	0,15%	0,18%

10.5 Solution directions

10.5.1 Execution of Repro-procedure

In this appendix the phases of the RePro-procedure are described.

Phase 1, 2 and 3
In the introduction and explanation, the objectives and procedures of the meetings were explained to the participants. During the individual idea generation, each participant individually evaluated all RePro principles usefulness and applicability to the inbound process at OR with the goal to improve supplier performance measurement. The participants were asked to evaluate the principles in order of their listing in the paper of Vanwersch (2014), which indirectly led to the multi-level design approach recommended by Vanwersch (2014). First the service concept principles were evaluated, then the main activities principles and finally the detailed activities principles were evaluated to redesign the inbound process. All individual ideas were then shared and listed.

Phase 4 discussion
In the discussion phase of the RePro procedure, the feasibility, the quadrangle tradeoffs and the position in the inbound process per listed idea are discussed with all participants. The individual ideas are merged in case of overlap and ideas based on clear misunderstanding of the principle concepts are neglected. The conclusions of the discussion per principle are described below. For every concluded principle, the impact of devil's quadrangle dimensions are concluded.

- *Measuring supply accuracy by sampling by a third party (Trusted party)*
  By a collaboration with a thrusted third party, the supply accuracy measurement can be outsourced. A third party samples the accuracy to verify supplier performance. This activity must be performed as soon as possible after the supply arrives at OR to avoid the supplier performance to be influenced by internal activities of OR. To avoid high impact on transportation schedules, this redesign is therefore positioned after the truck unloading. Evaluating the redesign option with the Devil's Quadrangle concludes that the quality of the process increases, but the cost, flexibility and time are negatively impacted. As this is an extra activity in the process, it will impact the speed of the process. A system could be developed that updates sampling parameters, like frequency, depending on previous results of streams or supplying DCs. Cost and flexibility are affected by the introduction of a third party.

  Devil's quadrangle conclusion: C+, F -, T +, Q +

- *Measuring supply accuracy by weight control (Integral technology)*
  By implementation of a new technology, physical constraints in a process can be elevated (Vanwersch, 2014). As volumes, weights per products and products per roll cage are known in the network, a weight scale could verify the completeness of the supply per roll cage. When weight deviates by for example a determined percentage, the supply must be manually verified. To increase the reliability, the manual verification should be performed by a third party. As reliability of the scale is essential, an investment with a certificate of conformance is recommended. Further research into the restrictions and opportunities of the weight scale technology is needed, but implementation of the scale at the dock of OR would prevent internal processes to impact the results. In case a deviation is found, the manual check is performed after the roll cage have been removed from the dock and before it is distributed over the aisles. The Devil's Quadrangle concludes that cost, flexibility and time are negatively impacted as the technology has a price and manual verification in case of a weight deviation takes additional time and resources. The impact on quality is unknown, as the redesign depends on data quality concerning weight and products per roll cage.

  Devil's quadrangle conclusion: C +, F -, T +, Q ?

- *Split storing and check-in activity (Triage)*
  By the division of a general task into two or more alternative tasks, activities are better aligned with the capabilities of resources and the characteristics of the cases being processes, which improves quality (Dumas, 2013). Currently the measurement of the supplier's accurateness is merged with the storing process. By splitting these tasks, the focus of the operators on the execution of each task could be improved. The separate check-in activity must be performed at a different area of the warehouse to not intervene with the storing activity. It must also be performed as soon as possible after the supply arrives at OR to avoid that the check-in results are influenced by internal activities. For these reasons, the activity is positioned before the splitting of supply at the temporal location. Evaluating the redesign option with the Devil's Quadrangle concludes that the effect on quality is unknown, and time and flexibility is negatively affected. Operators focus on either accurately storing supply or the accurate check-in of supply, which could improve the execution of the task. However, it still depends on the quality of the operators. The inbound process will require more time and resources, as the additional process requires an additional barcode scan per colli.

  Devil's quadrangle conclusion: C /, F -, T +, Q ?
- *Eliminating the check-in activity (Task elimination)*
  "A common way of regarding an activity as unnecessary is when it adds no value from a customer's point of view" (Dumas, 2013). The current check-in process is proven to be too unreliable to verify supplier's accuracy due to the perceived deviations. Hence, this activity could be eliminated. Products still need to enter the WMS of OR, but OR can import the supplier's notifications send by of MP. This is currently piloted in the network. The Devil's Quadrangle concludes that time is positively impacted. Quality is unknown as it is unknown if the supplier's notification is more reliable than the results of the check-in activity. By implementing automatic system check in, the control on the supply quality disappears and the dependency on the accurateness of the supplier increases.

