MASTER

Conceptual framework for complex decision making for business process improvement with qualitative data

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Conceptual framework for complex decision making for business process improvement with qualitative data.

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Abstract

Improvement projects are often related to big design spaces and several optional solutions, but the question in a lot of cases is: ‘What is the best solution for the company?’. This research does not focus on giving the optimal solution for a specific problem but shows how to structure and tackle a qualitative problem with varying options, requirements, stakeholder goals and criteria. The research tests a conceptual framework for complex decision making with qualitative data on a case study. Four main steps of this framework are 1. Process investigation, 2. Business process analysis, 3. Define design space (including QOC analysis and Decision tree) and 4. Analyze design space. An optional part of step 4 is TOPSIS calculation, to find the closest to optimal solution in the design space based on expected effects. This step is optional because if human aspects are involved in the decision it can lead to different qualitative ‘optimal’ solutions. Due to the fact that the priority of different stakeholders on variables like costs, customer service and risks can be different. The main and sub steps are executed in a case study for improving the order handling process at a fast moving consumer goods company. This results in a QOC analysis and a decision tree with all possible solutions (98) for this specific problem and their effect scores on the process, implementation, customer satisfaction and feasibility.

Executive summary

This report describes research on complex decision making with qualitative data. A framework for complex decision making with qualitative data is designed and tested with a case study. This framework is shown in Figure 1. Together with designing a framework for complex decision making the research is executed to fill the gap in literature on brownfield development. The main question of this research is:

Does the conceptual framework for complex decision making with qualitative data help to define options for improvement and choose among them?

The case study is about improving the order handling process, which is conducted for a fast moving consumer goods company. The order handling process can be described as a set of business processes that represent the order-to-cash part of the supply chain. The company has no insight in all facets and capabilities of improving this process. The design problem (Wieringa, 2014) for the case study can be described as:

Improve the insight in all facets and capabilities of improving the order handling process, by creating a decision model, such that it is easy-to-use, useful, complete and understandable, in order to create more order status transparency, lower time spend on out-of-stocks and earlier detection of out-of-stocks.

Conceptual framework for complex decision making with qualitative data		
Main steps	**Sub steps**	**References**
1. Process investigation	Process identification: Process checklist	(Dumas et al., 2018)
	Process architecture: Landscape model	
	Process discovery: Define as-is situation	
2. Business process analysis	Identify issues: Pareto analysis	(Craft & Leake, 2002)
	Issue description: Root-cause analysis	(Doggett, 2005)
3. Define design space	Define options: Framework for architectural design decisions.	(Gu et al., 2010)
	Design design space: QOC analysis	(MacLean et al., 1991)
	Rank options: Expected effect scores	(Triantaphyllou, 2000)
	Design decision steps: Decision tree	(Magee, 1964)
4. Analyze design space	Calculate optimal solution: TOPSIS calculations	(García-Cascales & Lamata, 2012)
	Discuss possible solutions: Focus Group	(Beck et al, 1986; Wilkinson 1998)

Figure 1 - Conceptual framework for complex decision making with qualitative data.

The case study is build up according to four research questions, the first research question is: *'What is the current order assigning situation?'* which can be described as the as-is situation. This question is answered using two phases, first the process investigation which results in a business process model, a stakeholder overview and an information flow diagram. The second phase is a business process analysis, which searches for problems in the current process. Three main problems are found using Pareto analysis and Root-cause analysis. The problems are order status transparency, time spend on out-of-stock situations and detection of out-of-stock situations.

The second research question: '*What option(s) for improving the order assigning situation are possible?*' This phase exists of designing and analyzing the artifact, which is done following a QOC analysis. The QOC (questions, options, criteria) analysis represents the design space analysis, which is 'a structured space of alternatives including considerations for choosing among them' (MacLean, Young, Bellotti, & Moran, 1991). The artifact design phase exists of three iterations, who includes document analysis, stakeholder interviews and a focus group, to define all possible alternatives and rank them according to the criteria. The research leads to a Decision tree and a list of closest to optimal solutions calculated with TOPSIS (García-Cascales & Lamata, 2012). The final QOC analysis exists of 3 problems, 3 possible options (including variants), the requirements for the options and 8 criteria. The QOC analysis results in the final decision tree, which is a guide for decision makers on: 'How to improve the order handling process?' and shows the 98 optional solutions including the expected effect of the chosen improvements on the current process, implementation, customer satisfaction and feasibility.

The third and fourth research questions represent the validation of the designed artifact. The third research question is: '*Does the designed artifact meet the artifact requirements (easy-to-use, usefulness, completeness and understandability)?'* This is validated with a presentation for stakeholders and a questionnaire. The fourth and last research question is: '*What is the effect of the solutions from the artifact on the stakeholder goals (order status transparency, time spend on out-of-stocks and detection of out-of-stock situations)?'* This research question is validated with case-based reasoning using an interactive presentation and instructions on the use of the artifact followed by a questionnaire to check cases on the relations between the possible options and stakeholder goals.

The case study shows that a complex decision based on qualitative data can be simplified by using the steps taken in this thesis. The final decision tree can be used as a guide for a discussion with all stakeholders on the decision that must be made. On top of that the calculations on expected effects can give direction within this discussion. This case study shows that the framework for complex decision making based on qualitative data can be used for this problem. A topic for future research can be testing of the framework for other problems, companies and industries. A major finding of this research for brownfield development is that the biggest part of the development process includes improvement or adjustment of the software. Five out of six requirements are related to software changes and only one is about changing the business process.

Preface

This preface describes my view on this master thesis, which I conducted as part of the master Operation Management & Logistics at the Technical University of Eindhoven. I started almost a year ago with searching for a company and topic for this last but definitely not least part of the master. I found a project by emails and Skype calls from my dorm room in Taiwan, which was described as a research topic that included technical, business and organizational issues. I was interested in such a project and I am very happy that Johan van de Bor gave me this opportunity. At the same time I want to thank him and the whole team of Customer Service Domestic for their help during my thesis and of course also for the 'green blanket' as they call it themselves.

Next to the organization, I want to thank the university and especially my first supervisor Maryam Razavian and second supervisor Baris Ozkan for their contribution to my work. Especially Maryam was a guiding factor with meetings which gave my research and ideas direction.

Finally I want to thank everyone who supported me during my whole study. First of all my family who always has confidence in me and in the choices I made in my study and private life. Second, the people who made my student time unforgettable. Studying hard and passing exams is one part of student life but for me the more important and memorable part is enjoying the life outside the university banks. Therefore, many thanks to Lalyta, Felix who was my soulmate in the biggest part of my study, UniPartners Nederland, Goaldiggers, and all other friends I made during my time in Eindhoven and Taiwan. You made me the person I am today!

Cheers,

Simone Horrevorts

Content

List of figures

List of tables

Abbreviations

ADD	Architectural design decisions
AMST	Availability management simulation tool
APO	Advanced planning & optimization
APS	Advanced planning system
ATO	Assemble-to-order
ATP	Available-to-promise
B2B	Business-to-business
B2C	Business-to-consumer
BPM	Business process management
CSD	Customer service domestic
FEFO	First expired first out
FTE	Full time equivalent
MTO	Make-to-stock
MTS	Make-to-stock
OOS	Out-of-stock
OTC	Order-to-cash
SLR	Systematic literature review
TOPSIS	Technique for order of preference by similarity to ideal solution
QOC	Questions, options & Criteria

1. Introduction

The research perspective of this master thesis focuses on the gap in literature on complex decision making for improving business processes based on qualitative data by designing and testing the conceptual framework for complex decision making with qualitative data. This report describes a case study of the conceptual framework on the possibilities of improving the current process for order fulfilment at a big fast moving consumer goods company for perishables in the Netherlands. The report is a result of the master thesis, the final assessment of the master Operations Management and Logistics of Eindhoven University of Technology (TU/e). The project is executed at an order fulfilment department called Customer Service Domestic (CSD), which receives and processes all incoming orders. This introductory chapter defines the company and department description in section 1.1, section 1.2 describes the problem description, 1.3 the case study description and the final section 1.4 describes the research design, design problem, research questions and methodology.

1.1 Company and department description

The company is a large independent brewer with more than 300 international, regional and local specialty beers and ciders. They have operating companies in several countries, and one is the Netherlands. The Dutch operating company has its own supply services which consist of all departments related to supply chain and logistic services. The project is executed at the customer service domestic department of the Dutch operating company. Customer Service Domestic (CSD) is responsible for the logistic account management for all big retailers and wholesalers in the Netherlands. Which means that they are responsible for part of the order-to-cash (OTC) system for inland distribution. Order-to-cash is a set of business processes that involve receiving and fulfilling customer requests for goods or services and it includes activities like documentation, fulfilment, shipment, invoice creation, payment and recording (Rouse, 2012).

1.2 Problem description

The problem is that there is not much research done on complex decision making for improving business processes based on qualitative data. This research formulates a framework that combines a set of existing techniques and approaches from literature that is evaluated by a case study described in the next chapter. The framework does not want to give an optimal solution for a specific problem but shows how to structure and tackle a quantitative business process improvement. The four main steps of the framework are 1. Process investigation, 2. Business process analysis, 3. Define design space (including QOC analysis and Decision tree) and 4. Analyze design space. The formulation of the framework is described in Chapter 3. Next to this problem, there is also a gap in literature on the business, technical and organizational needs and effects of implementing software in an already existing software environment. This can be described as brownfield development, the development and deployment of new software systems in the presence of existing software applications (Techopedia, n.d.)

1.3 Case study description

Customer Service Domestic is responsible for the whole order-to-fulfilment system for inland distribution. For inland distribution, a make-to-stock (MTS) policy is used, this means products are produced based on a forecast and planning made by demand, planning and scheduling departments. Orders from customers come in (via SAP, mail or fax) at this department and need to be processed by one of the members. The processing in SAP takes place in batch mode, one day before the delivery due date, which means the company has a lead time of less than 24 hours. The processing includes a few steps for almost every order. The only exceptions are zero-touch orders, which are orders that consists of a full truckload (FTL) of one product, these orders are processed automatically by the software system. The steps for each order are described in Table 1 and Table 2 and are graphically shown in Figure 2. After performing these steps for all orders, the out-of-stock (OOS) and final checks are done and the collection of orders is sent to the transportation company.

A problem for the company and this department is out-of-stock situations. Especially in high demand seasons are out-of-stock situations a big problem for the order handling process. The biggest problem for CSD is the extra rework that must be done when an out-of-stock occurs, and the biggest problem for the company is the lost sales and a decrease in customer satisfaction. The company is active in the fast moving consumer goods industry, where the standard lead time in the Netherlands from order to delivery is less than 24 hours. The company wants to improve problems with the OOS situations but has no insight in all facets and capabilities of improving the order handling process using the available-to-promise (ATP) functionality in SAP such that out-of-stocks can be prevented, or can better be acted on. ATP is a business function which works together with the master production schedule and provides a reliable response to the customer order request based on companies' resource availability (Horrevorts, 2018b). This master thesis tries to give insight into the facets and capabilities of improving the order handling process with among other things available-to-promise. The scope of this research project are the problems related to out-of-stock for CSD and the related departments.

Table 1 - Processing steps for all incoming orders

Task	Description
Check product allocation	Check what kind of products are ordered and if all orders are correctly ordered. This means no wrong or old product numbers or descriptions.
(re) Locate brewery	Orders are automatically assigned to one of the three breweries depending on the products in the order. In some cases it is better to deliver an order from another brewery due to transportation time or product availability. In this case the order is manually replaced to another brewery.
Check shipping conditions	Choose if the order is delivered from the internal or the external warehouse.
Full truckload (FTL) conditions	Check if the order is a full truckload of several products. Contact the customer if the order is not a full truckload to complement the order.

Table 2 - Tasks for every batch of orders

Task	Description
Check out-of-stock (OOS)	Check if products are out-of-stock, if a product is not available, call the customer(s) to ask if and what substitute they want. This is done after all orders (of that day) are saved, because this check only checks the saved orders against the available stock.
Send list of orders	A list of all orders is sent to the transportation company.

Figure 2 - Simplified order assigning steps per incoming order.

1.4 Research design

The research tests the designed conceptual framework for complex decision making with qualitative data using a case study. The case study is the described in the case study description Chapter 1.3. The case study aims to give an overview of all the aspects, effects and options of the current order handling process and possible changes to handle out-of-stock situations. The aim of this study is to fill the gap in literature on methods for complex decision making based on qualitative data, several frameworks/methods are combined as a guide for the decision maker. Next to testing the conceptual framework I aim to fill the gap in literature on the business, technical and organizational needs and effects of implementing available-to-promise in an existing ordering system. This can also be described as brownfield development, which includes the development and deployment of new software systems in the presence of existing software applications (Techopedia, n.d.). The systematic literature review on this topic is described in Chapter 2. This chapter describes the design problem (1.4.1), research questions (1.4.2) and methodology (1.4.3).

1.4.1 Design problem

The research perspective of the master thesis focuses on the gap in literature on complex decision making for improving business processes based on qualitative data by designing and testing the conceptual framework for complex decision making with qualitative data. Testing is done to show the application perspective of the master thesis with a case study. Table 3 shows the design problem (Wieringa, 2014) of the case study. In short, it can be described as:

Improve the insight in all facets and capabilities of improving the order handling process, by creating a decision model, such that it is easy-to-use, useful, complete and understandable, in order to create more order status transparency, lower time spent on out-of-stocks and earlier detection of out-of-stocks.

Table 3 - Design problem

Design problem	
Problem context	The company has no insight in all facets and capabilities of improving the order handling process using, among other things, available-to-promise.
(re) Designed artifact	A decision model, with an overview of business process redesign options, criteria and effects. The redesign options includes out-of-stock checks, available-to-promise and forecasts in SAP.
Artifact requirements	Easy-to-use, Usefulness, Completeness and Understandability.
Stakeholder goals	A decision model that leads to a solution that: - Creates more order status transparency. - Lowers time spend on out-of-stock. - Earlier detection of out-of-stock situations.

1.4.2 Research questions

The overall research question of this master thesis is shown in Table 4.

Table 4 - Main research question.

Main research question
Does the conceptual framework for complex decision making with qualitative data help to define options for improvement and choose among them?

The remainder research questions are defined to guide the case study of the research process, see Table 5. The first research question is part of the phase process investigation & business process analysis. This research question describes the current (as-is) situation. Which includes how the current process is executed including problems that occur. The second research question defines and analyses the design space (to-be situation), which represent new process structures including new availability solutions. These artifacts are designed following a QOC analysis (MacLean et al., 1991), framework for documenting architectural design decisions (Gu, Lago, & van Vliet, 2010), decision tree framework (Magee, 1964), TOPSIS calculations (García-Cascales & Lamata, 2012) and a focus group (Daneva, 2015). The last two research questions test the designed artifacts of the case study on their artifact requirements and stakeholder goals.

Table 5 - Research questions

Research question 1
What is the current order assigning situation? (as-is) *a. Business process model.* *b. Stakeholder overview.* *c. Information flow diagram.*

Research question 2
What options(s) for improving the order assigning situation are possible? (to-be)

Research question 3
Does the designed artifact meet the artifact requirements? (validation part 1) *a. Easy-to-use* *b. Usefulness* *c. Completeness* *d. Understandability*

Research question 4
What is the effect of the solutions from the artifact on the stakeholder goals? (validation part 2) *a. Order status transparency* *b. Time spend on out-of-stocks* *c. Detection of out-of-stock situations*

1.4.3 Methodology

The master thesis is executed according to a research cycle, which is shown in Figure 3 and is quite similar to the design science cycle (Wieringa, 2014). The design implementation phase is not included in the master thesis. The first three stages of the design science cycle are discussed below in combination with the case study.

Problem understanding

Problem understanding is the first phase of the master thesis. This phase includes the systematic literature review, which is conducted on the subject: Available-to-promise (ATP) with its capabilities, position in the supply chain, calculation methods, and key consideration in implementation (Horrevorts, 2018b). The second part is the research proposal (Horrevorts, 2018a) which is explained in this chapter and describes the problem statement, research design and outline (project plan). This chapter is based on data retrieved from observation, document analysis and interviews conducted with internal stakeholders.

Artifact design

This part of the thesis defines the conceptual framework for complex decision making with qualitative data. This framework is designed to make complex decisions on business process improvements. The framework is tested on a case study, further described in the artifact validation phase.

Artifact validation – Case study

The last part of the design science cycle is the artifact validation phase, which is executed using a case study. This chapter tests if the conceptual framework helps the decision maker to define questions, options, requirements and criteria and if it guides the decision maker to the preferred solution. The case study is described in the Chapter 1.3. The methodology of the case study is shown in Figure 4 and described below.

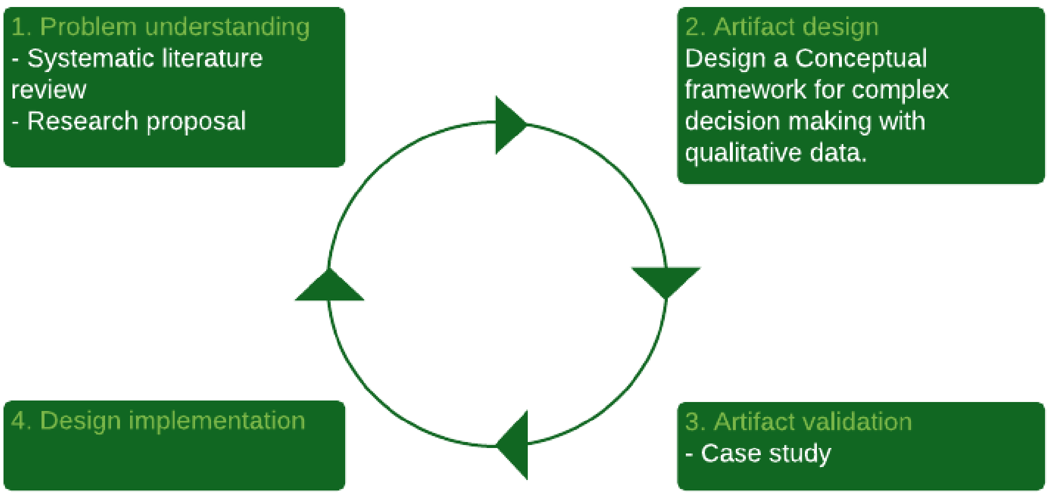

Figure 3 - Design science cycle for master thesis

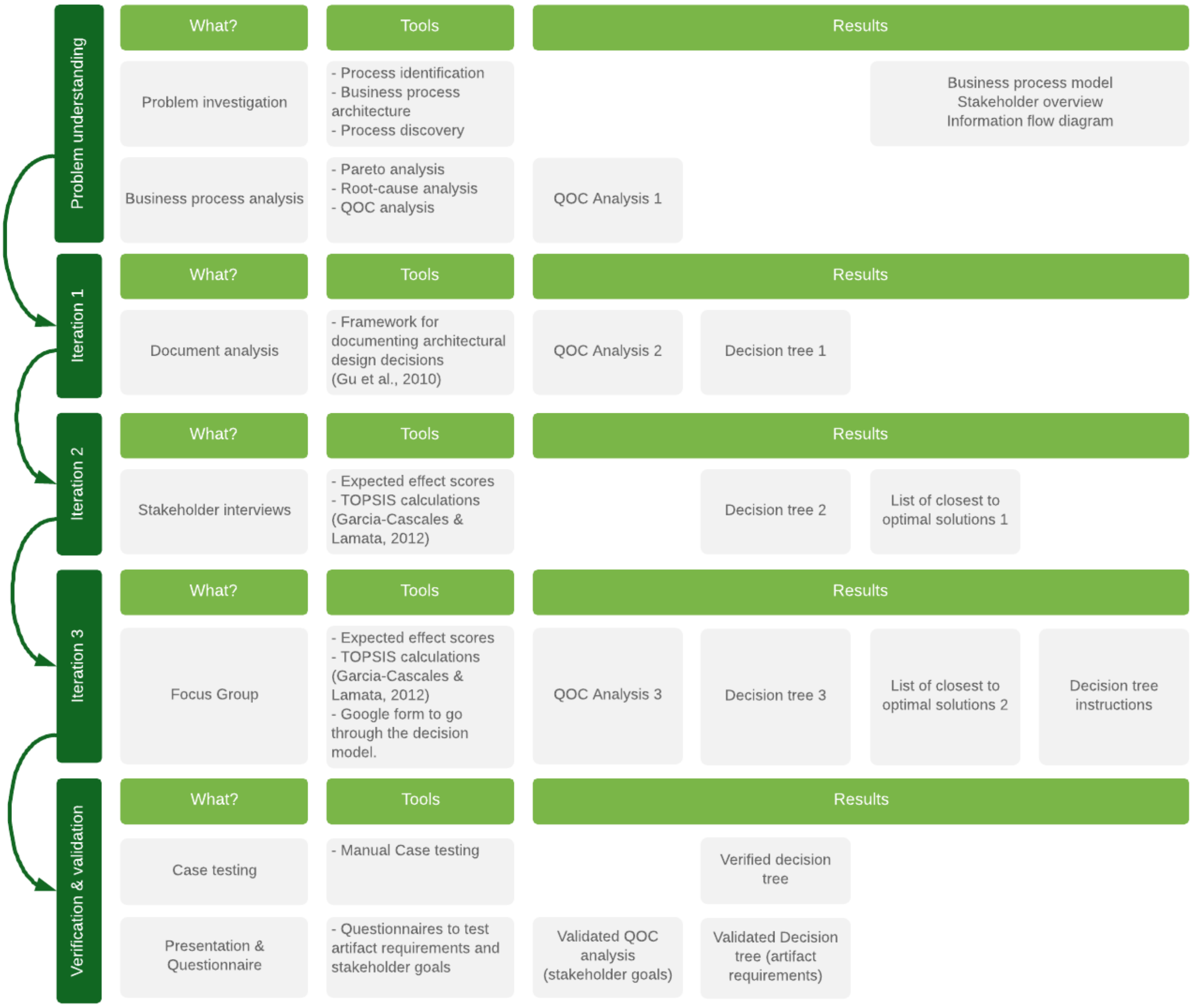

Figure 4 - Methodology of the case study in the validation phase.

The problem understanding includes the process investigation and business process analysis and leads to the complete description of the as-is situation using BPM phases: process identification, process architecture and process discovery (Dumas, La Rosa, Mendling, & Reijers, 2018). Which are shown in Chapter 4.1.1: Process investigation. The process identification includes a process checklist, the architecture exists of process categories, relationships between processes and process landscape model. The process discovery methods that are used are evidence-based and interview-based discovery. The second part of the problem understanding is the business process analysis which is shown in Chapter 4.1.2. This includes stakeholder analysis, issue documentation, Pareto analysis and Root-cause analysis. This results in a design space; a framework to define questions, options and criteria (MacLean et al., 1991).

The second phase is the defining and analyzing the design space. In this phase, the different artifacts (to-be situation) need to be designed. Which need to be done to define all options in the design space analysis. The artifact design phase consists of three iterations. The first iteration is based on document analysis using a framework for documenting architectural design decisions (ADDs) for an educational setting (Gu et al., 2010) and a decision tree framework (Magee, 1964). The second iteration consists of interviews with internal stakeholders to improve the decision tree framework of the first iteration. Together with this improvement, the effect scores of all solutions are calculated by the TOPSIS method, which is a technique for order preference by similarity to ideal solution (García-Cascales & Lamata, 2012). The third iteration is executed with a focus group with employees from all related departments. This designing and revising leads to a to-be process model, which is tested in the validation phase.

The artifact(s) is evaluated in the last part of the master thesis. The tests shows if the artifacts of the case study are feasible, what the effects are and if the artifact satisfies the requirements and stakeholder goals. The validation is split into two parts, the first part is the validation of the design requirements (research question 3) and the second part is the validation of the stakeholder goals (research question 4). Both parts are validated with a presentation followed by a questionnaire, the first one to check if users perceive the model as easy-to-use, useful, complete and understandable. The second part is based on case-based reasoning, questionnaire tests here if the cases have an effect on the stakeholder goals, which are order status transparency, less time spend on out-of-stock situations and earlier detection of out-of-stock situations.

2. Literature study

This chapter describes the summary of the systematic literature review (SLR) that is executed as a start of the master thesis (Horrevorts, 2018b). The literature review is done to increase the knowledge on a specific topic, in this case: available-to-promise. The reason for a systematic literature is that SLR is 'a means of evaluating and interpreting all available research relevant to a particular research question or topic' (Kitchenham & Charters, 2007). This literature review is about available-to-promise (ATP); its capabilities (2.1), the position in the supply chain (2.2), calculation methods (2.3) and key considerations in implementation (2.4).

2.1 What is available-to-promise and what are the capabilities?

The first mention of ATP is based on the master production schedule (Schwendinger, 1979). I defined a definition based on definitions found with SLR for available-to-promise (Chen, Zhao, & Ball, 2001; Christou, 2012; Kurbel, 2013):

'ATP is a business function which works together with the master production schedule and provides a reliable response to the customer order request based on companies resource availability'.

The ATP function has several capabilities, there are different models for make-to-stock (MTS), make-to-order (MTO) and assemble-to-order (ATO) markets. These models differ among other things on the position of the decoupling point, ATP granularity and order lead-time. Next to this, other capabilities of available-to-promise are batch or real-time assigning of orders. The difference between these capabilities is that customers are served with first-come-first-serve policy or orders are handled based on allocation rules for a batch of orders for a specific time frame (Kilger & Schneeweiss, 2008).

2.2 Where and how is available-to-promise positioned in the supply chain?

The answer to this question is described with a model that shows the position of ATP with a make-to-stock policy in the supply chain. The model shown in Figure 5 is a combination of the master planning (Entrup, 2005; Fleischmann, Meyr, & Wagner, 2005; Kilger & Schneeweiss, 2008; Vogel, 2014) and the SAP information software system (Fleischmann & Geier, 2012; Kurbel, 2013).

2.3 Which main concepts/methods are used to calculate available-to-promise?

There are several methods to calculate available-to-promise. The characteristics of the models are described according to four main categories namely:

Calculation model - Most papers use a linear or mixed integer programming model, only one paper describes a simple (not optimization) model.

Operating mode - There are two main operating modes, namely batch and real-time. These modes differ in timing and response (Vogel, 2014). In real-time mode, customers get an immediate reply to their order, while in batch mode replies are given at regular intervals.

Tested effects - Some papers test their model according to an already existing order assigning model to check several effects. These tested effects are the length of a batching interval, the availability of resource reserve or different models for customer segmentation.

Customer heterogeneity – this describes the optimization factors used in the model. Some models minimize the cost, some models maximize the profit, but also maximization of strategic value is used. Strategic value is the unit profit plus the assessment of the strategic importance of the customer (Vogel, 2014).

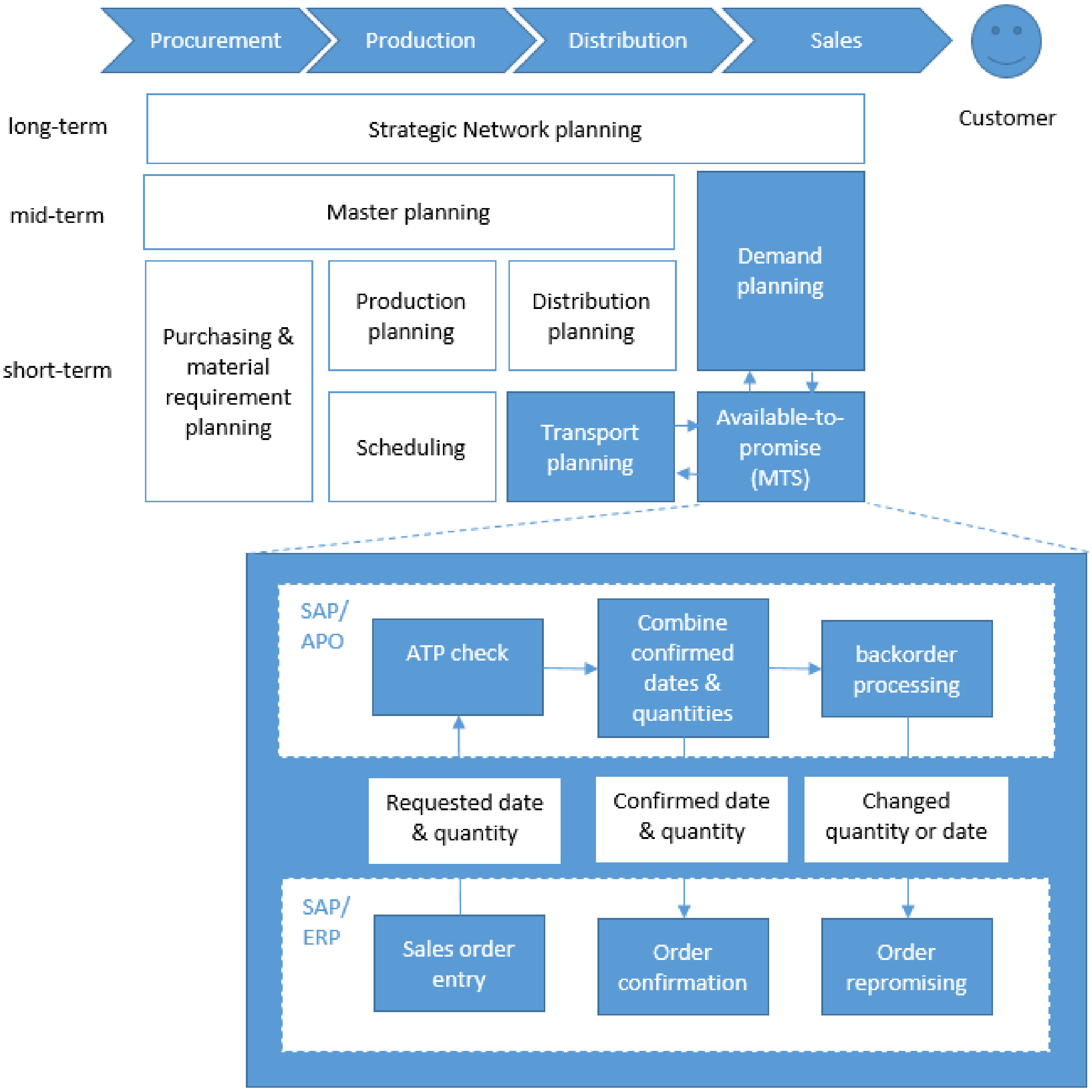

Figure 5 - The position of ATP (MTS policy) in the supply chain

2.4 What are the key considerations in implementing available-to-promise?

Some literature focuses on the considerations in implementing ATP. This question is answered in three categories, namely implementation factors, implementation process and tools for implementing ATP. The implementation factors, include front-end factors as customer response time and profitability and priority, back-end factors with for example system scope and resource type and the problem parameters, which are service level vs. product profitability, safety stock levels and so on. The considerations for the implementation process are about implementing an advanced planning system (APS), which includes ATP. The three main steps of this process are 1. Project definition, 2. Vendor selection and 3. Implementation. A drawback here is that it focuses on implementing a whole planning system instead of only implementing ATP in an existing system (brownfield). Two main tools that can be used are mentioned. The availability management simulation tool (AMST) (Lee, 2007), which is developed by IBM's computer hardware business. The second tool is SAP supply management system (Fleischmann & Geier, 2012; Knolmayer, Mertens, Zeier, & Dickersbach, 2009; Kurbel, 2013).

2.5 Discussion

The most important finding from the literature review is that all literature about ATP is relatively old. The first mention of ATP in literature is from Schwendinger (1979) and more than 80% of the literature from the SLR is written between 2000 and 2010. Next to this, almost all papers are about implementing a whole new system, for example manufacturing resource planning or SAP APO system. That is a bit outdated because in 2018 it is hard to find a company with no ordering system at all. I aim to fill the gap in the literature on the effects of implementing available-to-promise in an existing ordering system. This can also be described as brownfield development, which includes the development and deployment of new software systems in the presence of existing software applications.

3. Artifact formulation

This chapter defines the conceptual framework for complex decision making with qualitative data that is designed to make complex decisions on process improvements. Searching for methods for decision making leads to long lists of different techniques like expected-value optimization, decisional balance sheets, decision support systems and so on. Most of these techniques are based on quantitative data such as sales figures, profitability and return on investment. This research tries to design a technique that helps to make a decision based on qualitative data focused on process improvement. The conceptual framework is shown in Figure 6 and is described below.

Conceptual framework for complex decision making with qualitative data		
Main steps	**Sub steps**	**References**
1. Process investigation	Process identification: Process checklist	(Dumas et al., 2018)
	Process architecture: Landscape model	
	Process discovery: Define as-is situation	
2. Business process analysis	Identify issues: Pareto analysis	(Craft & Leake, 2002)
	Issue description: Root-cause analysis	(Doggett, 2005)
3. Define design space	Define options: Framework for architectural design decisions.	(Gu et al., 2010)
	Design design space: QOC analysis	(MacLean et al., 1991)
	Rank options: Expected effect scores	(Triantaphyllou, 2000)
	Design decision steps: Decision tree	(Magee, 1964)
4. Analyze design space	Calculate optimal solution: TOPSIS calculations	(García-Cascales & Lamata, 2012)
	Discuss possible solutions: Focus Group	(Beck et al, 1986; Wilkinson 1998)

Figure 6 - Conceptual framework for complex decision making with qualitative data.

The framework exists of four main steps, process investigation, business process analysis, define design space and analyze design space. The first step, process investigation (Dumas et al., 2018) includes the steps process identification, process architecture and process discovery. The goal of this step is to show the as-is situation and includes what the process actually is, the position in a broader context and if it is worth to improve the specific process.

If the as-is situation is defined by the first step, the as-is situation must be analyzed by the second step of the framework Business process analysis. The goal of this step is to find how the process performs and what the main problems are. Two methods for analyzing the process are Pareto analysis (Craft & Leake, 2002) to identify issues in the process and Root-cause analysis (Doggett, 2005; Myszewski, 2013) to describe among others the causes of issues. The benefits of these methods combined is the fact that the Pareto analysis identifies which issues should be given priority (Dumas et al., 2018) and the Root-cause analysis shows which causes of the identified problems are found to make sure the problem will not continue to exists (Doggett, 2005). The process investigation and business process analysis combined represent a structured way of identifying the current situation and issues in a process oriented context.

The next step of the framework is defining the design space, to show an overview of all possible options for improving the process. Defining the design space consists of a few steps, starting with define options using a framework for architectural design decisions (Gu et al., 2010). This framework helps to record all possible architectural design decisions in a structured way to support structured reasoning. All options that are accepted from the framework for architectural design decisions can be used for the QOC analysis, an approach for representing a structured space of design alternatives and the considerations for choosing among them (MacLean et al., 1991). The framework is used because it shows the questions, options and criteria in one model, such that it can be understood by all people that design and build it but also by those who need to use it. All options from the QOC analysis need to be ranked by the criteria defined in the QOC analysis, which is used for multi-criteria decision making (Triantaphyllou, 2000), important here is accurately estimate the pertinent data. An example is to use interviews or questionnaires to translate qualitative data to a ranked score. The last part of the defining the design space is designing the decision tree (Magee, 1964). The qualitative decision tree has as goal to guide a decision maker to the final solution instead of showing the optimal solution. An important advantage of the decision tree is that it forces the consideration of all possible outcomes, each path leads to a conclusion and next to this, it is easy-to-use for first time users.

After designing the design space the last phase is analyzing the design space, which can be done in a qualitative or quantitative manner. The qualitative manner of analyzing the design space can be done with a Focus Group (Beck, Trombette, & Share, 1986; Wilkinson, 1998). The most important advantage of this method is that participants can give explanation on the reasons why they made specific decisions in the decision tree to come at a conclusion. A disadvantage of this method is that participants can be biased or that no consensus on the decision is found. The quantitative manner of analyzing the design space can be done by a multi-criteria decision making method as TOPSIS calculations (García-Cascales & Lamata, 2012). A technique to define the order preference based on similarity to the ideal solution. An advantage of this technique is that the calculation is straight forward and gives a ranked overview of all solutions. A disadvantage is that the calculations are based on expected effect scores which is qualitative data translated to a ranked score, instead of quantitative data and it does not take into account human perceptions.

This conceptual framework for complex decision making with qualitative data is tested according to a case study executed for the problem at the company described in Chapter 1.3 and 1.1 respectively. The case study is described in the next chapter.

4. Case study

This case study tests the conceptual framework for complex decision making with qualitative data in a real world context. The real world context is a department called Customer Service Domestic of big brewer that wants to get insight in improving their order handling process. This chapter exists of four main parts, Problem understanding 4.1, 4.2 Artifact design, 4.3 Validation of the case study and a conclusion of the case study in Chapter 4.4.

4.1 Problem understanding

This chapter describes the problem understanding and exists of the process investigation and the business process analysis. The goal of the first step is to define the current (as-is) situation this can be done with research question 1 shown in Table 6. The current situation can be found by applying the BPM phases: process identification, process architecture and process discovery (Dumas et al., 2018). The second part, the business process analysis aims to find the issues in the current situation to get insight into the weaknesses of the current situation and their impact. This paragraph ends with a design space, the QOC (questions, options, criteria) analysis (MacLean et al., 1991), which is the start for the artifact design phase.

Table 6 - Research question 1

Research question 1
What is the current order assigning situation? (as-is) *a. Business process model.* *b. Stakeholder overview.* *c. Information flow diagram.*

4.1.1 Process investigation

The process investigation exists of process identification, business process architecture and process discovery. The process identification is the first step of analyzing the process to be managed, the problem is identified, delimited and interrelated (Dumas et al., 2018). This step includes a process checklist, which makes sure that the process that is analyzed is a real business process and stated by Dumas et al. (2018): 'not a chunk of work that is frequently repeated'. The identification leads to a process architecture, the architecture exists of process categories, relationships between processes and process landscape model. The last phase of the investigation is process discovery, which documents the current state of the process. There are two discovery methods used, namely evidence-based (using document analysis) and interview-based discovery.

I. Process identification

This paragraph describes the process identification, the goal of this process step is to check if the process is of strategic importance to the company. According to the book Fundamentals of business process management (Dumas et al., 2018), the process identification can be done with a process checklist. The reason for this checklist is that organizations should focus on those processes that either creates value of strategic relevance or that have substantial problems (or both). The process analyzed here is the order-to-delivery process for inland distribution at the customer service domestic department. Orders come in (via SAP, mail or fax) at this department and need to be processed by one of the members of the team. The order handling takes place in batch mode, one day before the delivery due date and includes some steps for every order, such as checking: product allocation, locate brewery, shipping conditions, full-truckload check, and out-of-stock check. The checklist questions and answers for the order handling process are described in Appendix A1. The order-to-delivery process is of strategic importance to the company because all process checklist questions can be answered. Which means among other things that the process can be controlled, customer or company is willing to pay for this service, there is 1:1 relation with the event that initiates the process and all activities in scope and the process is big enough to investigate.

II. Business process architecture

After showing that the process has strategic importance for the company via process identification, the business process architecture needs to be defined. The aim of a process architecture is to provide a representation of the processes that exist in an organization (Dumas et al., 2018). Next to this, process architecture helps with defining the scope of the project. The business architecture shows related processes and their relationship to the order handling process, using a process landscape model. The process landscape model shows the core processes on a very abstract level, each of the elements of the process landscape model points to one or more detailed business processes.

Appendix A1 Figure 21 shows all the separate processes in the master planning. The first (left) phase is based on a make-to-stock policy and exists of demand planning (forecasting), production planning, material requirement planning, operations scheduling and production. The last phase (right) shows the order-to-cash part of the core process. The process where this research is about is demand fulfilment and is delineated with red. The transport planning is shown in white because it is executed by an external company.

III. Process discovery

Process discovery can be defined as the act of gathering information about an existing process and organizing it in terms of an as-is process model (van der Aalst, 2011). There are three classes of discovery methods, evidence-based discovery, interview-based discovery and workshop-based discovery. The first two are used to discover the current process. Evidence-based discovery can be done with three methods, document analysis, observation and automated process discovery. There is no data to do automated process discovery, and observation is not an option because the process is done individually on a computer. For this reason, the focus lies on the document analysis and interview-based discovery. The combination of the structured information from document analysis and the context-rich insight from interviews contribute together to an overall view of the problem.

The interviews and document analysis lead to a business process model, stakeholder overview and information flow diagram. The business process model is defined to give a clear understanding of the whole process and every step of this process, it also provides consistency, controls the process and identifies redundancies and inefficiencies. The stakeholder analysis is done to show everyone’s contribution to the process. The stakeholder overview shows all departments related to the order handling process, their description, their connection to the process, and their goals related to the process. The information flow diagram describes the movement of information related to the process and for a better understanding of the information system structure.

Business process model

The business process model is defined with document analysis and unstructured interviews with the employees of customer service domestic department, who are the actors of the process. Figure 7 shows the overview of the process and Appendix A2 shows every step of the business process model including the description and in- and output.

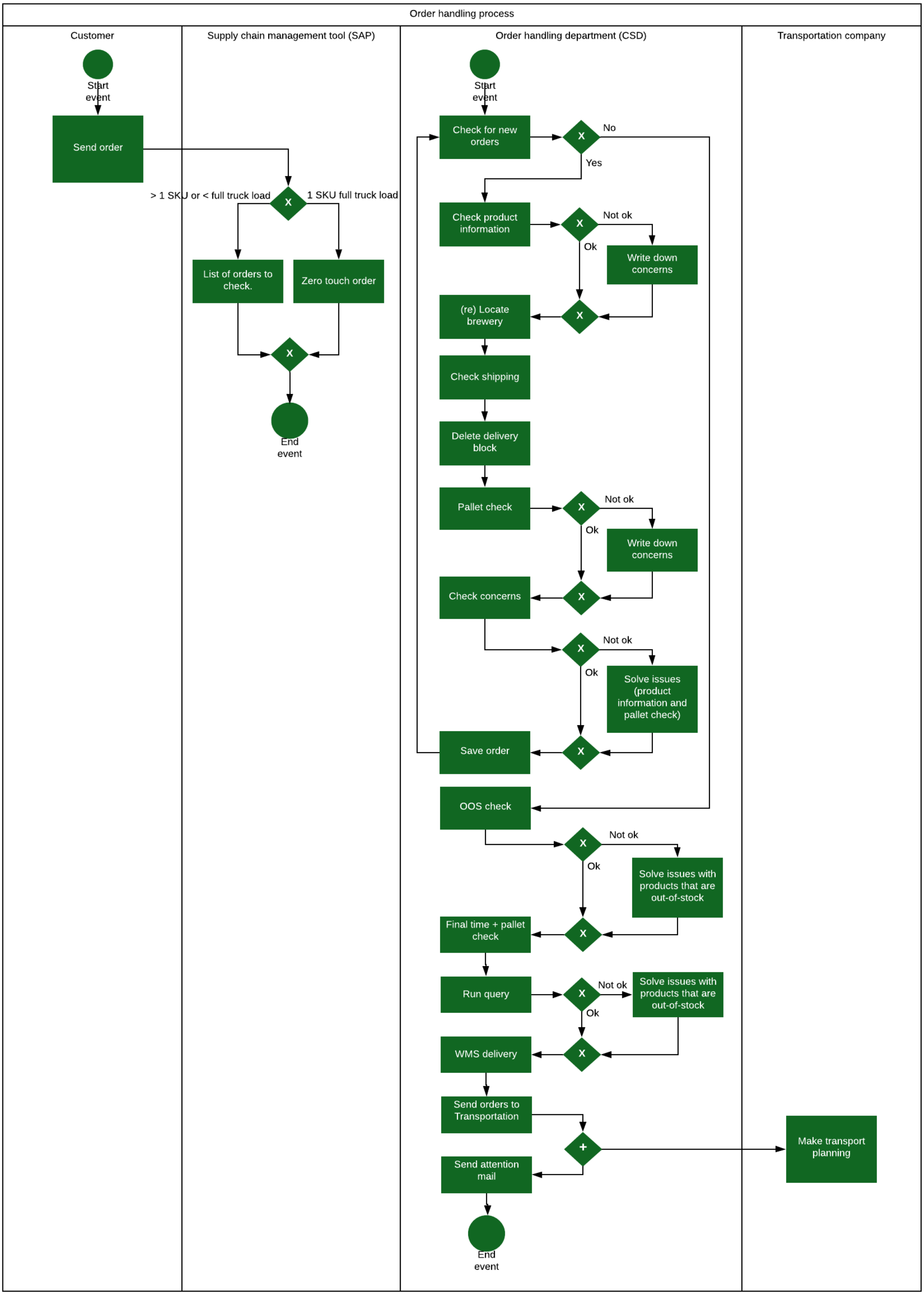

Figure 7 - Business process model – order handling process

Stakeholder overview

This paragraph describes the stakeholder overview, there are three categories of stakeholders, namely the actors of the process, internal stakeholders and external stakeholders. The first category is the actors, which are the employees of the CSD department, who actually execute the process. The second category is the internal stakeholders, these are related departments of the company, whom all have a different connection to the process. Figure 8 shows the position of all internal stakeholders in the organization in light green. The last category, are the external stakeholders, this category exists of the customers of the department, which are the Dutch supermarkets and wholesalers. Appendix A3 describes an overview of the stakeholders, their description and connection to customer service domestic department (CSD).