  Devil's quadrangle conclusion: C /, F /, T -, Q ?
- *Addition of control activity (Control addition)*
  This redesign heuristic promotes the addition of control to a business process which may lead to a higher quality of the business process execution. An additional manual control during replenishment by the operator and facilitated by the existing scanner could be a solution. The operator must confirm in the scanner the unit sizes per colli of a product or the number of colli stated to be supplied by MP before physically storing the product. The Devil's Quadrangle concludes that the additional check negatively impacts time and flexibility, as adding an activity lowers process flexibility. The impact on quality is unsure as it still depends on the accuracy of the operator. The process must be further developed to ensure operators correctfully check the supply.

  Devil's quadrangle conclusion: C /, F -, T +, Q ?

Phase 5 ranking

Lastly, the remaining ideas are ranked. It is acknowledged that systematic voting and ranking processes exists like described in Delbecq et all. (1975). However, due to the relatively small number of participants (n=4), it was chosen to rank the redesigns by concluding on a mutually agreed ranking. The participants concluded on the following ranking:

1. *Eliminating the check-in activity*
2. *Measuring supply accuracy by sampling by a third party*
3. *Measuring supply accuracy by weight control*

Eliminating the check-in activity was clearly favored by the participants. The ranking of the last two redesigns was based on the conclusions of the Devil's Quadrangle. The participants concluded that weight control is ranked number three as it requires high data quality and cost and time are negatively impacted. The current weight data quality in the network requires a thorough investigation. Thereby, the quality of data must be continuously guaranteed which will require a network wide data quality management approach (Schaffer, 2017).

10.5.2 Expert evaluation of solution design

The essence of the network performance evaluation framework is network agreeance, which emphasis the importance of a network-wide evaluation. The following protocol is used to evaluate the reactive solution designs:

- Evaluation goal*:* validate the ideas in the reactive solution design
- Interview approach: A semi-structured interview is chosen to be able to narrow don to important areas or topics.
- Interviewer approach: Objectively asking opinions and explain details in case of ambiguity
- Expert selection: two experts of OR, both from the problem holder department, and one expert of MP, a supply chain trainee. Although the more expert opinions are of need to provide a strong evaluation of the solution designs, due to time restrictions it is chosen to start with three experts.
- Interview preparation reactive solution design
    - Eliciting situation: One-on-one interviews, due to restrictions in the availability of the experts. Interviews are recorded.
    - Mode of communication: face-to-face
    - Evaluation topics chosen to give valuable insight into the quality of the ideas
        - Effectiveness of solution
        - Ease of implementation
        - Operational feasibility after implementation
        - Stakeholders involved
        - Completeness of design
    - Interview structure:
        - First, the inbound process redesign was discussed using an integrated approach per redesign element (a)
        - Second, the evaluation process is discussed using an integrated approach per process component. (b)
    - Prepared questions: Questions per topic were prepared in advance to stimulate the discussion of the topic.
        - Introduction
            - Do you understand the supply deviations problem?
            - Do you understand the model?
        - Effectiveness of solution
            - Do you think the solution will lead to improved reliable supply accuracy data? (a)
            - Do you think the solution will lead to improved tacking of supply deviations? (a)
            - Do you think it is a good idea to implement an evaluation process? (b)
        - Ease of implementation:
            - What kind of implementation issues do you foresee?
            - What do you think of the position in the inbound process? (a)
            - In what time-frame do you think this could be implemented?
            - In your opinion, do you think this solution is cost-efficient? Within budget?

        - Do you think there is enough network support to implement this solution design? (b)

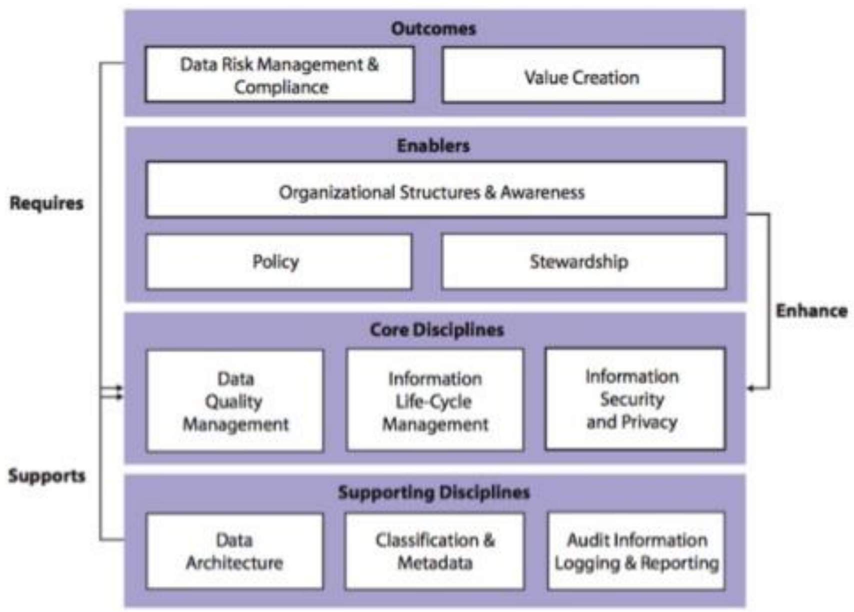
- Operational feasibility after implementation:
    - Once implemented, what problems do you foresee in the use of the solution?
    - What (dis)advantages do you think the solution offers with respect to the current situation?