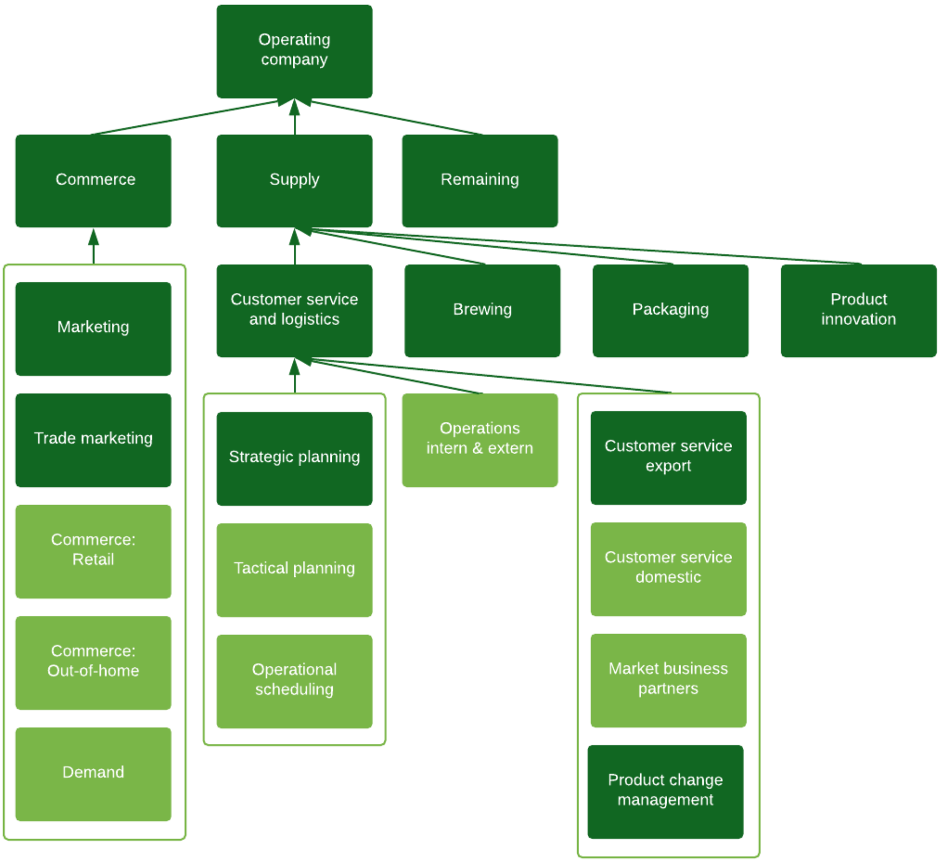

Figure 8 - Organogram with stakeholders of this project in light green.

Information flow diagram

The information flow diagram is designed for a better understanding of the information system structure within the company. The main reason for describing the information flow diagram is that different departments work with separate systems related to each other but not always consistent and accurate. For example, the demand department has its own forecasting system, operational scheduling has its own planning program and the operations use a warehouse management system, while CSD uses SAP for order handling.

The information flow diagram is defined with unstructured interviews with several internal stakeholders and employees of the customer service and IT department. Next to this, document analysis is done to check relations between information and other software systems. The information flow diagram in Figure 9 shows an overview of the software systems, which play a role in the order assigning process of CSD. The functionalities of all aspects of the information flow diagram are described in Appendix A4.

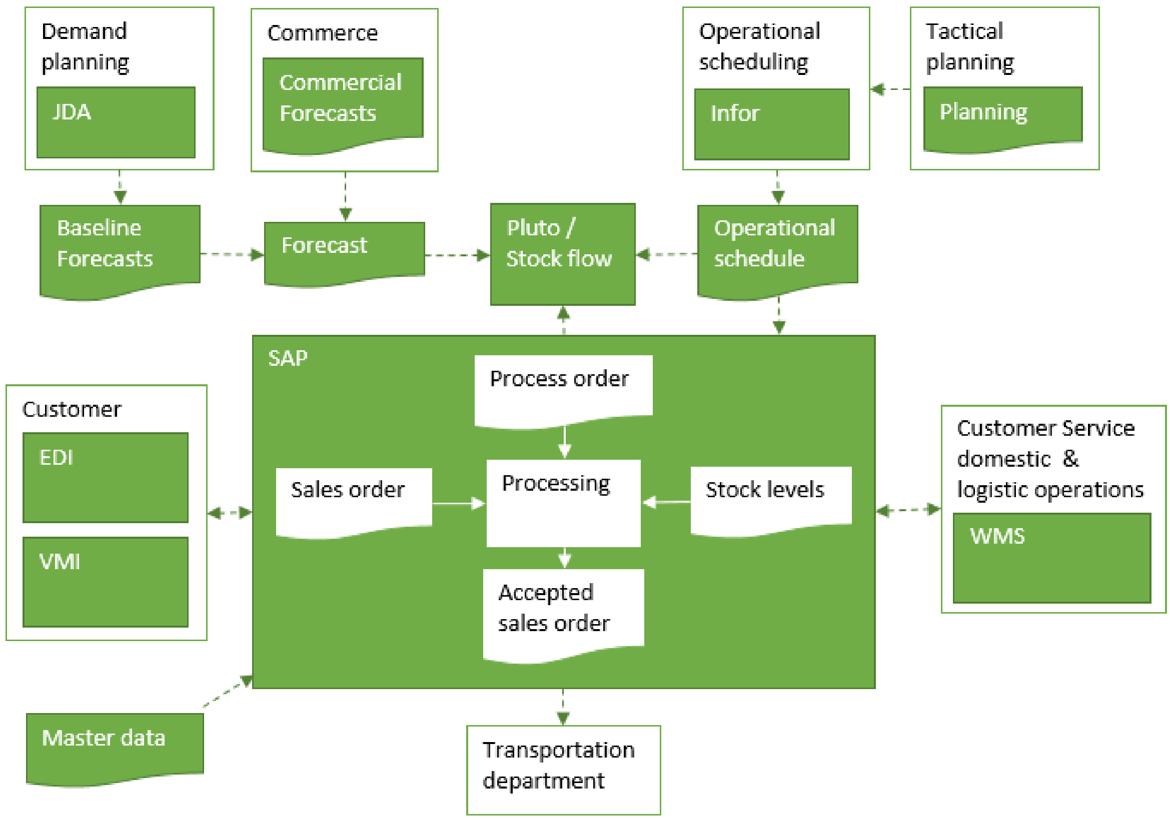

Figure 9 - Information flow diagram

4.1.2 Business process analysis

The process investigation has shown the as-is situation with a business process model, stakeholder overview and information flow diagram. This chapter is the sequel to the process investigation and analyses the as-is situation. This analysis is done to find how the process performs and to find what the main problems are. The analysis is done in a few steps, first starting with identifying issues using semi-structured interviews, than the issues are registered and a Pareto analysis is done to find the issues that need priority. The issues with priority are analyzed using a 5Whys diagram to find the root cause and are explained in detail in the issue description. This leads in the end to a QOC analysis as a basis for the artifact design in the next chapter.

I. Identify and register issues

Some semi-structured interviews are executed with actors and internal stakeholders to get insight into the current problems and the relation of every stakeholder to these problems and causes. The seven interviews are done with representatives of the departments: customer service domestic, market business partners, demand, account management retail, tactical planning, operational scheduling and operations. The results on the main questions of the interviews are shown in Appendix A5. The main questions are shown below:

1. What are the causes of out-of-stock situations?
2. What must be improved in the current situation/process?
3. How are availability problems measured?
4. Do you have remaining remarks?

Using these main questions, some issues are defined which are shown in Table 7 together with the number of times they are mentioned by the seven interviewees. The issues are registered in Appendix A6. Issue G, more material requirement planning is outside the scope of the master thesis because this is not a responsibility of the customer service domestic department. Material requirement planning is done by the tactical planning department and they prefer using their current planning tool (See information flow diagram).

Table 7 - Issues of the as-is situation

Task	Description	Number of mentions
A. Communcation with the customer	The customer is not always updated on their order and products that are not available. This can better be described as low order status transparency.	4
B. Give notification to CSD if a customer exceeds its own forecast	Customers send in their own forecast to the commerce department. This forecast is not known by CSD and therefore not used. It occurs sometimes that a customer exceeds its own forecast 3 times.	3
C. Decrease time spend on OOS	In some periods of the year, the time spend on out-of-stock is too high with an average of 0.43 full-time equivalent (FTE) a week, see description in Table 8. In these periods some employees cannot do their daily work because they need to handle the out-of-stock situations.	2
D. Detect OOS problems earlier	In many cases the out-of-stock is detected too late, it is detected when an incoming order exceeds the product availability. It is too late to plan a quotation meeting with commerce to divide the remaining stock.	4
E. Handle orders not at the same time	At the moment, most customers send their daily orders before 11 a.m. but the biggest customer: Albert Heijn with 30% of the sales is done with help of vendor managed inventory (VMI) by Heineken, and this is done in the afternoon because then most data is available. This difference in moment of order handling leads to an unrealistic overview of stock positions because there is no zero-time point.	1
F. Segmentation for customers	At the moment some customers have a priority status, but this is not transparent to the customers.	1
G. More material requirement planning (MRP)	At the moment CSD and tactical planning work mostly seperate from each other, with MRP planning all these processes will be connected.	1

II. Pareto analysis

The Pareto analysis is founded by Joseph M. Juran, who stated: ‘in any series of elements to be controlled, a selected small fraction, in terms of numbers of elements always accounts for a large fraction in terms of effect.’ (Craft & Leake, 2002). The aim of Pareto analysis is to identify which issues should be given priority (Dumas et al., 2018). The priority issues can be selected by reflecting the issues to the company goals, which are cost savings and higher customer satisfaction.

Table 8 shows the issues with the number of mentions and the effect score on cost savings and customer satisfaction. The effect score is estimated by the researcher, based on the arguments provided by the internal stakeholders and actors showed in Appendix A7. The table shows the effect on the cost savings and improvement of customer satisfaction if the issue improves/is solved. These rankings are also shown in a PICK graph in Figure 10, which shows which issues are possible, implemented, challenges or killed (Dumas et al., 2018).

- Possible: issues that can be addressed if there are sufficient resources to do so.
- Implement: issues that should definitely be implemented as a matter of priority.
- Challenge: issues that should be addressed but require a significant amount of effort.
- Kill: issues that are probably not worth addressing or at least not to their full extent.

Table 8 - Issues with estimated effects on stakeholder goals.

Issues	Ranking from interviews	Cost savings (1-5)	Customer satisfaction (1-5)
A. Communcation with the customer	4	1	5
B. No notification if a customer exceeds its own forecast	3	3	3
C. Too much time spend on out-of-stock situations.	2	5	2
D. Late detection of out-of-stock.	4	5	5
E. Handle orders not at the same time.	1	2	1
F. No strict segmentation for customers	1	1	2

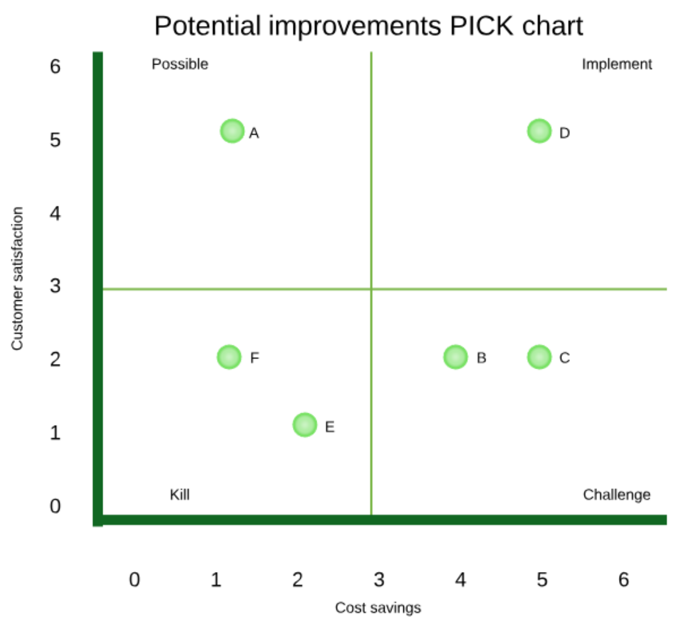

Figure 10 - Potential improvements in a PICK chart

III. Root-cause analysis

The Pick diagram is derived from the estimated effect score of the Pareto analysis and only the issues in the categories challenge, implement and possible are further analyzed. The issues A, B, C & D are for this reason chosen for further analysis. The issues are analyzed using root cause-analysis because if the root cause is not identified the problem will continue to exist (Doggett, 2005). The technique that is used is the scheme of 5Whys, which is credited to Sakichi Toyoda (1867-1930). The purpose of this 5Whys diagram is to stimulate problem-oriented thinking, starting with the problem and find the root causes (Myszewski, 2013). One of the advantages is that the technique is relatively easy to use and practical. The results of the 5Whys analysis are shown in Appendix A8.

According to these tables the name of the first issue (A) is changed, the communication with the customer, can better be described as order status transparency to customers. Issue B, no notification if customer exceeds its own forecast is more an optional solution than a problem, for this reason it is not be discussed in chapter IV. Issue description. The three main problems are defined using the 5Whys analysis, these are: order status transparency, too much time spend on out-of-stock situations and late detection of out-of-stock situations. The whole picture around these problems is described in the issue description with some examples for every problem.

IV. Issue description

This chapter describes the three main problems of the current process and shows some examples of these problems.

Order status transparency

Customers that order more than one day in advance, have to wait till the last day before delivery before they are informed about the fulfilment of their delivery. This occurs because the order fulfilment is done in batch mode on the last day before delivery. The reason for this late decision model is that the company works with vendor management inventory (VMI) for one big customer. VMI is a continuous replenishment system between supplier and customer, where the supplier replenishes the warehouses of the customers based on the customers' inventory position (Waller, Johnson, & Davis, 1999). VMI works optimal if you measure the inventory position as late to the delivery as possible because all incoming and outgoing transports of that day in every specific warehouse are known. The late decision model is a problem for the other customers because the update on the status and communication about their order is also done only one day in advance (because of batch mode order fulfilment). This problem counts for customers that order more than one day in advance and who are not served by VMI. For this reason the order status can change, late to the delivery which means that the order status is not transparent. This low transparency can lead to unsatisfied customers.

An example of this problem is shown in Appendix A9. The figure shows an SAP (MD04) overview of the availability of product 109203 at the brewery, which is the normal crate with 24 bottles. As can be seen, the available quantity is shown and orders that are already sent in by customers. The date on which this stock requirement list is made is 13 November 2018, which means the orders for the day after (14 November) are already 'delivered'. This delivery means that the order is send to the transportation company. The problem can be seen at the bottom of the table, there are already orders for December 5th, which is 3 weeks from now. But these customers will be informed about the availability and delivery of their order on December 4th.

Time spend on out-of-stock situations

The next problem: if there is an out-of-stock situation customers need to be informed. If an order comes in and it can be fulfilled the customer gets an automatic confirmation. If it turns out that there is an out-of-stock situation, the customer needs to be informed about the planned availability and possible substitutes by a call from CSD. This takes a few minutes for one customer, but can take a lot of time of CSD if all customers need to be informed. This time spend on the call is not only a problem for the CSD department but also for other internal stakeholders. Because there are some other actions that need to be done by internal stakeholders that have a role in OOS situations (See example below). The internal stakeholders are described in the process investigation - stakeholder overview. Table 9 describes the time spend on OOS situations from January 1st 2018 – September 16th 2018. In this time period (37 weeks), 272 out-of-stock situations occurred. As can be seen in the table, all out-of-stock activities take on average around 12.8 hours a week.

Table 9 - Time spend on OOS situations (in minutes).

What	Time (per OOS situation)	Time (per week)	Number of employees	Total time
Weekly meeting, check problems with forecast and stock positions.		60	5	11100
Out-of-stock mail	10		1	2720
Informing customers	15		1	4080
Impending OOS meeting		30	5	5550
Quotation meeting (only in +/- 10% of the OOS situations)	30		6	4896
Total time	28346			
Total time per week	766 (= 12.8 hours)			

Detection of out-of-stock situations

At the moment the CSD detects some out-of-stock situations too late. They see most situations coming by the impending OOS meeting, but there are still some situations in which OOS is detected too late. There are four causes for this late detection of out-of-stock situations:

- One of the reasons is that all orders are handled only one day in advance. If the product is not discussed at the impending OOS meeting, it is possible that an out-of-stock is found at the moment a customer orders more products than available. This results in very late detection of an out-of-stock situation and there is no other choice than wait for the next production batch.
- The second cause is the inconsistency between the warehouse management system (WMS) and SAP inventory system. Sometimes it happens that the inventory position in SAP that is used by CSD is not equal to actual inventory position. If this is the case, out-of-stock situations are found at the moment an order is prepared by the operations department.
- The third reason is that the out-of-stock check in SAP that is executed once a day to check if there are out-of-stock situations does only check single orders against the availability. Instead of a sum of all orders together against the available inventory. This cause also detects out-of-stock only one day in advance.
- The last cause of late detection of OOS is that the customer-specific forecast is not used by CSD. The demand department calculates the forecast for every stock keeping unit (SKU) based on their own trends and the forecasts send in by customers. This customers' own forecast is not used by CSD to detect if customers order more than their own forecast. Sometimes a supermarket has a promotion on a specific sales item that is sold 3 times more than expected, this can have a huge effect on the inventory of this specific product. And can lead to out-of-stock situations in the future.

Appendix A9 shows two examples of OOS situations that are not detected on time, the first one because of the inconsistencies of SAP and the second one because the out-of-stock check is not correctly executed. The first table shows the overview for product 108895, a cask with Weizen 50 Liter on date 12 November 2018. The table shows that the available quantity is 682 pieces, but this quantity is blocked in the warehouse management system because of exceeding the best before date. It seems like this product is still available, but it is not available for delivery. Another problem is shown in the last table of Appendix A9. This product is not shown in the OOS check, because the orders do not exceed the available quantity individually but they do together.

V. QOC analysis

After defining the three issues, the question, option, criteria (QOC) analysis can start. This analysis represents the design space analysis, which is a structured space of design alternatives including considerations for choosing among them (MacLean et al., 1991). The phases of the design space analysis (MacLean, Bellotti, & Shum, 1993) are added in Appendix A10. The first phase of the QOC analysis is: Identify relevant information. This relevant information is found with the stakeholder and employee interviews and the business process analysis steps. The three issues are the input for the three main questions:

1. How to create more order-status transparency?
2. How to create less time spend on out-of-stocks?
3. How to detect out-of-stock situations earlier in time?

The second phase is: Structure material into rough QOC. Using issue description and the questions, three options (a, b & c) are defined, together with some requirements.

a. Change the out-of-stock check.
b. Implement available-to-promise.
    - Solve inconsistencies in SAP & WMS
    - Change process order data in SAP
    - Change order handling process
    - Prepare IT structure for ATP (decision/checking rules)
c. Use forecasts in SAP.

These three options can be ranked according to some criteria, the criteria are based on the Devil's Quadrangle (Brand & H. van der Kolk, 1995) and the overall company goals, improve customer satisfaction and reduce costs.

I. **Process time** – the time the order handling takes from the moment the order comes in to the order that is delivered or rejected.
II. **Process costs** – the costs that are related to the process, this costs are related to the process time, because a longer process time results in higher costs.
III. **Process quality** – the quality of the process can be described as being suitable to perform the process on an intended level.
IV. **Process flexibility** – the amount in which the process can deal with uncertainty resulted from unexpected changes.
V. **Implementation time** – the expected time needed for implementing a new process, structure or system.
VI. **Implementation costs** – the expected costs of implementing a new process, structure or system.
VII. **Customer satisfaction** – the percentage of customers who reported the experience with the company as exceeds specified satisfaction goals.
VIII. **Feasibility** – the feasibility of a process is the chance on a successful change in the process, structure or system.

Figure 11 shows an overview of the questions, options and criteria and the connection between them. This is the first version of the QOC analysis and is used as a starting point for the artifact design phase, which is described in Chapter 4.2.

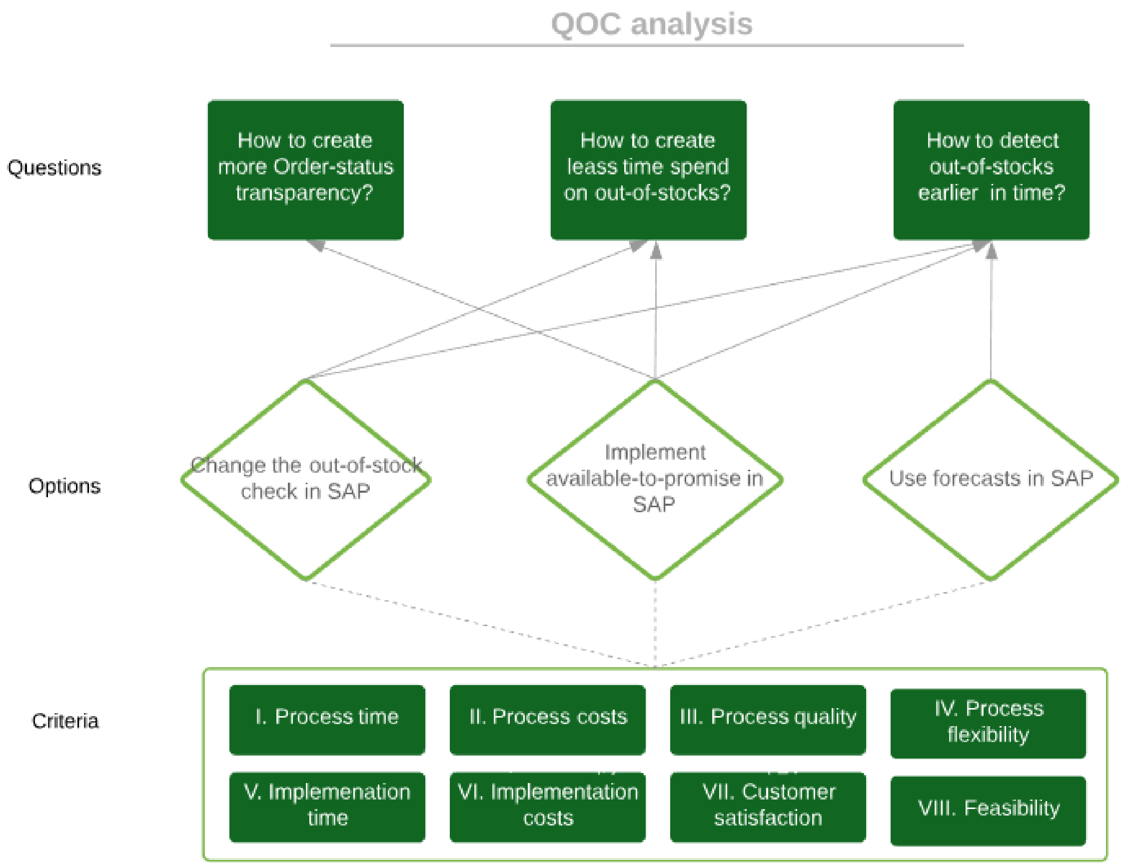

Figure 11 - Relations between Questions, Options & criteria

4.2 Artifact design

The artifact design phase is executed to answer research question 2, which is shown in Table 10. This artifact design phase results in a decision model that gives insight in all facets and capabilities of improving the order handling process. The artifact has to meet requirements like easy-to-use, usefulness, completeness and understandability, this is tested in the validation phase, which is described in Chapter 4.3.

Table 10 - Research question 2

Research question 2
What options(s) for improving the order assigning situation are possible? (to-be)

The artifact design consists of three iterations, see Figure 12 for the tools and results of every iteration. The first iteration is based on document analysis using a framework for documenting architectural design decisions (ADDs) for an educational setting (Gu et al., 2010) and a decision tree framework (Magee, 1964). The second iteration results in a more detailed decision tree framework, based on qualitative interviews with actors and internal stakeholders. The reason for the descriptive interviews is to get a detailed interpretation of the situation that helps the researcher define all possible solutions. This iteration results in scores for all possible solutions, which are analyzed by the quantitative TOPSIS method (García-Cascales & Lamata, 2012) which is a technique to define the order preference based on similarity to the ideal solution. The last step of the artifact design is the third iteration, which is a focus group to find out the feelings, concerns, perceptions and thoughts about the decision model and the steps that need to be taken (Wilkinson, 1998).

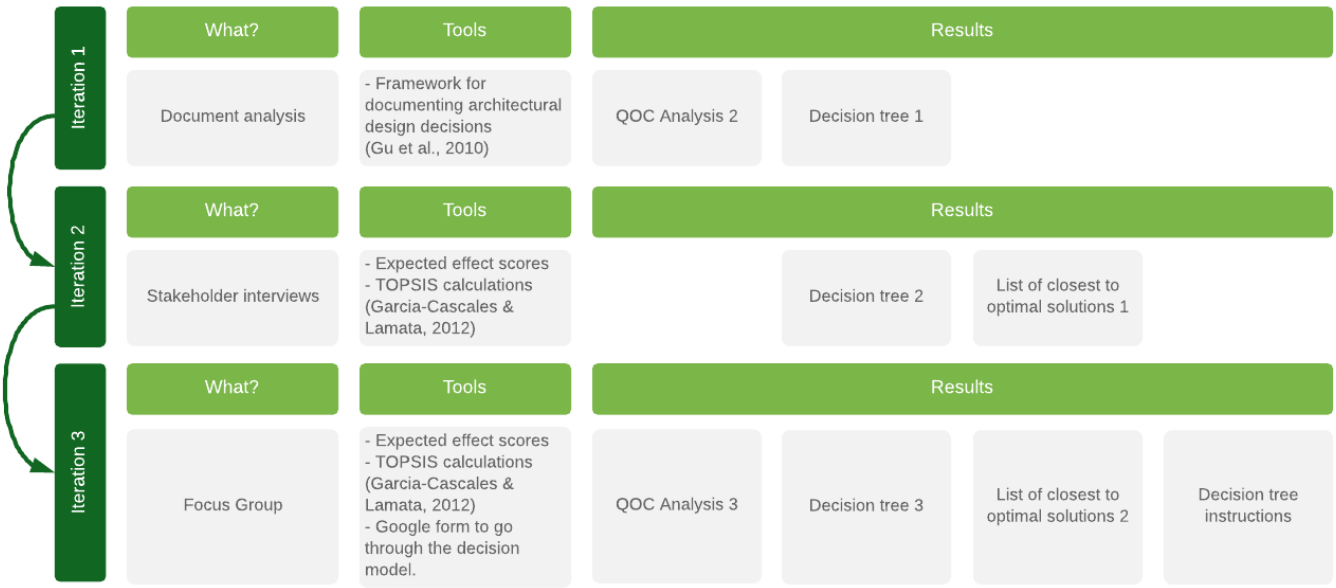

Figure 12 - Framework for artifact design phase

4.2.1 Artifact iteration 1

The first part of this iteration is made with document analysis, using, among other things, a framework for ADDs for an educational setting (Gu et al., 2010). This framework is used to check all possible options, with the reason for rejection and process overview. Some minor parts of the theoretical model of Gu et al (2010) are changed to use it in combination with the QOC analysis. For example, the quality attributes are exchanged for the criteria from QOC: process time, process costs, process quality, process flexibility, implementation time, implementation costs, feasibility and customer satisfaction. The whole framework is shown in Appendix B1, Table 11 shows a summary of the design issues, identifiers and status and Figure 13 shows the new QOC analysis with options and requirements.

Table 11 - Design issue, identifiers and status per identifier.

Design issue	Identifier	Status	Reasoning
D1: how to change the out-of-stock check?	D1-Opt1: Change the out of stock check in SQ01	Rejected	This option is not feasible because the SQ01 in SAP can only make queries, which can only be a report instead of doing calculations.
	D1-Opt1: Make a new out-of-stock check in another module in SAP.	Accepted for further research	The feasibility for this option depends on the research of the SAP consultants. Heineken decided to spend a project of (40 hours) on this project, to check the possibilities.
D2: How to implement available-to-promise	D2-Op1: Solve inconsistencies between SAP & WMS by searching for the current problems and solve these.	Rejected after research of the WMS team	The feasibility is too low because some of the biggest problems that are reported are difficult to change. For example: - The best before dates are not stored in SAP. - The process batch is not stored in SAP.
	D2-Op2: Solve inconsistencies between SAP & WMS by changing to another warehouse management system.	Accepted for further research	The project will cause some risk because changing a warehouse management system, changes a lot of processes within departments of Heineken. Next to this, the implementation time and cost are high, but acceptable for Heineken.
	D2-Op3: Change process order data in SAP.	Accepted for further research	This option should be investigated because it will change the process of adding and changing process orders in SAP for the operations scheduling department and/or tactical planning department. At the same time, it can decrease the process time for CSD. For this reason, the feasibility and effects need to be changed.
	D2-Op4: Change order handling process	Accepted for further research	The research will be done on the number of changes and the effect of changes. The most important thing is that the change in process results in a situation that makes it possible to do reservations in SAP.
	D2-Op5: Prepare IT structure for ATP	Only accepted after approval of D2-Opt2, 3 and 4.	This option is only started if the options 2, 3 and 4 are accepted after research. The reason for this is that if one of the other options is not possible, research on this one could be useless.
D3: How to use forecasts in SAP?	D3-Opt1: Use forecasts in SAP	Only accepted after approval of D1 & D2	This option is accepted after research and approval of D1 and D2. The reason is that it can only partly contribute to the goals (questions) of the QOC analysis, order-status transparency, time spend on out-of-stock and detect out-of-stock earlier.

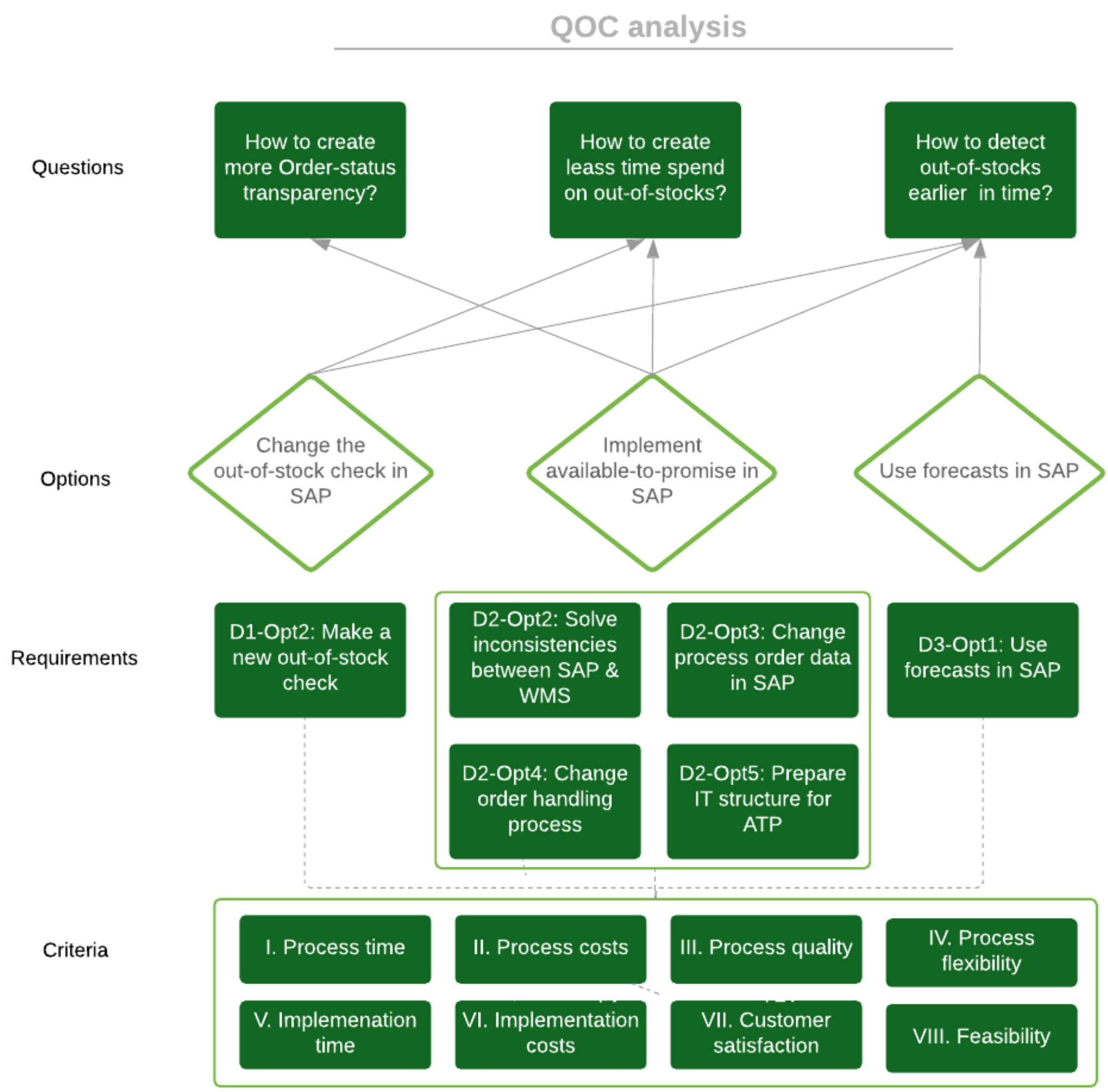

Figure 13 - QOC analysis including results of the framework of Gu et al. (2010)

The first part of this artifact iteration describes the current options in the design space. From now, the actual artifact is developed. March and Smith (1995) distinguish 4 kinds of artifacts, namely constructs, models, methods and instantiations. Constructs can be the vocabulary of a domain, a model is a set of propositions or statements expressing relationships among constructs, a method is a set of steps necessary to perform certain tasks and instantiation is the realization of an artifact in its environment (March & Smith, 1995).

The kind of artifact that is made here is a method, which graphically represents the steps that can be taken in the decision process. According to March & Smith (1995), a method can be used to give a representation of the improvement needs of a system. A decision-making tool of John F. Magee (1964) is used to show the decisions that need to be made, namely a decision tree. 'The decision tree can clarify the choices, risks, objectives monetary gains and information needs involved in an investment problem' (Magee, 1964).

The decision-event chain in Figure 14 is a multiple stage decision tree, where every option has two possible outputs: 'yes' or 'no'. If more information is needed, extra research can be done and the decision tree needs to start over again. There is a difference between change events (circles) and decision points (squares). The decision points represent the decision on a design option while the other chance events are decisions on one of the requirements each. These requirements together lead to a final decision for that category. The decision points represent the design options of the QOC analysis. The different paths in the decision tree can result in four main outcomes namely: do nothing, implement out-of-stock check (D1-Opt2), implement out-of-stock check (D1-Opt2) and ATP or implement out-of-stock check, ATP and forecasts in SAP (D3-Opt1). This iteration shows an overall overview of the steps and decisions that need to be made, further iterations focus more on the details of these decisions and other possible options.

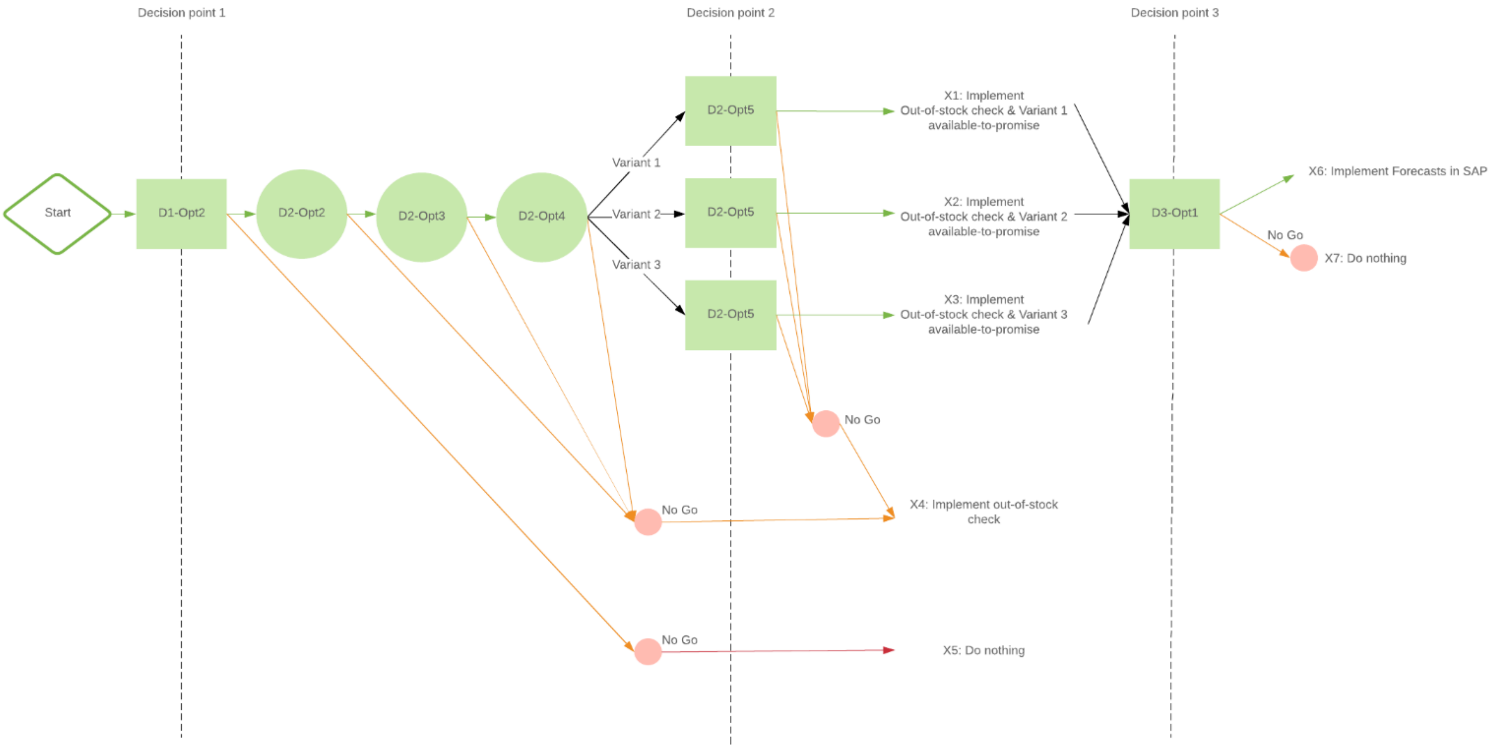

Figure 14 - Artifact 1 - decision tree

4.2.2 Artifact iteration 2

The second iteration is based on the first iteration and defined with stakeholder interviews. These descriptive interviews are held to get a detailed overview of the advantages and disadvantages of all possible solutions. According to Triantaphyllou (2000) one of the critical steps in dealing with any multi criteria decision model is to accurately estimate the pertinent data. For this reason the interviews are held for every decision point and change event to show all considerations for the decision and the expected ratings of the criteria of the QOC. The process criteria are based on the Devil's Quadrangle and the other criteria are about the implementation, effect on customer satisfaction and feasibility. These other criteria show the impact of the suggested solutions, but also the time and cost that is needed for implementation and the feasibility of the proposed solutions. The criteria are shown in Table 12 and are ranked on a 5 points scale (--, -, +/-, +, ++) which represents: very low, low, acceptable, high and very high. Some criteria have a star (*), this means that a low score is positive and vice versa.

These effects can be summarized in a design option score, in four different categories, namely the effect on the process, total time and cost of implementation, the effect on customer satisfaction and feasibility. This paragraph describes how the design option score is calculated. Every effect is translated to a number, from -2 to 2 (-- is -2, - is -1, +/- is 0, + is 1 and ++ is 2). For the calculations on the first two levels scores with (*) get a (-) extra to make every score positive if it is positive and every score negative which has a negative effect. In this iteration, there is no ranking between criteria, which means every criterion has the same effect size.

A simple example, every criteria that has a + results in these scores:

Process = (-) process time + (-) process costs + process quality + process flexibility

= (-) 1 + (-) 1 + 1 + 1 = 0

The process score can be between -8 and 8, where a positive score means a positive effect on the process and a negative score means a negative effect.

Implementation = (-) implementation time + (-) implementation costs

= (-) 1 + (-) 1 = -2

The implementation score can be between -4 and 4, where a positive score means less implementation effort (time & cost) and a score under zero means that the implementation effort is high.

This example shows that the effect on the process is zero, which is negligible because it shows that this change has no effect. The implementation score, on the other hand, is -2, which means that the effort of implementation is high. With these scores together you can take the conclusion that this example is not a gainful project for implementation. If it turns out that a project has a chance to be successful for the process, the researcher can check the effects on customer satisfaction and the feasibility to define a conclusion. In the final decision tree, the scores per criteria and decision point lead to a total effect score.

Table 12 - Criteria for the QOC analysis (left).

Table 13 - Effect scores in words for options (right).

Criteria	Effect	Effect in numbers	Score
I. Process time*	+	1	0 (between -8 and 8)
II. Process costs*	+	1	
III. Process quality	+	1	
IV. Process flexibility	+	1	
V. Implementation time*	High	1	-2 (between -4 and 4)
VI. Implementation costs*	High	1	
VII. Customer satisfaction	+	1	1
VIII. Feasibility	High	1	1

	Process	Implemen-tationt	Customer satisfaction	Feasibility
Very high	6,7,8	-4	2	2
High	4,5	-2,-3	1	1
Medium high	2,3	-1		
Medium	-1,0,1	0	0	0
Medium low	-2,-3	1		
Low	-4,-5	2,3	-1	-1
Very low	-6,-7,-8	4	-2	-2

In the coming paragraphs, the scores per option are shown. The numerical rating scale per criteria is now transformed into four overall ratings for the process, implementation, customer satisfaction and feasibility. The scores are on ratio level, which means the numbers indicate a magnitude of difference including a zero point. This zero point is for every score the same, only the range per score differs because the scores are built from a different number of criteria. For this reason Table 13 shows the scores per factor relative to the descriptive value (from very low to very high).

I. Decision point 1 – Out-of-stock check

D1-Opt2 - Make a new out-of-stock check in another module in SAP.

The out-of-stock check in SAP is executed once a day to check if there are out-of-stock situations. The problem with this check is that it only checks single orders against the available inventory instead of a sum of all orders together. The framework for architectural design decisions in iteration 1 showed that this out-of-stock check needs to be changed in another module than the SQ01. The estimated effects are shown in Table 14 together with the reasoning.

Score

The process score is 2, which means the project has a positive effect on the order fulfilment process of the customer service domestic department. Next to this, the implementation score is 3 which means the implementation cost and time are acceptable. These two scores together show that this project could be useful in the future. Also, feasibility and customer satisfaction are positive, which is an extra reason to give a 'go' for this project.

Drawback

- A drawback of this option is that it is also possible that this project fails. If that is the case another out-of-stock check must be designed to detect out-of-stock. The disadvantage is that this project focuses on the integration of software systems and if it turns out it is not possible in SAP, another software system for this problem must be chosen, which makes the information flow diagram/system even more complex.
- Another drawback is that the customer service department cannot work accurately at the moment because they do not have a working out-of-stock check, so the decision for implementation and actual implementation needs to be as fast as possible.

Table 14 - Estimated effect score of D1-Opt2

Criteria	Effect	Reasoning	Score
I. Process time*	-	Process time decreases because no re-work needs to be done on out-of-stocks, that did not show up before in the previous OOS check.	2 'Medium high'
II. Process costs*	+/-	The process stays the same only the OOS check SAP is changed.	
III. Process quality	+	Process quality increases because all out-of-stocks will show up in the out-of-stock check.	
IV. Process flexibility	+/-	No direct effect on flexibility, because there are no actors or tasks added that can increase flexibility.	
V. Implementation time*	Very low	Implementation time is very low because it can be done by a SAP professional when they still work with the current OOS check.	3 'Low'
VI. Implementation costs*	Low	There are some implementation costs but these are only the costs of the working hours of the SAP professionals (+/- 40 hours).	
VII. Customer satisfaction	+	Out-of-stock is detected earlier in time, so the production planning can change to solve the problem before the product actually goes out-of-stock.	1 'High'
VIII. Feasibility	Very high	It is probably a quick win (easy change) for the out of stock team.	2 'Very high'

II. Decision point 2 – Available-to-promise

This decision point describes the requirements of the second option of the QOC analysis, namely implement available-to-promise in SAP. The decision point can be reached in several different manners, a 'go' on all four requirements leads to the optimal implementation of available-to-promise but there are also options for an adjusted version of available-to-promise. The description of these requirements, their effect scores and the total effect score of implementing available-to-promise are described in this section.

D2-Opt2 Solve inconsistencies between SAP & WMS

One of the requirements for implementing available-to-promise is solving the inconsistencies between SAP ERP system & the warehouse management system (WMS). The reason for this requirement is that the information in SAP is not perfect and up-to-date, so you can implement ATP but this does not solve the whole problems if you do not solve the inconsistencies. A team with members from different departments started a project about searching for a solution for the inconsistencies between SAP and WMS. The inconsistencies between these two systems are among others:

- Types of stocks are not the same in WMS & SAP.
- Best before date is only stored in WMS, not in SAP.
- The production batch is only stored in WMS, not in SAP.
- SAP and WMS automatically synchronize every 15 minutes, not constant.
- Differences in IDoc's (transfer information between SAP & WMS).
- Last minute changes in orders that are already started in WMS cannot change anymore.

At the moment, the team focuses on a feasibility study on the implementation of Astro WMS® instead of using the current WMS. The business and technical needs of this changeover need to be investigated by this project team.

Score

Table 15 shows the score for the first requirement (D2-Opt2) of implementing ATP. The effect score for the process is 3, which can be a sufficient influence on the process. The implementation score, on the other hand, has a negative score of -4 because the implementation time and costs of this project are very high. This leads to the first and most important drawback in the next section. There can be a positive effect on customer satisfaction, but the feasibility is not very high because there are different interests of different departments.

Drawbacks

- The first and most important drawback is that this project influences many departments with different goals, who want different functionalities in a warehouse management system. This project can have a positive effect on the CSD department, but this can have the reverse effect on for example the operations department which does all their tasks based on the warehouse management system or the customer service export department who work according to a make-to-order policy.
- As described before, there is a team working on this project, the execution of the project about a new WMS is outside the scope of this thesis. The result of the project is an important input for the realization of the implementation of ATP.