- Completeness of conceptual design:
    - Are there other solutions redesigns possible or what can/must be added to conceptual evaluation process?
    - Do you have ideas on how to improve the solution in a way it will lead to higher data quality?

The following protocol is used to evaluate the preventive solution designs:

- Evaluation goal: Evaluate potential of conceptual preventive solution directions potential with stakeholders
- Interview approach: A semi-structured interview is chosen to be able to narrow don to important areas or topics.
- Interviewer approach: Objectively asking opinions and explain details in case of ambiguity
- Expert selection: Same experts as in reactive solution design evaluation.
- Interview preparation reactive solution design
    - Eliciting situation: One-on-one interviews, due to restrictions in the availability of the experts. Interviews are recorded.
    - Mode of communication: face-to-face
    - Prepared question:
        - Do you recognize potential in the preventive solution design? Why? Why not?

10.5.3 Elements of effective data governance (IBM, 2007)



10.5.4 Inter-organizational performance management development framework

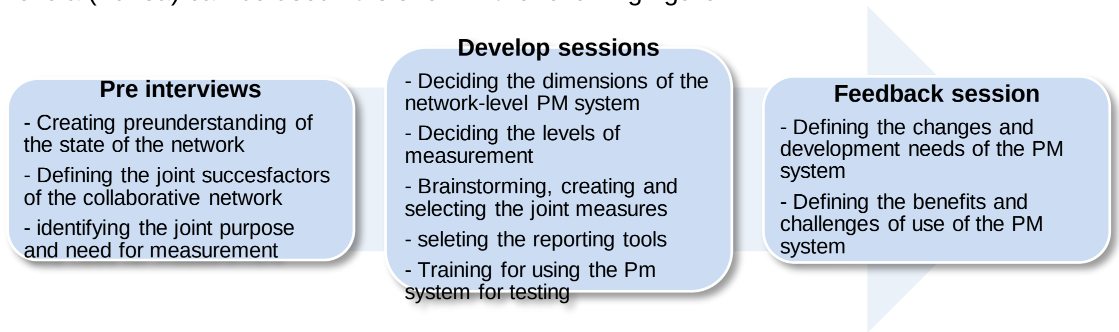
The stages of of Folan (2005) for the development and implementation of a network wide performance management system are described in this appendix.

Stage 1 Develop network directions and requirements plan

In stage 1, the strategy, direction and requirements plan of the entire network must be developed. The goals should focus on the continual improvement for end customers because satisfied customers determine the extent to which all chain members successfully generate real sales (Simatupang, 2002). End customers in the network in scope are the physical store customers and the online customers. The strategy must be balanced with the network capabilities.

Stage 2&3: Translate plan into critical success factors & select performance measures

In stage 2 and 3, the process of designing performance measurements for a collaborative network of Pekola (2013a) can be used. It is show in the following figure.



Stage 4& 5: Periodic review

Stage 4 contains the implementation of the performance measures. The last stage entails a periodic review of the performance measurement system. This stage ensures relevancy at any moment in time to avoid redundancy (Medori, 2000). The maturity model of Pekola (2013b) can be used to evaluate the state of the performance management system at the network of OR and focus on goals to further develop the system.

Knowledge maturity stages and management attributes from the perspective of collaborative network-level performance management Pekola (2013b)					
	Organization, roles and responsibilities	Systems and processes	Skills and knowledge	Incentives and measurement (PM)	Culture
5- Optimization	Customer-driven flexible roles	Advanced performance reporting tool, automatic link to network-link information	Overall knowledge of network-level performance and comprehensive use in decision making	Complete, open, causal model-based PM and incentive system of the whole network	Acting as one company
4- Quantitative management	Bottom-up/Reseller-driven	Advanced performance reporting tool, no link to network-level information	Formalized knowledge on network-level performance	Network-level PM system, open for the network, and a comprehensive incentive system	Learning from others' businesses
3- Establishment	Top-down/Main company	Systematic local reporting tool	Tacit knowledge on network-level performance	Formal PM and incentive system, partially shared	Interested in others' businesses
2- Awareness	Negotiational, a more open relationship	Local reporting system	Understanding of one won business	Some informal measures	Interest in one's own business
1- Initial	Negotiational, isolated relationship	No reporting system	Tacit understanding of one's own business	No PM and incentive system	Minding one's own business