Table 15 - Estimated effect score of D2-Opt2

Criteria	Effect	Reasoning	Score
I. Process time*	-	The process time of CSD can go down, at the moment they use WMS separate from SAP to check for example best before date. If this is integrated into one system it can decrease the process time.	3 'Medium high´
II. Process costs*	+/-	The process costs will stay the same, there are no extra handling activities.	
III. Process quality	+	The quality of the process goes up if the inconsistencies are solved because there are some wrong stock positions in SAP which cause problems.	
IV. Process flexibility	+	The flexibility increases because information is correct, which can lead to faster reaction to problems in the process.	
V. Implementation time*	Very high	This is a very big project, with a long feasibility study, change of processes and pilot test phase, before actual implementation.	-4 ´Very high´
VI. Implementation costs*	Very high	Implementation costs are very high because a new WMS system needs to be bought and the investigation time on this new system is very long.	
VII. Customer satisfaction	+	The customer satisfaction can increase if there are no inconsistencies between SAP and WMS anymore because there are no inconsistencies between order and delivery.	1 'High'
VIII. Feasibility	Low	The feasibility is low because the implementation of Astro affects most departments within Heineken Nederland Supply. And next to this many business processes that need to be changed.	-1 ´Low´

D2-Opt3 Change process order data in SAP.

Another requirement for implementing available-to-promise is changing the process order data in SAP. At the moment this information in SAP is not always up-to-date, due to changes in the planning and delays in the production line. The production is planned in the program Infor, one week in advance by the operations scheduling department. They release their planning to SAP every week on Thursday for the coming week. After this release, some changes in planning can occur. These changes can be caused by priority products that are out-of-stock, unavailable packing materials or delays on the production lines. These changes are processed in Infor but are only processed in SAP after production instead of before production. The correct information on the number of products is important if there are impending out-of-stocks or if the stock position is low. In this case, it is crucial that the exact production, release time and the number of products is correctly inserted in SAP.

Operational Scheduling started a project for automatic (continuous) releasing if this project succeeds this will be positive for the implementation of ATP where data correctness is crucial. The project is complex and the main goal is increasing the interface between Infor, Pluto, MES, and SAP.

Score

Table 16 shows not only the scores per criteria but also overall scores for the process, implementation, customer satisfaction and feasibility. The influence on the process is positive, it will decrease process time because less rework is needed on problems with incorrect information. The implementation time is low because nothing will change in the process of CSD and costs include only the investigation costs of the process. The last aspects of customers' satisfaction and feasibility are both sufficient.

Drawbacks

- There is a chance that the project does not succeed, this results in the fact that the data in SAP will stay incorrect, which would have a negative effect on the results of ATP. Because if you use incorrect data as input the output will also be incorrect. The risk of failure is not very high, the expectation is to finish the project in May 2019. If it turns out that the project doesn't solve the issues with process orders another option to solve this issue needs to be found.
- As described before, there is a team working on this project, the execution of the project about a new release option for process orders is outside the scope of this thesis. The result of the project is an important input for the realization of the implementation of ATP.

Table 16 - Estimated effect score of D2-Opt3

Criteria	Effect	Reasoning	Score
I. Process time*	-	A small decrease in process time, because with correct information some past problems with incorrect process order information can be prevented.	3 'Medium high´
II. Process costs*	+/-	This stays the same because there is no change in the process of CSD.	
III. Process quality	+	Process quality increases because fewer problems should occur due to incorrect information.	
IV. Process flexibility	+	The process flexibility increases a little bit because correct information is continuously shared by the operational planning department.	
V. Implementation time*	Low	Implementation time could be low, it could be implemented while there will not change anything for CSD:	1 ´Medium low´
VI. Implementation costs*	Medium	Implemenation costs could be medium because a new systems needs to be investigated and possibly bought by the company.	
VII. Customer satisfaction	+	Correct information leads to less problems in the order handling and less shortages. Which will have a small effect on the customer satisfaction.	1 'High'
VIII. Feasibility	High	Feasibility is doable because the project on this issue is already started.	1 ´High´

D2-Opt4 Change order handling process.

Changing the order handling process is divided into three variants for available-to-promise. From the interviews is found that all variants have some drawbacks, especially the implementation and expected effects differ per variant. The three different options are Full ATP, where available-to-promise is applied in SAP, the order handling process is changed and the customers are informed. The second variant is ATP for promotion orders (with informing customers), this means ATP is implemented in SAP, the order handling process stays the same but customers are informed to change their order process for promotion orders only. Sometimes customers order in one week way more than their normal demand because they have an article in the listing, this is called a promotion order. These listings are in most cases promoted on television or in a promotional brochure to attract customers to their stores. The last variant is implementing ATP in SAP, order handling process changes but customers are not informed. An overview of the effects of all three variants are shown in Table 17. The reasoning for the scores and description of all variants in the sections below.

Table 17 - Overview of scores for ATP variants.

Criteria	Full ATP	ATP for promotions	ATP on the background
I. Process time*	--	-	+/-
II. Process costs*	+/-	+/-	+/-
III. Process quality	+	+	+
IV. Process flexibility	+	++	+
V. Implementation time*	Very high	High	High
VI. Implementation costs*	Very high	High	Medium
VII. Customer satisfaction	++	+	+/-
VIII. Feasibility	Medium	High	Very high

Variants

1. Full ATP

Use ATP for all orders and all customers, in this case, orders need to be handled differently and customers need to be informed. The order handling process date and time need to be changed so that orders are handled immediately when they come in. Customers need to be informed because they can change their ordering process as well and get advantages of the new system. Because the new situation can lead to earlier detection, less out-of-stock situations and less contact with customers about problems.

Score

The scores for this variant are shown in Table 18. The effect on the process is the highest of all versions, but together with this positive effect the implementation is also the biggest because SAP needs to be changed, order handling process needs to be changed and customers need to change their process. It leads to low feasibility, because the project is quite big, but if it works this will have a huge effect on customer satisfaction.

Drawbacks

- Implementation time and cost seem to be very high, examples are the recent implementation at other operating companies which took over a year in Romania, and 9 months in Russia.

Table 18 - Estimated effect score of D2-Opt4 variant 1

Criteria	Effect	Reasoning	Score
I. Process time*	--	The process time goes down if out-of-stocks are detected earlier and can be prevented because customers do not need to be informed and there is no rework needed.	4 ´High´
II. Process costs*	+/-	Process costs stay the same, probably the same amount of people are needed to handle the orders.	
III. Process quality	+	Quality can improve because information about orders from customers is shared earlier in time. Which means CSD can react to problems earlier in time and have more time to solve possible problems.	
IV. Process flexibility	+	Flexibility increases because CSD has more time and information to find the perfect solutions for problems in the process.	
V. Implementation time*	Very high	The SAP system needs to be changed, the order handling process needs to be changed and the customers need to be informed.	-4 ´Very high´
VI. Implementation costs*	Very high	The SAP system needs to be changed, the order handling process needs to be changed and the customers need to be informed.	
VII. Customer satisfaction	++	If ordering according to a full version of ATP works, customers can order in advance and are sure they get their products in time. Also, out-of-stock situations can be lowered and this leads to more satisfied customers.	2 'Very high'
VIII. Feasibility	Low	A lot of things need to be changed, so only if all related departments accept this version, ATP can be feasible.	-1 ´Low´

2. **ATP for promotion orders** (with informing customers) –

ATP can be implemented and used for promotion orders only, the handling process stays for the biggest part the same. Orders are still handled by CSD one day in advance but customers can send in promotion orders earlier with extra notification that this stock needs to be reserved. The process will only change for the specific promotion orders.

Score

The scores for this variant are shown in Table 19. The score for this variant is relatively good, the effect on the process is almost the same as for variant 1, the effect on process time is a bit lower but flexibility on the other side increases more. Positive about this variant is that the implementation time and cost are lower due to fact that the process handling does only change for special promotion orders.

Drawback

- A drawback of this variant is that the costs for implementing ATP are quite high, but the module is not optimally used because the process does not change for all orders.

Table 19 - Estimated effect score of D2-Opt4 variant 2

Criteria	Effect	Reasoning	Score
I. Process time*	-	The process time decreases because customers with big planned promotion orders can send them earlier. These promotion orders are often a cause of out-of-stock situations because these orders are in some cases above customers´ own send-in forecasts.	4 ´High´
II. Process costs*	+/-	Costs of the process stay the same because the order handling stays the same.	
III. Process quality	+	This change can increase quality, for the reason that customers that send in their orders on time, be sure their order is delivered on the requested date.	
IV. Process flexibility	++	This change can have a very high impact on process flexibility because customers get more choices at the moment they send in their orders. If they send in their orders as soon as possible, the chance on the fulfilment of the order is higher.	
V. Implementation time*	High	The SAP system needs to be changed and the customers need to be informed about the new policy.	-2 ´High´
VI. Implementation costs*	High	The SAP system needs to be changed and the customers need to be informed about the new policy.	
VII. Customer satisfaction	+	Customers who are unsatisfied on promotion orders that are not fulfilled at the moment will be satisfied if they send in their orders on time. The responsibility moves to the customer itself.	1 'High'
VIII. Feasibility	High	The feasibility is high because only SAP must undergo som changes and customers need to be informed. There are no changes in the order handling process.	1 ´High´

3. **ATP on the background** (without informing customers)

ATP can be implemented and the order handling process changes so that all orders can be handled when they come in. Customers do not get a notification, so they do not know that it is an advantage to order earlier in time. This solution has only a small desired effect. It will not lead to more customer transparency but can lead to the detection of out-of-stocks earlier. The effect on out-of-stocks is also small because most customers do not order early at the moment.

Score

The scores for this variant are shown in Table 20. The process quality and flexibility increase, but on the other hand implementation cost and time will be the same as for the second variant, quite high. The customer satisfaction of this variant is medium because customers are not informed about the changes in the order handling process, but will detect a decrease in out-of-stocks.

Drawback

- The costs and time of implementation seem to be too high for the process increase and the increase in customer satisfaction. But it can be the first step to full implementation of ATP. The question that needs to be asked with this variant is: ‘is it really necessary?’.

Table 20 - Estimated effect score of D2-Opt4 variant 3

Criteria	Effect	Reasoning	Score
I. Process time*	+/-	Process time stays the same, the process will change to a process that is executed earlier in time but it is not expexted that this results in longer or shorter process time.	2 ´Medium high´
II. Process costs*	+/-	Process costs stay the same because the same tasks need to be performed only in another order and time frame.	
III. Process quality	+	The quality will slightly increase due to the fact that orders that are sent in early are also handled earlier. For this reason some stock can be reserved for specific orders.	
IV. Process flexibility	+	A small increase in process flexibility is expected because of the bigger time frame in which orders are handled.	
V. Implementation time*	High	The SAP system and order handling process need to be changed. Only the customers are not informed about the new order assigning process.	-2 ´High´
VI. Implementation costs*	High	The SAP system and order handling process need to be changed. Only the customers are not informed about the new order assigning process.	
VII. Customer satisfaction	+/-	The change will probably have a really small effect on customer satisfaction. This increase in negligible and can be explained by the fact that customers do not know that the ordering process is changed.	0 'Medium'
VIII. Feasibility	Very high	Only intern processes need to change, so the feasibility of this project is very high.	2 ´Very high´

D2-Opt5 Prepare IT structure for ATP

This is the last research and task that needs to be done before implementing available-to-promise, namely preparing the IT structure in SAP for ATP. This step needs to be done by somebody from the IT department or an external SAP consultant. This step has another structure than the decisions before because it is not possible to give a design option score to this step. There are also no variants for this decision because the only choice is: the step has to be fulfilled or not. For this reason, this requirement is called a hard requirement.

III. Decision point 3 – Forecasts in SAP

If decision point 2 results in one of the options X3 to X14, the decision leads to this decision point 3. On top of available-to-promise, a module in SAP can help with the comparison of incoming orders against customers' own forecast. This can result in earlier detection of out-of-stock situations.

D3-Opt1 Use forecasts in SAP

Forecasts are sent in by customers to the commerce and demand planning department but are at the moment not used by CSD. CSD is handling the incoming orders on a daily basis but has no idea what the forecast per customers is, which results in some out-of-stock situations that could be prevented. If CSD tracks the weekly orders per customers in comparison to their own forecast for every SKU (stock keeping unit), they are notified when a customer drastically exceeds its own forecast and there is a possibility for an intervention.

Score

The scores for this variant are shown in Table 21. Implementing this solution could have a positive effect on the process, especially on quality and flexibility. The implementation time and cost are medium, due to the fact that there are already Operating Companies (OpCo's) that use a comparable module. The feasibility and customer satisfaction depend on the effort customers put in this project.

Drawbacks

- The most important drawback is the fact that the company is dependent on the customers' forecast. The customer has to send in their own forecast but this forecast can be used against the customer if he/she orders more than forecasted. The positive side of this drawback is that the customer improves its forecast accuracy. A fear of this method is that customers structurally increase their forecast to be safe.

Table 21 - Estimated effect score of D3-Opt1

Criteria	Effect	Reasoning	Score
I. Process time*	+	The process time will increase because an extra check of the orders against the forecast needs to be made.	4 ´High´
II. Process costs*	+/-	Process costs stay the same because no extra actors are needed.	
III. Process quality	++	The quality can have a high increase because customers put more effort into their forecasts and out-of-stock situations can be prevented.	
IV. Process flexibility	+	Flexbility increases because CSD has more information abut the forecasted orders of customers	
V. Implementation time*	High	Implementation time is high, the module is already used by another operating company but also the customers need to be informed on the date they need to provide their forecasts.	-1 ´Medium high´
VI. Implementation costs*	Medium	Implementation costs are medium, becuase a comparable module already exists which means the IT department does not have to do a lot of research on the topic.	
VII. Customer satisfaction	+	The customer satisfaction will increase because if customers send in their accurate forecasts, every customer will get what they want and out-of-stocks will be prevented.	1 ´High´
VIII. Feasibility	Medium	It could be easy to adjust the SAP system to this change, but the company will be dependent on customers forecasts for the feasibility of this solution.	0 ´Medium´

IV. Decision tree artifact iteration 2

Figure 15 shows the decision model as a result of iteration 2. This figure is a sketch to show the overview of decisions and optional solutions. Next to artifact 2, Appendix B2 shows a link to a Google form that represents a walkthrough of the decision model. The form can be used as a guide, to check if all requirements are met, and if not all requirements are met, it shows what could be the result of implementing ATP while some requirements are not met. If there is not enough research done to make a decision this must be solved first and the participant needs to start the decision model from the beginning. All these decisions together lead to several solutions, defined as X1 to X17. Where every decision point has its own solutions, Decision point 1 has X1 or X2, decision point 2 has X3 to X15 and decision point 3 results in X16 or X17. In the next paragraph, an effect score is calculated for every solution, to show what would be the effect from every solution on the process, implementation time and cost, customer satisfaction and feasibility. The walkthrough of the decision model, shows the effect scores for every decision point, the effect scores in words for solutions are shown in Table 22.

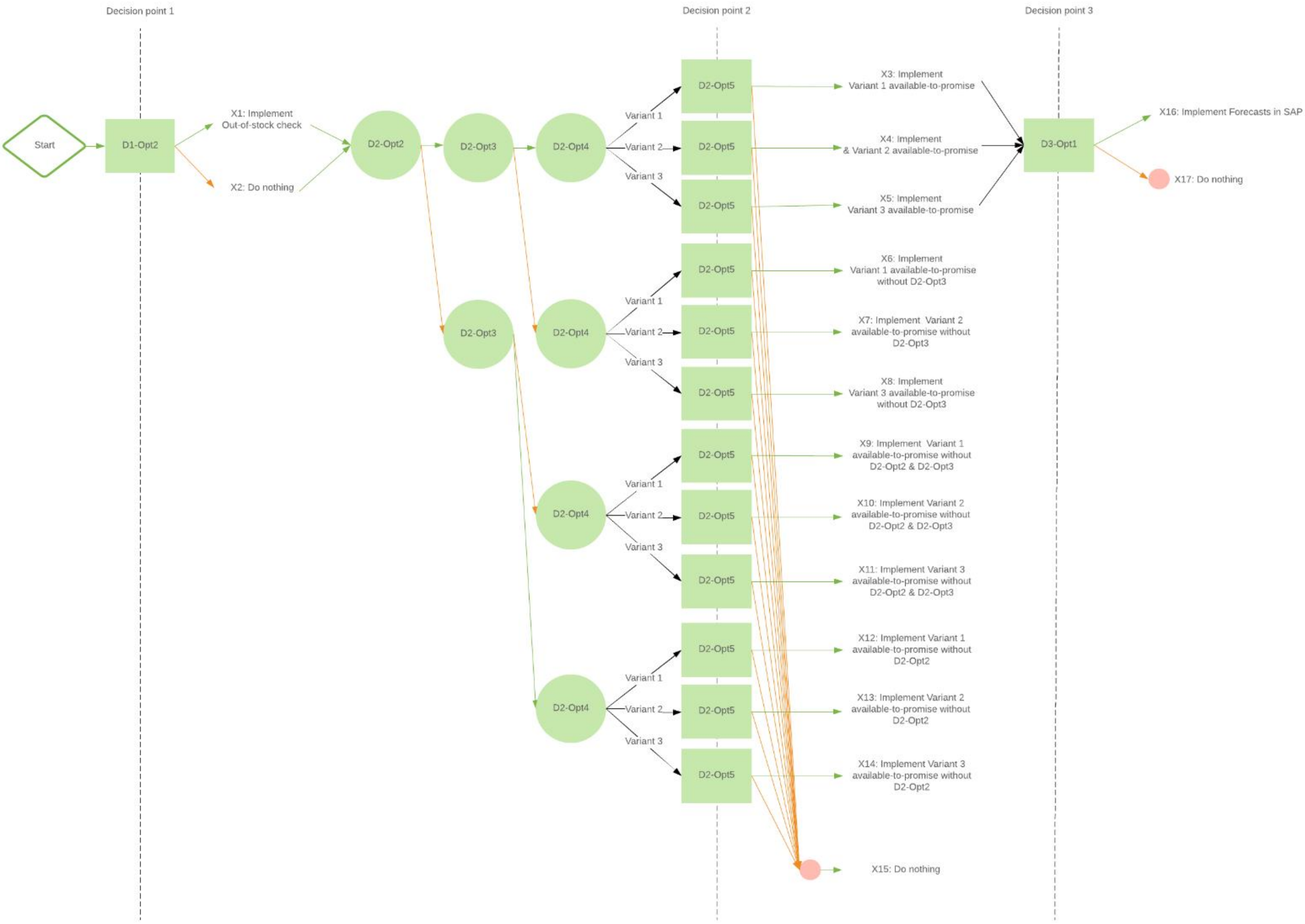

Figure 15 - Decision model of iteration 2

Table 22 - Effect scores in words for solutions

	Process	Implemen-tationt	Customer satisfaction	Feasibility
Very high	10	-8	4	3
High	8,9	-6,-7	3	2
Medium high	6,7	-4,-5		1
Medium	5	-2,-3	2	0
Medium low	3,4	0,-1		-1
Low	1,2	1,2	1	-2
Very low	0	3,4	0	-3

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TOPSIS calculations of artifact 2

The effect scores defined during the artifact design phase can be analyzed by quantitative methods. There are some famous multi-criteria decision making methods, which all have their strengths and weaknesses. Some of the widely used methods are weighted sum model (WSM), weighted product model (WPM), analytic hierarchy process (AHP), ELECTRE and TOPSIS (Triantaphyllou, 2000). From research on all the methods, TOPSIS is chosen in this case. this is a technique for order preference by similarity to ideal solution (García-Cascales & Lamata, 2012). This method is chosen because this method is one of the most widely accepted variants, it assumes that 'each criterion has a tendency of monotonically increasing or decreasing utility, which leads to easily define the positive and the negative ideal solutions.' (Triantaphyllou, 2000) and the computation processes are straightforward (García-Cascales & Lamata, 2012). García-Cascales & Lamata (2012) define a set of formulas to search for the optimal solution based on the weighted criteria. The decision model leads to 50 combinations of options from decision point 1, 2 and 3. The overview of all effect scores from this iteration is shown in Appendix B3. The seven steps that need to be taken are:

1. Create an evaluation matrix, with m alternatives and n criteria.

$$(x_{ij})_{mxn} \quad (1)$$

2. Normalize the evaluation matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}}, \ i = 1,2, \dots, m, j = 1,2, \dots, n \quad (2)$$

3. Calculate the weighted normalized decision matrix.

$$t_{ij} = r_{ij} * w_j, i = 1,2, \dots, m, j = 1,2, \dots, n \quad (3)$$

Where $w_j = \frac{W_j}{\sum_{k=1}^{n} W_k}, j = 1,2, \dots, n$

So that $\sum_{i=1}^{n} w_i = 1$

4. Determine the positive ideal and negative ideal solutions.

$$A^+ = \{t_1^+, \dots, t_n^+\} = \{\max_i t_{ij}, j \in J)(\max_i t_{ij}, j \in J')\}, \ i = 1,2, \dots, m \quad (4)$$

$$A^- = \{t_1^-, \dots, t_n^-\} = \{\min_i t_{ij}, j \in J)(\min_i t_{ij}, j \in J')\}, \ i = 1,2, \dots, m \quad (5)$$

5. Calculate the separation measures.

$$d_i^+ = \{\sum_{j=1}^{n} (t_{ij} - t_j^+)^2\}^{1/2}, \ i = 1,2, \dots, m \quad (6)$$

$$d_i^- = \{\sum_{j=1}^{n} (t_{ij} - t_j^-)^2\}^{1/2}, \ i = 1,2, \dots, m$$

6. Calculate the relative closeness to the ideal solution.

$$R_i = \frac{d_i^-}{d_i^- + d_i^+}, d_i^+ = \{\sum_{j=1}^{n} (t_{ij} - t_j^+)^2, \ i = 1,2, \dots, m \quad (7)$$

$$if \ \overline{R_i} = 1 \rightarrow A_i = \bar{A}^+$$

$$if \ \overline{R_i} = 0 \rightarrow A_i = \bar{A}^-$$

7. Rank the preference order.

In this iteration, the four criteria process, implementation, customer satisfaction and feasibility have all the same weight to check what the result will be. The results of the calculations are shown in Appendix B3. Table 23 shows the five best solutions according to the TOPSIS method. These five solutions have the best combination of effects related to the optimal solution. This means a high influence on process compared to low implementation effort, and a positive score on customer service and feasibility. The results of these calculations are discussed in Chapter 4.2.4 the conclusion of the artifact design.

Table 23 - Best options according to the TOPSIS method

Option	Decision point 1	Decision point 2	Decision point 3	TOPSIS
43	X1: Out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X17: No forecasts in SAP	0.670
41	X1: Out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X16: Forecasts in SAP	0.640
7	X1: Out-of-stock check	X4: ATP variant 2	X16: Forecasts in SAP	0.634
42	X2: No out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X16: Forecasts in SAP	0.616
44	X2: No out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X17: No forecasts in SAP	0.616

4.2.3 Artifact iteration 3

The third iteration exists of a focus group, which is 'an informal discussion among selected individuals about specific topics' (Beck et al., 1986). The reason for a focus group is that it is not meant to arrive at a consensus or level of agreement but to identify the feelings, perceptions, and thoughts on the decision model (Wilkinson, 1998). The main purpose of this focus group is to get new ideas to improve the decision tree or identify new relationships. The Google form of iteration 2 shown in Appendix B2 is designed to help employees go through the steps of the decision model and find the solution that suits the organization best. The results of the focus group are compared to the results of the TOPSIS method of iteration 2 and 3. Daneva (2015) defined the process for a focus group in six steps. Which includes among other things defining the research questions, select participants, execute the session and analyze the data (Daneva, 2015). The information and execution of every step are shown in Appendix B4. This paragraph is divided into three parts, first the suggested improvements of the model, second the opinion on the variants of available-to-promise and third the decision tree resulted from iteration 3.

I. Decision model improvements

The focus group helped to find areas for improvement in the decision model. These improvements are analyzed using the same framework as at iteration 1, the framework for architectural design decisions (Gu et al., 2010). The detailed description of the architectural design decisions can be found in Appendix B5 and an overview is shown in Table 24 This new design decisions lead to a new QOC analysis which is shown in Figure 16. These new QOC has two new artifact requirements for the option available-to-promise. The first requirement is batch management, the second requirement is the integration of VMI and ATP in SAP which is a hard requirement. Next to this extra requirements, the participants of the focus group asked for better model understandability. All these improvements are described below.

Table 24 - Design issue, identifiers and status per identifier.

Design issue	Identifier	Status	Reasoning
D1: How to integrate batch management in SAP?	It3-D1-Opt1: Batch management in SAP	Accepted for further research	It can be a very big project, which leads to an easier way of working for CSD (inventory management) and is a requirement for ATP.
D2: Combination of ATP with other SAP modules	It3-D2-Op1: Zero-touch-ordering	Rejected	Zero-touch-ordering (ZTO) is not a problem in combination with available-to-promise. This module in SAP can use ATP in the same manner as the orders that need to be handled by the employees of CSD.
	It3-D2-Op2: Vendor management inventory	Accepted for further research	Research on this topic is a requirment for the implementation of ATP. For example on dummy orders; orders that make a reservation of stock based on the forecast which is deleted when the actual order is made.
D3: How to use forecasts in SAP?	It3-D3-Opt1: Design usage & utility instructions	Accepted	This is a good improvement for the model, because it will help to fulfill the artifact requirements as easy-touse, usefulness, completeness and understandability.
	It3-D3-Opt2: Decision tree redesign	Accepted	This option can help to make to model easier to read for first time users, which is one of the artifact requirements.

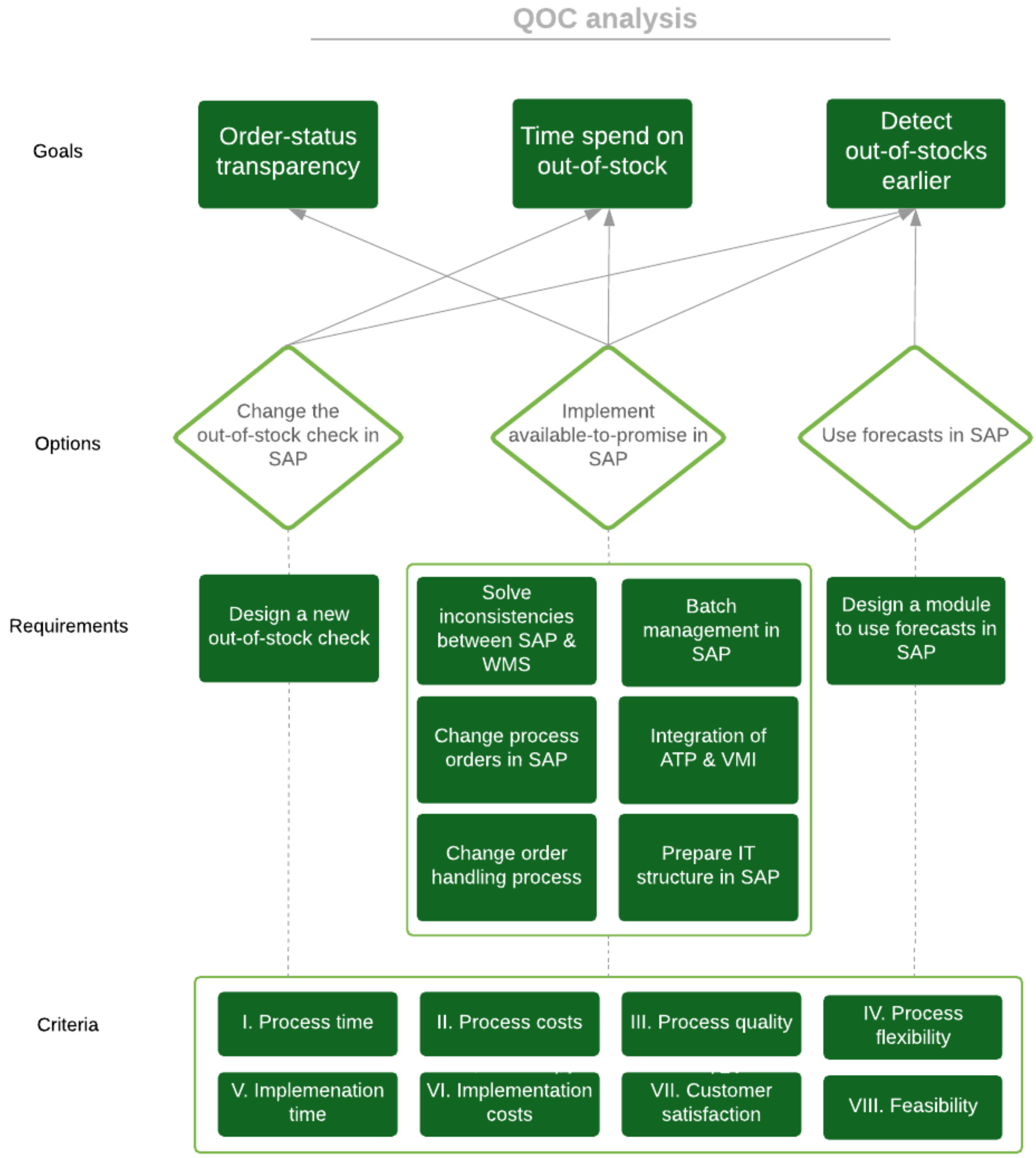

Figure 16 - QOC analysis artifact iteration 3

Batch management

At the moment production batches including best-before-dates (BBD) are only accurately stored in the warehouse management system (WMS) while orders of customers are handled in SAP. Some customers accept a postponement of the remaining shelf life (less than 4 months), so an improvement will be a checkpoint in the order handling process where the employees of CSD can manage remaining shelf life per customer. An automatic built-in can be made in SAP, which automatically takes the batches according to the FEFO (first executed first out) principle. If the company decides to deliver a specific batch to specific customers they must give an extra notification with the order. The reason that it is preferred to integrate the batch management is SAP is that it is better to make SAP the leading software system instead of WMS. Batch information is a requirement for available-to-promise because available-to-promise calculates the available quantity based on the available stock and process orders. If a part of the available quantity exceeds the shelf life of 4 months in the coming week the stock must be blocked automatically in SAP. This is done manually in WMS in the current situation.

Score

The effect score is shown in Table 25. The effect on the process is medium high because this option can have a positive impact on process quality and flexibility. This is caused by the fact that it will be possible for CSD to assign batches to different customers if they want another batch than the standard policy: FEFO. The effort of implementation is medium, some changes need to be made in SAP but most of the functionalities are already available in SAP. The effect on the customer is medium because the improvement is focused to make the work for CSD easier instead of improving customer satisfaction. Feasibility is also high because it is easy to implement this change.

Drawback

- If the stock that exceeds the shelf life cannot be blocked automatically, it is an option that this must be done manually every month. This is done in this way at the moment, but that is easier now because it is only one day before delivery instead of a week or one and a half week before the new month in the new situation.

Table 25 - Estimated effect scores of It3-D1-Opt1

Criteria	Effect	Reasoning	Score
I. Process time*	+/-	The process time stays probably the same because the same steps must be executed but in another system (SAP instead of WMS)	2 ´Medium high´
II. Process costs*	+/-	The process costs stay the same because no extra actors are needed or extra tasks need to be performed.	
III. Process quality	+	The information quality can increase if the company has all information stored in one system instead of several systems.	
IV. Process flexibility	+	Flexbility increases because CSD can assign different batches to different customers.	
V. Implementation time*	Medium	Implementation time is medium because the master data in SAP needs to be changed for every product and a new SAP built-in needs to be made.	0 ´Medium´
VI. Implementation costs*	Medium	Implementation costs are only the hours that a SAP consultant needs to make a new built-in to change the policy from FEFO for specific customers. SAP has already a MRP function where batch information can be stored.	
VII. Customer satisfaction	+/-	This improvement is made to make the work of CSD more flexible and has no effect on customer satisfaction.	0 ´Medium'
VIII. Feasibility	High	Feasibility is high because SAP already has a MRP functionality, which is not used at the moment.	1 'High'

Integration of VMI & ATP

Integration between vendor management inventory and available-to-promise is very important. The reason is that these systems work optimally in a reversed way, available-to-promise wants to have orders as early as possible, while vendor management inventory wants the stock information and orders as late to the delivery as possible. The problem is that if other customers order as early as possible and the stock is reserved for them, the VMI customers are most of the time hardest hit by out-of-stock situations. To ensure this is not the case, initial dummy orders must be made based on the forecasts to reserve part of the stock for the VMI customer. The dummy orders must show up automatically and deleted automatically if a real order is made. This is a hard requirement for available-to-promise because without integration of these modules available-to-promise will not have its desired effects.

Score

Table 26 shows the effect scores. The effect on the process is medium, but that does not mean this requirement is not important. It is an important requirement because without integration of VMI and ATP is available-to-promise not achievable. Implementation time and cost are medium high, because a customized module must be designed to make initial dummy orders and delete them when an actual order comes in. This requirement on its own does not lead to higher customer satisfaction, only in combination with ATP it will. The feasibility is medium because only changes in SAP are needed.

Drawback

- This is a hard requirement, so if there is no option to combine ATP and VMI, no option of available-to-promise will be achievable.

Table 26 - Estimated effect scores It3-D2-Opt2

Criteria	Effect	Reasoning	Score
I. Process time*	+/-	The process time will stay the same because the integration of VMI & ATP must ensure that VMI makes automatic dummy stock reservations. Which means no extra tasks for the process owners.	1 ´Medium'
II. Process costs*	+/-	The process steps stay the same, only an automatic check must be executed.	
III. Process quality	+	Quality can increase because if VMI & ATP work together in a good manner, OOS situation due to high increase of demand can be detected earlier in time.	
IV. Process flexibility	+/-	There is no effect on the flexibility of the process	
V. Implementation time*	High	The integration of VMI & ATP is not easy, the current VMI module only calculates initial orders one day in advance, this must be changed with a project by the SAP consultatnts.	-1 ´Medium High´
VI. Implementation costs*	Medium	Cost of implementation is only the hours of the SAP consultants.	
VII. Customer satisfaction	+/-	This requiremetn on its own results not in more customer satisfaction only in combination with ATP.	0 ´Medium'
VIII. Feasibility	Medium	Feasibility is expected to be medium, because only changes in SAP are needed.	0 ´Medium´

Model understandability

The last decision tree improvement is not based on the aspects of the model but on the model understandability. The first reaction of people in the focus group was that they did not know where to start, and did not exactly knew what was expected from them. One of the reasons is that the participants of the focus group are not the actual target audience, the target audience is actually the management team who in the end decide on all big improvement projects. Nevertheless, two of the artifact requirements are understandability and easy-to-use, so an improvement on this part is useful. The improvement exists of two parts, increase the ease-of-use of the decision model by making the visual model more clear and structured and add instructions on the usage and utility of the model. The instruction manual is a summary of the artifact design phase (Chapter 4.2) and is for that reason not added in the Appendix but is handed over to the company together with the decision model.

II. Variants of available-to-promise

This paragraph describes the individual preferences of the participants in the focus group. As can be seen in Figure 17, the participants' opinion is divided over the three variants. Three participants have chosen for the third variant where ATP is used on the background and customers are not informed. Two participants have chosen for the second variant, where ATP is mainly used for promotion orders and customers get their own responsibility in ordering on time. One participant has chosen for the full option of ATP but mentions that this is the ideal solution. The advantages and disadvantages discussed during the Focus Group are also shown in Figure 17.

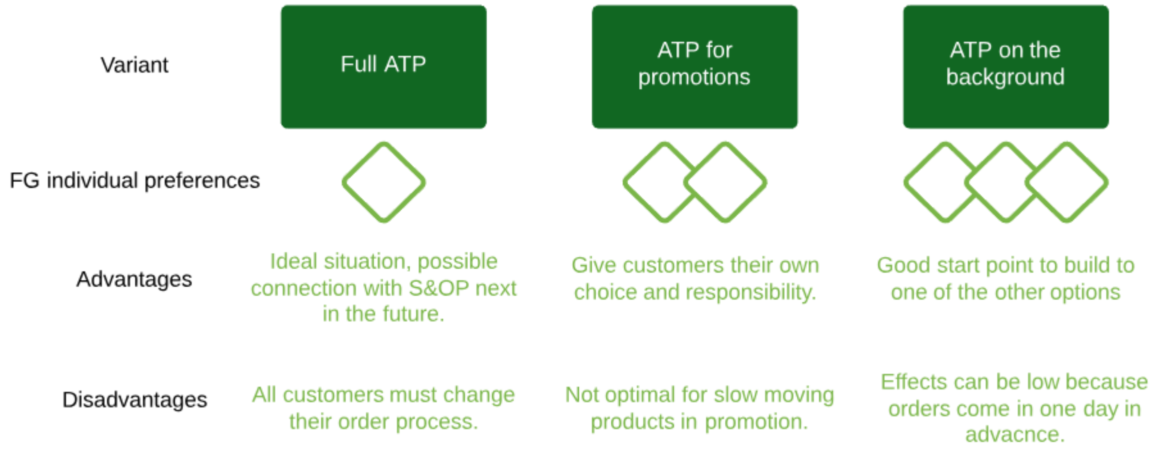

Figure 17 - Individual preferences for variants of ATP

III. Decision tree artifact iteration 3

Figure 18 shows the simplified artifact of iteration 3 and Appendix B6 shows the complete artifact of iteration 3. The complete artifact is based on the artifact of iteration 2 including the decision model improvements batch management and integration of VMI & ATP. The complete artifact looks complex and is probably not easy-to-use for first time users, for this reason an interactive presentation is made with Prezi to show how to go through the steps including information that shows the options per decision point. A link to the interactive presentation is added in Appendix B7. The decision tree in the appendix is not excluded from the thesis because it shows all the options and together with that the complexity of the decision. In the complete artifact in the appendix, the red dotted delineated area is the main process of the decision tree, if one of the soft requirements is not met the decision tree leads to one of the solutions on the left. If all soft and hard requirements are met it leads to one of the optimal solutions including X3, X4 and X5. The TOPSIS calculations for artifact 3 are shown in the next paragraph.

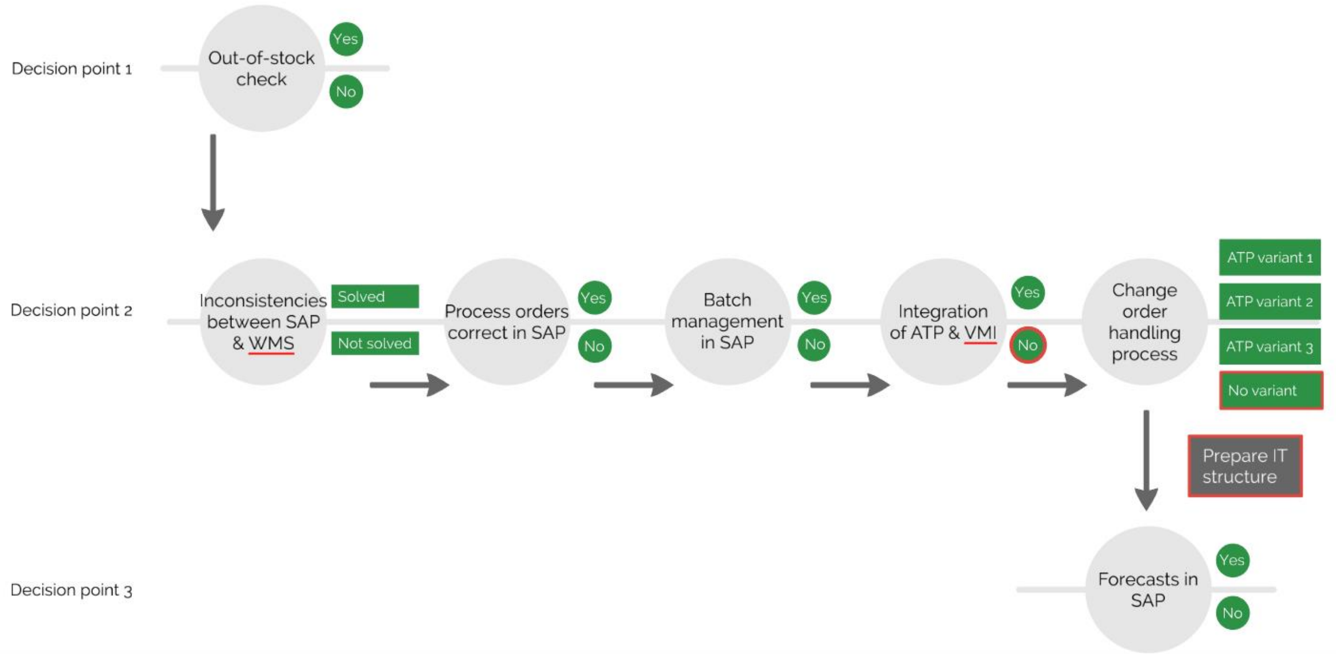

Figure 18 - Options per step of the decision tree.

TOPSIS calculations of artifact 3

Together with the extra requirements for this artifact, extra solutions arise. The TOPSIS calculation is done with 98 possible solutions. The results of the calculations are shown in the link in Appendix B7 and the five best solutions are displayed in Table 27 below. These five solutions have the best combination of effects related to the optimal solution. This means a high influence on process compared to low implementation effort, and a positive score on customer service and feasibility. Striking in these results is that decision point 1 and 3 have only two possibilities which are both represented in the top five. Decision point 2 has a lot of options from what options X4, X5 and X13 appear in the top five, striking on this is that 4 out of 5 solutions represent an option including variant 2: available-to-promise with promotions.

Table 27 - TOPSIS calculation artifact 3

Option	Decision point 1	Decision point 2	Decision point 3	TOPSIS
7	X1: Out-of-stock check	X4: ATP variant 2	X16: Forecasts in SAP	0.705
43	X1: Out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X17: No forecasts in SAP	0.693
8	X2: No out-of-stock check	X4: ATP variant 2	X17: No forecasts in SAP	0.671
41	X1: Out-of-stock check	X13: ATP variant 2 without solving inconsistncies between SAP & WMS	X16: Forecasts in SAP	0.657
11	X1: Out-of-stock check	X5: ATP variant 3	X17: No forecasts in SAP	0.654

4.2.4 Conclusion artifact design phase

This paragraph shows the conclusion of the artifact design phase. It compares the individual preferences to the results of the TOPSIS calculation of artifact 2 (Table 23) and the TOPSIS calculation of artifact 3 (Table 27). The participants in the focus group are divided on the choice of the variants of available-to-promise, compared to the TOPSIS calculation which is congenial in the options of both iterations. Decision point two shows among others the preferred available-to-promise variant. In 9 out of 10 cases from both the top 5's, is this an option that represents variant 2 available-to-promise, which is the ATP variant for promotions. Decision point 1 represents the choice for a new out-of-stock check, where X1 is represented most, this is argumentative because the implementation time & cost are low for this option compared to the desired effects. The same counts for decision point 3 forecasts in SAP. Option 16 is represented most, because implementation time & cost are low compared to the desired effects, but the difference is not big with not implementing forecasts in SAP. This comparison shows that there is a difference between the calculative optimum and the opinion of the focus group on this topics. This difference can be linked to the fact that the calculations give the same weight to all four criteria, while the participants give a higher weight to process improvement than for example implementation time.

4.3 Validation

This chapter tests the case study validation, the validation shows if the model meets its requirements and specification and proves if the model fulfills its intended purpose. 'Validation is building the right system' (Boehm, 1981). Validation is done in two ways to answer research questions 3 & 4, with as goal to test the model. These research question are respectively shown in Table 28 and 29. Validation checks if the artifact meets the predefined artifact requirements (research question 3) in 4.3.1 and the stakeholder goals (research question 4) in 4.3.2.

Table 28 - Research question 3

Research question 3
Does the designed artifact meet the artifact requirements? (validation part 1) *a. Easy-to-use* *b. Usefulness* *c. Completeness* *d. Understandability*

Table 29 - Research question 4

Research question 4
What is the effect of the solutions from the artifact on the stakeholder goals? (validation part 2) *a. Order status transparency* *b. Time spend on out-of-stocks* *c. Detection of out-of-stock situations*

4.3.1 Validation of artifact requirements

The artifact requirements are easy-to-use, usefulness, completeness and understandability. These are all functional requirements, which can be described as a requirement for the desired functions of an artifact (Wieringa, 2014). The reason that is chosen for these four requirements is to make sure the model does what it is intended to do (usefulness), does not miss parts (completeness) and can be used by all decision makers without background knowledge (easy-to-use and understandable). The reason for the last two requirements is that the company is not ready for the provided improvement at the moment, so it will also be understandable for stakeholders in the future who did not participate in the research. To test the effect on the artifact requirements, a presentation followed by a questionnaire is prepared for the users of the decision tree. The research design including goal, participants, response rate and method of analysis is shown in Appendix C1. The questions are also shown in Appendix C1, all questions have the answer options: 1-5 which represent respectively strongly disagree to strongly agree. Some questions have a star, the results of these questions needs to be reversed. Three participants went through the decision model and answered the validation questions. The results of the questionnaire are shown in Appendix C1, and a summary of results on the requirements are shown in Figure 19. As can be seen from this figure, all requirements are ranked above 3.00, which represents a sufficient score. But it needs to be mentioned that improvement is possible, because all average values are between 3.00 and 4.00.

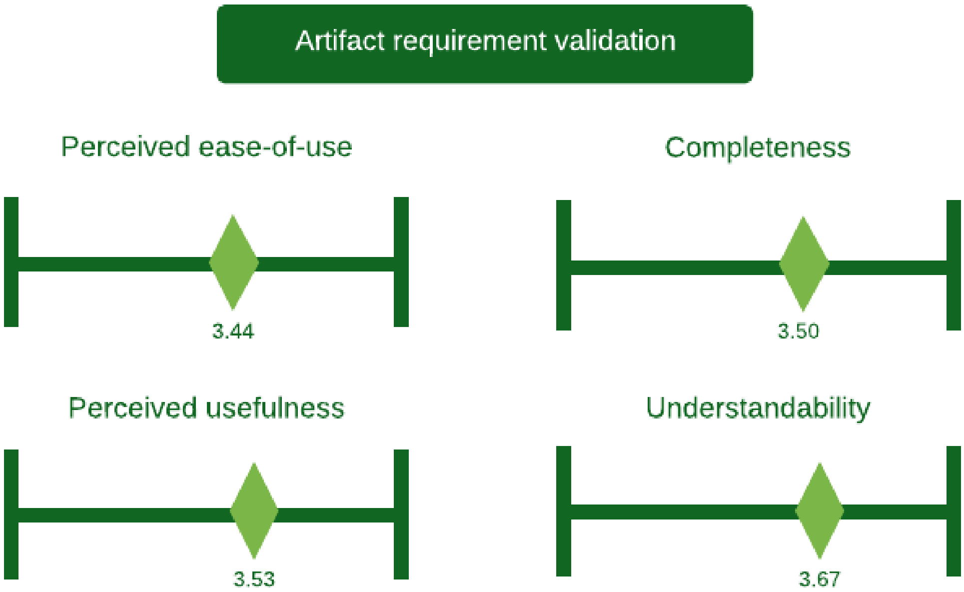

Figure 19 - Artifact requirement validation results

4.3.2 Validation of stakeholder goals

The validation of the stakeholder goals is done to show that the score of the solution provides a valid advice that helps to reach at least one of the stakeholder goals. These stakeholder goals are shown in the QOC analysis and are more order status transparency, less time spend on out-of-stock and detect out-of-stock earlier in time. The validation is done according to a case-based reasoning principle, case-based research studies single cases in sequence to draw conclusions between case studies. In design sciences, case-based reasoning explains observed behavior in terms of mechanisms in the artifact and context (Wieringa, 2014). More specific a single-case mechanism experiment is executed to investigate the effect of a difference of an independent variable on a dependent variable (Wieringa, 2014). The validation of the artifact related to the stakeholder goals is done based on a case for every decision point in the decision model. The cases (objects of study) that are chosen to check the effect on the stakeholder goals are the options from the QOC analysis: out-of-stock check, all ATP variants and the forecasts in SAP separately. The solutions with deviant requirements for the ATP variants are out-of-scope of this validation due to the fact that the optimal score is reached if all requirements are met. To test the effect on the stakeholder goals a presentation to the stakeholders is given about the artifact and participants are asked to fill in a questionnaire afterwards. The questions and results of the whole questionnaire are shown in Appendix C2, and a summary of results is shown in Figure 20. The ranking is on a 5 points scale, where 1 is a strong negative effect, 3 represents no effect and 5 is a strong positive effect. For this reason only relations between the options and goals with an average score higher than or equal to 4.00 are marked as 'valid'. Figure 19 shows only the relations which are valid, these are the same as the relations in the QOC analysis, which means the stakeholder goals are validated in relation to these cases, which represent the separate parts of the possible solutions.

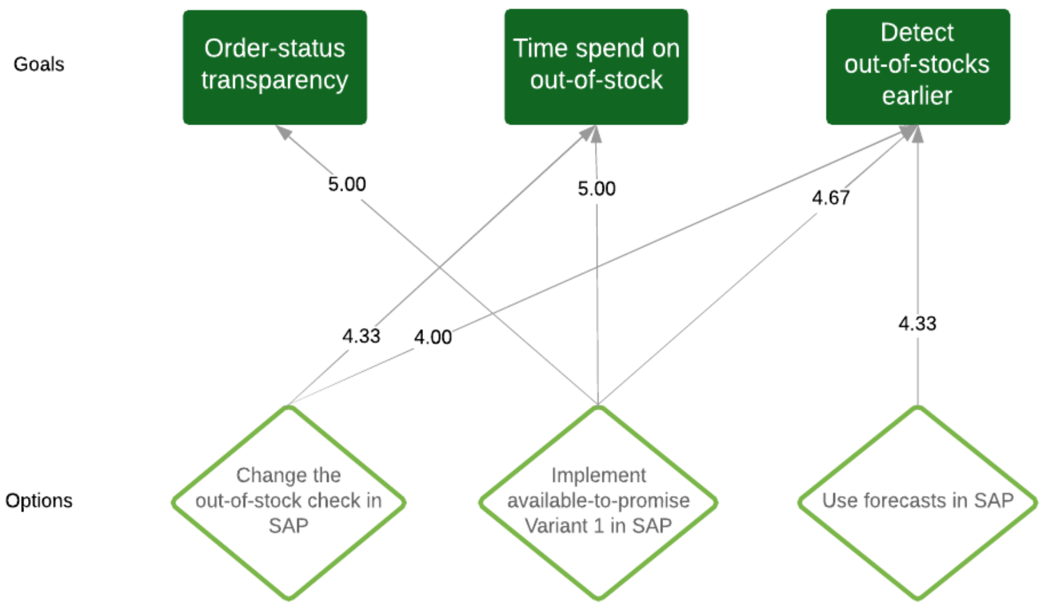

Figure 20 - Validated relations between options and goals.

4.4 Conclusion Case Study

This paragraph shows the conclusion of the case study related to the literature. The research design stated that together with designing an artifact that solves the design problem for the company, the goal is to fill the gap in literature on brownfield development and methods for complex decision making based on qualitative data. The lesson learned on brownfield development is that possible design options are related to many requirements. In this case, 5 out of 6 requirements for available-to-promise are related to improvements and adjustments of the current software systems. The other requirement is based on changing the business process and way of working. The conclusion on this topic is that it is very important to focus on all possible changes in an existing software environment, because implementation of a new brownfield development should not negatively influence the current software system. The main part of the research perspective is testing the framework for complex decision making with qualitative data on a real life example by performing a case study. The artifact design phase showed that all steps of the framework could be performed for this specific case. Something that can be mentioned here is that some iterations where needed to come to the detailed QOC overview and the decision tree. This is not included in the framework because it is about the execution of one of the sub steps of the framework. The case study gives a complete overview of the options for improvement and guides the decision maker to choose among them.

5. Conclusion & Discussion

The conclusion and discussion exists of several parts, first the main results are summarized in 5.1. Thereafter, the limitations are described in 5.2 and implications for future research are shown in the last part 5.3 of this conclusion and discussion.

5.1 Main results

This chapter describes the main results of the research starting with the main research question, focused on the research perspective.

Does the conceptual framework for complex decision making with qualitative data help to define options for improvement and choose among them?

The case study showed that is useful to use the framework for complex decision making with qualitative data. The reason is that combining a set of existing techniques and approaches lead to a better overview of all facets and capabilities of improving a process. The framework helped to define all possible options for improvement and resulted in a decision tree which guides the decision maker during the process to all possible solutions. This framework can be used for all kinds of complex decisions and helps the decision maker to split up a big decision in smaller decision points. The research shows that a calculated optimal solution can be used as guide for the decision, but will not automatically be the preferred solution of stakeholders. If human aspects and different stakeholder goals are involved in the decision it can lead to different qualitative 'optimal' solutions. Due to the fact that the priority of different stakeholders on costs, customer service and risks can be different. According to the advantages and disadvantages of the calculations and focus group it is recommended to use both qualitative and quantitative techniques together. Such that a calculated optimum and individual results of the decision tree can be used as a starting point for a focus group. The rest of the main results are focused on the application perspective and answer the four research questions of this part.

5.1.1 Research question 1

1. What is the current order assigning situation at the customer service domestic department?

The first research question is answered with process investigation (process identification, business process architecture and process discovery) and business process analysis (Pareto analysis and Root-cause analysis) and results in a QOC analysis with three main issues. The first issue is order status transparency, the department works with a short lead time of less than 24 hours. Customers are allowed to send in orders more than one day in advance but the order fulfillment is done in batch mode on the last day before delivery. The late order handling is ideal in combination with vendor management inventory which is done for the biggest customer but not ideal for small customers who order earlier. The status of their orders is not transparent, which can lead to unsatisfied customers if it turns out orders cannot be fulfilled. The second issue is the time spend on out-of-stock situations. Out-of-stock is not only a problem for the customer satisfaction but also some rework needs to be done. Some actions that need to be taken in an out-of-stock situation are customers need to be informed about the planned availability or possible substitutes, all customers get an out-of-stock notification and quotation meetings need to be planned, next to this there are weekly micromanagement meetings and impending OOS meetings. The third issue is the detection of out-of-stock situations, some of the out-of-stock situations are detected too late due to four main causes. Firstly, the short lead time sometimes provokes an OOS is found if the orders are handled, less than 24 hours before delivery. The second cause is inconsistencies between the warehouse management system (WMS) and the SAP system, in this case the order handling department thinks a product is available but it turns out it is already out-of-stock. Another reason is an incorrect calculation done by the out-of-stock check, this check in SAP only checks single orders against the inventory instead of a sum of all orders. A last cause is the fact that customer specific forecasts are not used by the order handling department, so if a specific customers orders way more than expected no warning arises.

5.1.2 Research question 2

2. What options for improving the order assigning situation are possible?

This research question is answered by following a QOC (questions, options and criteria) analysis (MacLean et al., 1991) and a decision tree which can result in all 98 possible solutions. The purpose of the decision tree is to guide the decision maker through all requirements and options to a final solution. The questions of the QOC analysis are based on the three issues found with research question 1, then 3 options are defined namely change the out-of-stock check in SAP, implement available-to-promise and use forecasts in SAP. These options are based on several requirements and are ranked based on eight criteria, process time, process costs, process quality, process flexibility, implementation time, implementation costs, customer satisfaction, feasibility. The three options including the requirements can lead to 98 different combinations of solutions which are all ranked based on the given criteria and a closest to optimal solution is found with TOPSIS calculations (García-Cascales & Lamata, 2012). The decision tree is a guide, not a tool to find the optimal solution based on expected effects but helps to make a qualitative decision on the complex improvement options.

5.1.3 Research question 3 & 4

3. Does the designed artifact met the artifact requirements?

4. What is the effect of the (possible) solutions from the artifact on the stakeholder goals?

The last two requirements are related to the validation of the QOC analysis and decision tree. The validation checks if the right system is build (Boehm, 1981). Validation tests the model based on the artifact requirements (easy-to-use, usefulness, completeness and understandability) and the stakeholder goals (order status transparency, time spend on out-of-stocks, early detection of out-of-stocks). Based on a presentation and questionnaires, all artifact requirements are met and the relation between the options and stakeholder goals are validated with help of case-based reasoning.

5.2 Limitations

The limitations of this research are mostly due to time, costs and resource restrictions of a master thesis and the company. The most important limitations are described below and are bias of the participants, no possibilities for simulation or case testing, the time limit and the internal- and external validity.

The calculations and model are based on qualitative data extracted from questionnaires, interviews and a focus group. An important limitation of qualitative data retrieved in this way is that opinions, statements and judgements can be biased. Response bias can be the result of numerous factors, for example the way the experiment is conducted, ignorance or social desirability. Next to this, using numerical scales is a traditional way converting qualitative data into a quantitative format but the problems here are 'not everyone has the same perception of a particular linguistic description and the choice of scales can influence the outcome' (Erol & Ferrell, 2003). The research was limited to qualitative data because simulation or case testing was not possible in the current system and too much aspects of the current way of working needed to be changed which made a pilot not feasible.

The time limit of the master thesis, is a limitation for the level of detail of the model and the number of iterations. More case studies, iterations and more participants in the design and validation phases could result in a more detailed model and better substantiated conclusions.

The last limitations can be described as internal- and external validity. The internal validity is the extent to which the collected data enables researcher to draw conclusions in a valid manner. In this case, same as for the participants, the researcher can be biased. Another problem with internal validity is that the effect scores are estimated by the researcher based on the interviews with stakeholder and actors. The reason for the estimation by the researcher is the lack of time of the stakeholders to participate in this part of the research, which is unfortunately a limitation of the research. Next to internal validity, there is also external validity, the extent to which findings can be generalized is important. This thesis is rigorous because it is mainly focused on the case study, which results in a framework only tested on one case study.

5.3 Implications for future research

Three main implications for future research on this topic are discussed in this paragraph. The first implication is the extent of the results from the case study to other companies within the FMCG industry or to other industries, in other words make it more rigorous. The second implication is challenging the weights of the TOPSIS calculation and the third implication is to do more research on the implementation of available-to-promise in an existing software system.

The first implication for future research is to extent the case study results to other companies with related problems in the FMCG industry because there are a lot of companies' business-to-business (B2B) or business-to-consumer (B2C) who have short lead times. The same counts for other industries, the research can also be expanded to other industries with for example longer lead times. The case study is about the improvement of the order handling process, with a focus on available-to-promise. Chapter 2, the literature reviews shows that there are a lot variants of available-to-promise, which can also be used in other industries where for example a make-to-order strategy is used.

Future research can also focus on the TOPSIS calculations. I assumed equal weights for the four criteria categories process, implementation, customer satisfaction and feasibility. Future research can challenge these weights, which can result in another closest to optimal solutions.

The literature review helped to find a gap in literature, namely the implementation of available-to-promise in an already existing software system. Most literature found was about implementing a whole new system, also called green field software development. This case study focuses on possible improvements for the order-to-cash process, in a brownfield environment but the actual implementation of a solution is out of scope. More research can be done on the phase after this research: the implementation phase, for example where a company can focus on in this implementation process.

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Appendix A: Additional tables and figures Chapter 4.1

This appendix encloses all additional tables and figures of chapter 3: Problem understanding. Table 30 describes the process checklist which is executed to check if the process is of strategic importance to the company.

Appendix A1

Table 30 - Process checklist

Process checklist question	Description	Answer
1. Is it a process at all?	Identify the main action of the form verb + noun:	Handling incoming orders
2. Can the process be controlled?	Is it a repetitive series of events and activities to execute individually observable cases?	Yes, orders are handled in batch mode but observed per individual case.
3. Is the process important enough to manage? (at least one must be applied)	(a) is there a customer who is willing to pay for its outcomes? (b) the organization that carries out the process would be willing to pay another party for taking over? (c) Is there a legal mandatory framework that compels an organization to execute it?	a) Yes, customers want to have products they ordered, so they pay for the service. (b) Yes, outsourcing could be an option, just like the transportaition is outsourced. (c) No, there is no legal mandatory framework.
4. Is the scope of the process not too big?	Is there a 1:1 relation between the event that initiates the process and each of the activities that are thought to be in scope?	Yes, the process is executed for every incoming order. Other external functionalities are taken out of scope.
5. Is the scope of the process not too small?	At least three different actors.	There are multiple process participants, customers and process owners.

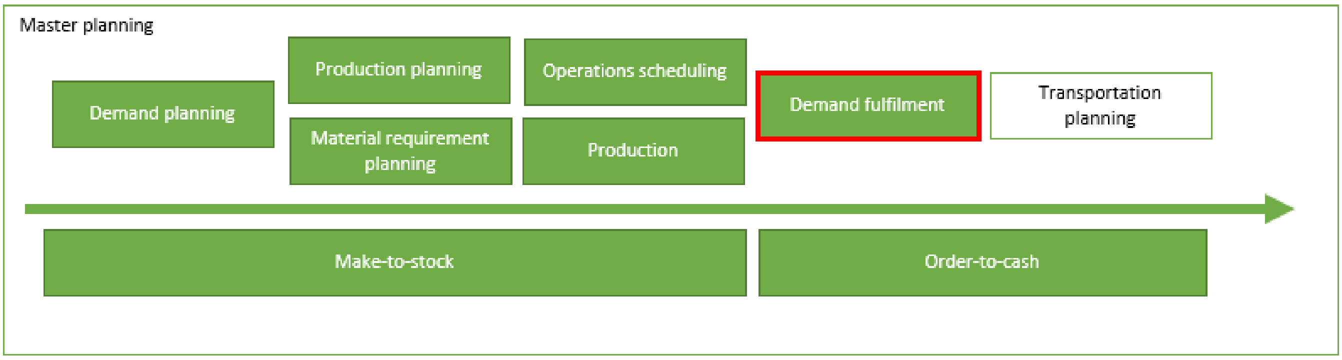


Figure 21 - Process landscape model

Appendix A2

Table 31 - Business process management steps including description and in- and output.

Number	Process step	Description	Input	Output
	Send order	The customer sends an order in via EDI in SAP or via fax. This orders is automatically assigned to a list of orders to check or to the zero-touch orders list.		Incoming order with product information, quantity, brewery, warehouse type and due date.
1.	Check if there are unhandled orders for tomorrow.	The orders come in via EDI in SAP or fax. The order gets an automatic delivery block is is defined as a zero touch order. This step checks if there are new orders for tomorrow.	Incoming order with product information, quantity, brewery, warehouse type and due date.	Order labeled as zerotouch order or delivery block order.
2.	Check product information	When an order is received, h order is checked for mistakes, such as unkown article numbers or missing information.	Delivery block order: product information, quantity, brewery, warehouse type and due date.	Delivery block order: correct product information, quantity, brewery, warehouse type and due date.
2a.	Write down concerns	If unkown article numbers or information is found, customers need to be notified, but this is done after all the checks (otherwise a customer can be contacted 3 times about one order).	Delivery block order with incorrect product codes or information.	Delivery block order with a concern on the incorrect product or information.
3.	(re) Locate brewery	Orders are automatically assigned to one of the threebreweries when the order is received depending on the products in the order. In this task CSD manually checks if the order is assigned to the right brewery.	Delivery block order: (in) correct product information, quantity, brewery, warehouse type and due date.	Delivery block order: (in) correct product information, quantity, correct brewery, warehouse type and due date.
4.	Check shipping	Orders are automatically assigned to the internal or the external warehouse. CSD checks if the order is assigned to the right warehouse and changes it otherrwise.	Delivery block order: (in) correct product information, quantity, brewery, warehouse type and due date.	Delivery block order: (in) correct product information, quantity, brewery, correct warehouse type and due date.
5.	Delete delivery block	If previous (product allocation, brewery and warehouse) are correct the delivery block is deleted by CSD.	Delivery block order: (in) correct product information, quantity, correct brewery, correct warehouse type and due date.	Order (without delivery block): (in) correct product information, quantity, correct brewery, correct warehouse type and due date.
6.	Pallet check	This step checks if the order exists of enough pallets. Incorrect if: for wholesale customers < 6 pallets, off-trade customers <26 pallets.	Order: (in) correct product information, quantity, correct brewery, correct warehouse type and due date.	Order with or without sufficient quantity.
6a.	Write down concerns	Write down concerns according to the pallet check.	Order without sufficient quantity	Order with a concern about the pallet quantity.
7.	Check concerns	Check concerns with unkown article numbers, information or insufficient number of pallets.	Order: (in) correct product information, (in) correct quantity, correct brewery, correct warehouse type and due date.	Order: correct product information, correct quantity, correct brewery, correct warehouse type and due date.
8.	Save order	Save the order and go to step 1, to check if there are more orders.	Order: correct product information, correct quantity, correct brewery, correct warehouse type and due date.	Saved order: correct product information, correct quantity, correct brewery, correct warehouse type and due date.
9.	Check out-of-stock products	Check if some products are out-of-stock.	List with all saved orders.	Orde with OOS items.
9a.	Contact customers & offer substitute products	Offer substitute products to fill the full truck load or ask the customer to extend the whole order to a later delivery date.	Order with OOS items	Order without OOS items.
10.	Final time + pallet check	Check number of pallets and times for all orders together.	List of all orders	List of correct orders or list with incorrect orders.

Continues on next page.

Number	Process step	Description	Input	Output
11.	Run query	Run query for combination freights, to check if the orders have correct pallet and layer loads.	List of all saved orders	List of correct saved orders or list of incorrect saved orders.
11a.	Resolve occurred problems	Run the occurred problems in run query or final time + pallet check.	List with incorrect orders.	List of correct orders.
12.	WMS delivery	Send the orders which need to be processed in the external warehouse to the responsible person.	List with complete orders.	List of compleet orders including a separate list with orders that need to be processed.
13.	Send orders to the transportation company.	List of all orders is send to the transportation company.	List of complete ordes incuding a separate list with orders that need to be processed.	List of complete ordes incuding a separate list with orders that need to be processed.
14.	Send attention mail	Send a mail with all attention points about that day to all stakeholders.	List of complete ordes incuding a separate list with orders that need to be processed.	Mail with all orders that need special attention.

Appendix A3

Table 32 - Stakeholder overview

Department	Description	Connection to the process	Stakeholder key performance indicators	Stakeholder KPI in relation to the order handling process
Customer service domestics	Responsible for the logistic account management for retailers and wholesalers.	They execute the business process from order-to-transportation.	- Case fill rate: on time, infull, availability. - Transportation cost per hectoliter.	Case fill rate: availability.
Market business partner	The connection between the brewery and changes in the market.	MBP is in close contact with CSD, to check the stock situation compared to forecasts and changes in the market.	- Forecast accuracy - Forecast bias - On track status of projects - SKU harmonization - Joint business plan savings - Open POP tasks	Forecast accuracy & forecast bias.
Demand	Make all forecasts more than one week ahead.	Their connection to CSD is that they discuss over- or undersell and how to deal with and prevent future out-of-stock problems.	- Forecast accuracy - Forecast bias - Obsolete costs	Forecast accuracy
Commerce retail & out-of-home	The account managers are in close contact with the customers, about customers' sales and promotions.	They have a weekly meeting with CSD about the problems and impending out-of-stocks of that week.	- Number of sales per customers - Customer satisfaction.	- Number of sales per customers - Customer satisfaction.
Tactical planning	Tactical planning plans production, availability of raw materials and resources 2 to 13 weeks ahead.	They are in contact with CSD about changes in planning due to long-term impending out-of-stocks.	- Product availability. - OPI change over - Material availability. - Outsourcing costs - Obsolete packagin materials - Obsolete finished products - Warehousing costs.	- Product availability - Obsolete finished products
Operational planning	Operational planning plans production for the coming 1 to 2 weeks.	Make changes in weekly production schedule if there are impending out-of-stock situations.	- Product availability (export) - Quality (with OS/CSE/TSCP) - OPI change over - Material availability.	- Quality of finished products. - Material availability.
Operations: Intern & extern	Operation handles all in-and outgoing products and transports in the intern and extern warehouses.	All in- and outgoing prodcuts are registered in the information systems that are used by CSD.	- Safety - Number of fractures - Number of damaged tools - Production efficiency - Stock positions - Resources used - Number of pallet moves per minute.	- Production efficiency - Stock positions
Customers	The domestic customers which order their products via CSD. There are two categories: retail (supermarkets) and out-of-home: Wholesalers.	Customers are served and infomed in case of exceptions by CSD.	- Service level - Price level	- Service level - Price level

Appendix A4

Description of all systems of the information flow diagram.

SAP system

SAP is the main information system used by CSD and can also be described as enterprise resource planning software. The whole order process from CSD works in this system with several inputs. Sales orders come in via VMI (vendor management inventory) or EDI (electronic data interchange). Process orders come in via Infor (scheduling module) from operational scheduling and inventory/stock levels come in via WMS (warehouse management system). The master data which includes the information of all products (bill of material, kind of pallet, product information and so on) is also included in SAP. After the processing of CSD all accepted sales orders are delivered to the external transportation department.

EDI

The electronic data interchange is the link between the customer and the company. EDI translates customers' orders to the SAP standards. All customers except Albert Heijn and Aldi (use an old fashioned fax) order in this way.

VMI

Vendor managed inventory is a business model with total data interchange between supplier and buyer. In this case, the company replenishes the inventory of Albert Heijn, which is useful for both companies because of the total supply chain transparency and flexibility.

Master data

Master data files include product information for every SKU, which can be a product code, product description, bill of material, packaging specifications and so on.

JDA Demand

A software system that is used by the demand department which creates accurate forecasts by leveraging machine learning (JDA, n.d.). This software system gets actual sales from SAP to use for their baseline forecasts.

Infor

is a constrain-based scheduling solution (Infor, 2015) which is used by operational scheduling, to make the weekly operation planning. The planning is linked to Pluto and SAP, to show on which day products are scheduled.

Pluto / Stock flow

Pluto combines the forecasts including commercial forecasts (from JDA), actuals (from SAP) and planning (from Infor). This tool is among other things used for detection of out-of-stock situations.

WMS

This warehouse management system is used by the logistic operations in the warehouse. The incoming and outgoing products are exactly shown with location in the warehouse.

Appendix A5

Table 33 - The results on the main questions of the interviews

	Causes of OOS?	What must be improved?	How are availability problems measured?	Remaining?
CSD	- Incorrect forecasts - Full occupation in production factory	- Communication with the customer - Decrease time busy with OOS. - Planning orders from all customers at the same time (also VMI orders) - Lower number and times of OOS.	- Notifcation E4 (except for VMI orders) - Number of on-time deliveries. - Product availability. - Infull	- Divide products in categories (ranking) - There is no fully implemented MRP system.
Market business partner	- More sales than expected (incorrect forecasts) - Not enough capacity in the factory - No access to forecast per customer	- Detect problems earlier. - Give notification to CSD if a customer exceeds his own forecast. - Communication with the customer.	- Customer satisfaction	- Divide products in categories - Reserve stock for different customers
Demand	- Oversell/ under forecast - Connection with production planning is missing/ - Export products (MTO) have priority. - Stock differences (measured vs. reality) - Production output is lower than expected.	- More MRP planning. - Check coming OOS in a longer time window.	- Service performance - Forecast accuracy - Obsolete costs	
Account management Retail	- Incorrect communication - The impact of weather on sales - Customers substitute to lower sales items in case of OOS.	- Decrease time busy with OOS. - Lower unsatisfied customers. - Lower missed sales. - Communication with customer.	- Number of delivered orders.	- Customers need to be rewarded for early ordering. - Show customers' own forecast to CSD. - Use customers' own forecast against structural over ordering.
Tactical planning	- Oversell/underforecast - No packing material available. - No classification between product categories. - Product output is lower than expected. - Problems with best-before date.	- Classification for different products. - Segmentation for customers - More clarity for customers		- Priority for ABC product classification. - More clarity for customers about OOS.
Operations		- Problems between WMS & SAP		- Location 999 is used in WMS to store damaged products but these are not deleted.
Operational scheduling		- Take planning and market together, and show to OS which products have priority.		- Focus on one product or a group of products for easier data research. - Check how other companies tackle this problem.

Appendix A6

Table 34 - Issue 1: Communication with the customer

Name	Communication with the customer
Description	The customer is not always updated on their order and products that are not available. This can better be described as low order status transparency.
Priority	4
Data and assumptions	The customer satisfaction is ok (within targets) but some customers recommend tahat the process can be improved. They state that other big breweries are better in handling OOS situations.
Qualitative impact	- Negatively influences customer satisfaction. - In the long term, if customers stay unsatisfied they will exchane some products for substitutes of other companies which can lead to a lower market share (long-term supplier relationship).
Quantitative impact	- It can lead to revenue loss or loss of market share on the long term.

Table 35 - Issue 2: Too much time spend on out-of-stock situations

Name	Too much time spend on out-of-stock situations
Description	In some periods of the year, the time spend on out-of-stock is too high with an average of 0.43 full time eployee (FTE) a week. In these periods some eployees cannot do their daily work
Priority	2
Data and assumptions	Some data is shown about how many OOS situation occur a year and an estimation on the time spend is made based on the experience of employees.
Qualitative impact	The quality of the daily tasks is lowered because employees do not have enough time, which can lead to lower employee satisfaction and stress.
Quantitative impact	Time spend on rework.

Table 36 - Issue 3: Handle orders not at the same time

Name	Handle orders not at the same time.
Description	At the moment, most customers send their orders before 11 a.m. but the biggest customer with 30% of the sales is helped with vendor managed invenotry (VMI), this is done in the afternoon because than most stock data is available. This difference in moment of order handling leads to unrealistic overview of stock positions, because there is no zero time point.
Priority	1
Data and assumptions	The time and planning rules are defined by the department together with the transportation and commerce department.
Qualitative impact	There is no good overview of inventory, which can result in inconsistencies between order and fulfillment.
Quantitative impact	

Table 37 - Issue 4: Late detection of out-of-stocks

Name	Late detection of out-of-stocks
Description	In many cases the out-of-stock is detected too late, it is detected when an incoming order exceeds the product availability. On this moment, it is too late plan a quotation meeting with commerce to divide the remaining work.
Priority	2
Data and assumptions	Data is stored in several systems instead of one system for an overview of all information.
Qualitative impact	No availability for customers that order more than one day in advance, no quotation possible and lower customer satisfaction.
Quantitative impact	Lower sales because customers need to wait till the product is available.

Table 38 - Issue 5: No notification if a customer exceeds its own forecast

Name	No notification if a customer exceeds its own forecast.
Description	Customers send in their own forecast to the commerce department. This forecast is not known by CSD and therefore not used. It occurs sometimes that a customer exceeds its own forecast by ordering 3 times more.
Priority	3
Data and assumptions	Forecasts are known by the commerce department but not shared. The commerce department does not use forecasts to punish the customer but reward in case their forecasts are accurate.
Qualitative impact	Customers who are strictly under their forecast can be unsatisfied by out-of-stock situations and there is a higher change on late detection of out-of-stock situations.
Quantitative impact	

Table 39 - Issue 6: No strict segmentation for customers

Name	No strict segmentation for customers
Description	At the moment some customers have a priority status but this is not transparent to the customers.
Priority	1
Data and assumptions	There is no strict priority list but the related departments know that there is priority for some customers.
Qualitative impact	Unsatisfied customers
Quantitative impact	

Appendix A7

Issues & expected effect score for Pareto analysis.

Communication with customer – Improving the communication will not lead to cost savings (1) because improved communication will take time and that costs money. It leads to a direct increase in customer satisfaction (5) because customers are better informed on their orders and know what to expect.

No notification if a customer exceeds its own forecast – If there comes a notification if a single customer exceeds its own forecast, it can lead to medium cost savings (3) because out-of-stock situations could be detected earlier in time and could probably be prevented. The customer satisfaction (3) can increase if out-of-stock situations are prevented.

Too much time spend on out-of-stock situations – If the time spend on out-of-stock decreases it will result in a big cost saving (5) because employees can spend their time on the operations. There is only a small effect on customer satisfaction (2) because the reaction to out-of-stock is improved but with a focus on the employee.

Late detection of out-of-stock – Early detection will lead to a lower number of out-of-stock situations, which saves time on re-work and makes sure all demand can be delivered. This means there is an opportunity on big cost savings (5). No out-of-stock situations makes sure that customers get what they want, which has a big impact on customer satisfaction (5).

Handle orders not at the same time – If orders are handled at the same time, the overview of stock positions is more realistic. This can solve some small inconsistencies between the actual stock and stock in the information systems. This can lead to small cost savings (2), but will have really small to no effect on customer satisfaction (1).

No strict segmentation for customers – If the priority status for customers is known by the customer, it can increase customer satisfaction (2) of only a part of the customers, which is the reason for a small increase in customer satisfaction. This change will not lead to cost savings (1).

Appendix A8

Table 40 describes the causes of the communication with the customer that is not always correct. The communication problem occurs when there are several out-of-stock situations and not all orders can be fully delivered, because the availability of different materials depends on the different products. This bad communication can better be described as *low order status transparency*, because the real problem is not the communication with the customer.

Table 40 - Why-why diagram issue A: Communication with customer.

Issue A	Communication with the customer
Why?	Customers are not always up-to-date on the status of their order.
Why?	Some customers send in their order more than one day in advance and this is inconsistent with the order handling process of the company.
Why?	Orders are handled in batch-mode only one day in advance.
Why?	Because that is the lead-time.
Why?	This lead time is used to be competitive to competitors.

Table 41 describes the 5Whys for the issue: no notification if the customer exceeds its own forecast. The problem for CSD is that the forecast is not included in SAP, there are two reasons, one is that it is not possible in SAP yet and on the other hand commerce don't want that customers are punished for their own forecast. But apparently, the fact that CSD does not get a notification is not a problem on its own but more a possible solution. For this reason the issue is not be discussed as an problem in chapter 4.1.2.

Table 41 - Why-why diagram issue B: No notification if customer exceeds its own forecast.

Issue B	No notification if customer exceeds its own forecast
Why?	The forecast is not known by CSD department.
Why?	The forecast is not included in SAP.
Why?	Commerce does not want to share the forecasts with CSD.
Why?	They are afraid that CSD will use the forecasts for quotation while this is their responsibility.
Why?	They are afraid that customers will get punished based on the forecasts they send in and need these forecasts so they prefer rewarding based on forecasts.

Table 42 describes issue C: too much time spend on out-of-stock. This problem had two root causes, namely out of stock is detected too late (issue D) and there are several actions that need to be done if an out-of-stock situation occurs. The first cause is further described at issue D.

Table 42 - Why-why diagram issue C: Too much time spend on out-of-stock.

Issue C	Too much time spend on out-of-stock situations		
Why?	Because out-of-stock is detected to late.	Why?	There are several actions that need to be done if an out-of-stock occurs.
Go to:	Issue D	Why?	Customers need to be informed on every product that is out-of-stock.
		Why?	All products go in and out-of-stock on a differnt moment in time.
		Why?	This depand on the operational schedule.

Table 43 describes the 5Whys for late detection of out-of-stock. There are 2 main causes, the fact that orders are handled only one day in advance and the out-of-stock check is not accurate.

Table 43 - Why-why diagram issue D: Late detection of out-of-stock.

Issue D	Late detection of out-of-stock		
Why?	Orders are handled only 1 day before delivery.	Why?	The out-of-stock check is not accurate.
Why?	That is the lead time.	Why?	The OOS check does notsum up orders for the coming day.
Why?	That is the leadtime to be competitive/	Why?	Because this is not possible in a query in SAP .

Appendix A9

Figure 22 shows a SAP stock/requirements list on November 13th for product 109203, the normal crate with 24 bottles as example for the order transparency.

Stock/Requirements List as of 11:50 hrs

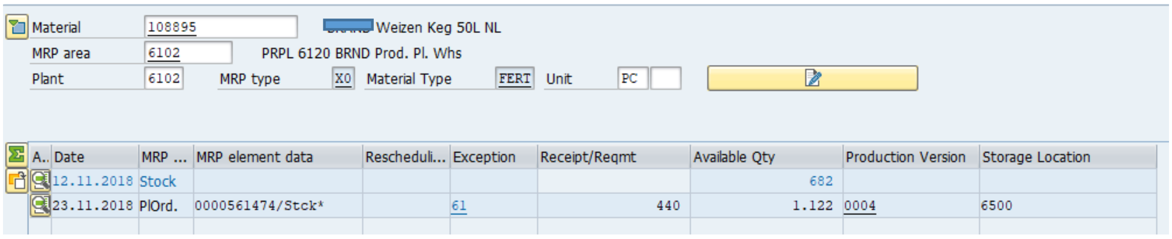
Show Overview Tree

Material 109203 RB Crate 24x30cl K2 NL
MRP area 6101 PRPL 6120 HBOS Prod. Pl. Whs
Plant 6101 MRP type X0 Material Type FERT Unit PC

A..	Date	MRP ...	MRP element data	Rescheduli...	Exception	Receipt/Reqmt	Available Qty	Stc...	Suppl./Receiving Plant	Storage Location
	14.11.2018	Deliv.	0081584798/000010/0…			210-	36.123	0		6501
	14.11.2018	Deliv.	0081584800/000010/0…			840-	35.283	0		6501
	14.11.2018	Deliv.	0081584801/000010/0…			1.330-	33.953	0		6501
	14.11.2018	Deliv.	0081584803/000010/0…			630-	33.323	0		6501
	14.11.2018	Deliv.	0081584805/000130/0…			1.050-	32.273	0		6501
	14.11.2018	Deliv.	0081584809/000110/0…			560-	31.713	0		6501
	14.11.2018	Deliv.	0081584815/000010/0…			210-	31.503	0		6501
	14.11.2018	Deliv.	0081584832/000010/0…			840-	30.663	0		6501
	14.11.2018	Deliv.	0081584834/000010/0…			840-	29.823	0		6501
	14.11.2018	Deliv.	0081584837/000270/0…			96-	29.727	0		6501
	15.11.2018	Order	0002589935/000010/0…			420-	29.307	0		
	15.11.2018	Order	0002590456/000010/0…			350-	28.957	0		
	15.11.2018	Order	0002590754/000030/0…			140-	28.817	0		
	21.11.2018	Order	0002589757/000010/0…			770-	28.047	0		
	21.11.2018	Order	0002590341/000010/0…			1.750-	26.297	0		
	22.11.2018	Order	0002590685/000010/0…			630-	25.667	0		
	28.11.2018	Order	0002587939/000110/0…			490-	25.177	0		
	29.11.2018	Order	0002588294/000010/0…			280-	24.897	0		
	29.11.2018	Order	0002588302/000010/0…			700-	24.197	0		
	29.11.2018	Order	0002588304/000010/0…			1.050-	23.147	0		
	29.11.2018	Order	0002588305/000010/0…			840-	22.307	0		
	30.11.2018	Order	0002588293/000010/0…			350-	21.957	0		
	30.11.2018	Order	0002588300/000050/0…			70-	21.887	0		
	30.11.2018	Order	0002588303/000050/0…			140-	21.747	0		
	30.11.2018	Order	0002588306/000010/0…			840-	20.907	0		
	04.12.2018	Order	0002588297/000010/0…			700-	20.207	0		
	04.12.2018	Order	0002588309/000010/0…			700-	19.507	0		
	05.12.2018	Order	0002588296/000010/0…			350-	19.157	0		
	05.12.2018	Order	0002588298/000110/0…			700-	18.457	0		

Figure 22 - SAP - MD04 Stock/requirements list for product 109203

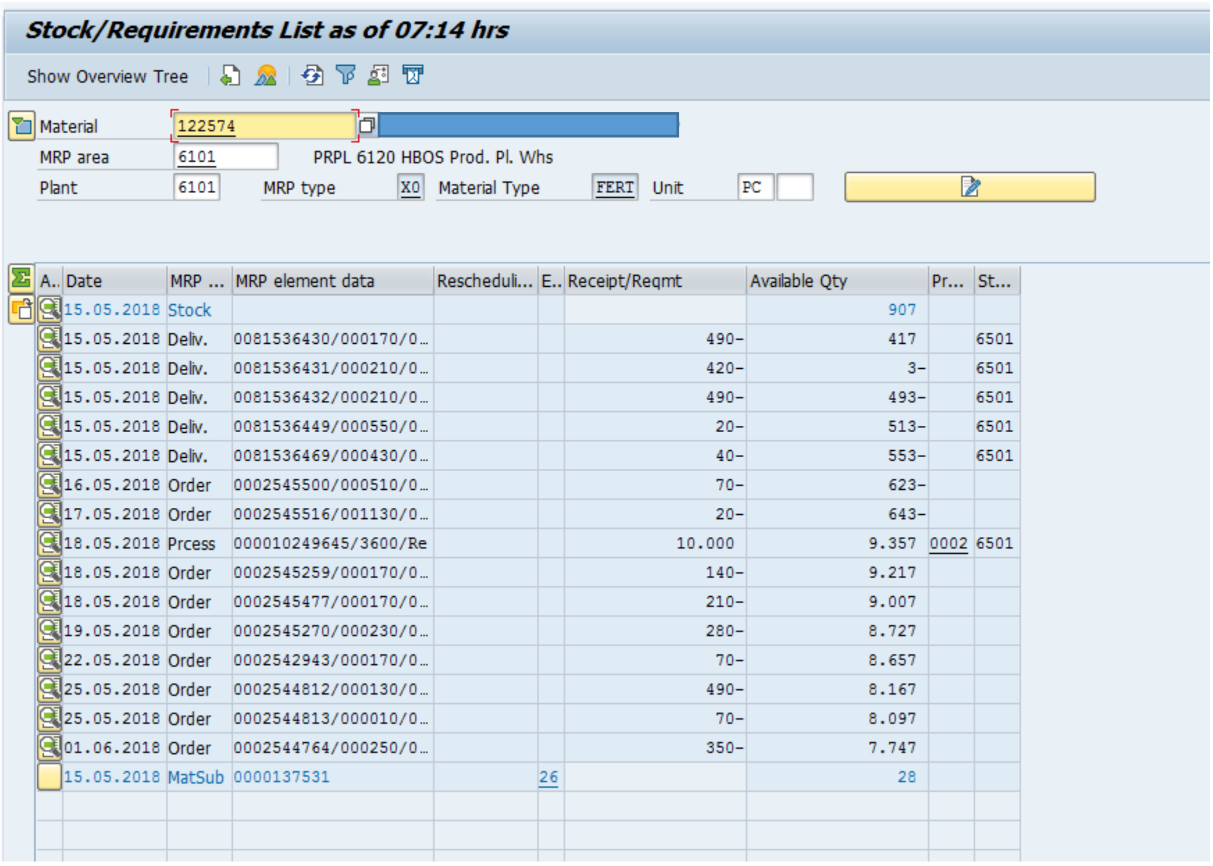
Figure 23 shows a SAP MD04 overview on November 13th for product 108895; cask with Weizen 50 Liter. As an example for detection of OOS situations.


Material 108895 [redacted] Weizen Keg 50L NL
MRP area 6102 PRPL 6120 BRND Prod. Pl. Whs
Plant 6102 MRP type X0 Material Type FERT Unit PC

A..	Date	MRP ...	MRP element data	Rescheduli...	Exception	Receipt/Reqmt	Available Qty	Production Version	Storage Location
	12.11.2018	Stock					682		
	23.11.2018	PlOrd.	0000561474/Stck*		61	440	1.122	0004	6500

Figure 23 - SAP - MD04 stock/requirements list for product 108895

Figure 24 shows a SAP MD04 overview on May 15 2018 for a products that goes out-of-stock but does not show up in the OOS check.


Stock/Requirements List as of 07:14 hrs

Show Overview Tree

Material 122574 [redacted]
MRP area 6101 PRPL 6120 HBOS Prod. Pl. Whs
Plant 6101 MRP type X0 Material Type FERT Unit PC

A..	Date	MRP ...	MRP element data	Rescheduli...	E..	Receipt/Reqmt	Available Qty	Pr...	St...
	15.05.2018	Stock					907		
	15.05.2018	Deliv.	0081536430/000170/0...			490-	417		6501
	15.05.2018	Deliv.	0081536431/000210/0...			420-	3-		6501
	15.05.2018	Deliv.	0081536432/000210/0...			490-	493-		6501
	15.05.2018	Deliv.	0081536449/000550/0...			20-	513-		6501
	15.05.2018	Deliv.	0081536469/000430/0...			40-	553-		6501
	16.05.2018	Order	0002545500/000510/0...			70-	623-		
	17.05.2018	Order	0002545516/001130/0...			20-	643-		
	18.05.2018	Prcess	000010249645/3600/Re			10.000	9.357	0002	6501
	18.05.2018	Order	0002545259/000170/0...			140-	9.217		
	18.05.2018	Order	0002545477/000170/0...			210-	9.007		
	19.05.2018	Order	0002545270/000230/0...			280-	8.727		
	22.05.2018	Order	0002542943/000170/0...			70-	8.657		
	25.05.2018	Order	0002544812/000130/0...			490-	8.167		
	25.05.2018	Order	0002544813/000010/0...			70-	8.097		
	01.06.2018	Order	0002544764/000250/0...			350-	7.747		
	15.05.2018	MatSub	0000137531		26		28		

Figure 24 - SAP - Available quantity and deliveries.

Appendix A10

Figure 25 shows the phases of the design space analysis (MacLean et al., 1993).

Phase 1: Identify relevant information

Activities:

- Get a feel for the main issues
- Work out what information provided is relevant (& classify as Q, O, and C if possible)

Phase 2: Structure material into rough QOC

Activities:

- Structure and make sense of the information available
- Find good Questions

Phase 3: Flesh out design space

Activities:

- Use current understanding of design to help generate new ideas
- Generate new Options
- Generate new Criteria

Phase 4: Reformulate design space to tidy it up.

Activities:

- Tidy up description and make it more coherent
- Reword Q, O, C if necessary
- Reformulate Questions (and reorganise O, C) to improve decomposition

Phase 5: Make design decisions

Activities:

- Evaluate and select Options
- Use Criteria to evaluate Options
- Represent decisions by drawing a box around selected Options

Figure 25 - The five phase sequential process model and the activities underlying each phase.

Appendix B: Additional tables and figures Chapter 4.2

Appendix B1

Table 44 - Framework for architectural design decisions (ADDs)

Design issue		D1: How to change the out-of-stock check?
Context		The out-of-stock check in SAP is executed once a day to check if there are out-of-stock situations. This check only checks single orders against the available inventory instead of a sum of all orders together.
Quality attributes		Cr1: process time, Cr2: process costs, Cr3: process quality, Cr4: process flexibility, Cr5: implementation time, Cr6: implementation costs, Cr7: feasibility and Cr8: customer satisfaction.
Architectural options	Identifier	D1-Opt1: Change out-of-stock check in SQ01 (a module in SAP)
	Description	Change the out-of-stock check in SQ01, which means that the already existing check, sums up orders instead of checking every order separately.
	Relationship	
	Status	Rejected
	Evaluation	Cr5,6: Implementation will not take a lot of time and costs because it could be a small programming changein SAP. Cr7: The feasibility for this option could be low due to the limitations of SAP.
	Rationale	This option is not feasible because the SQ01 in SAP can only make queries, which is only a report instead of doing calculations.
Architectural options	Identifier	D1-Opt2: Change out-of-stock check in another module in SAP.
	Description	Change the out-of-stock check in SAP, with help of another module instead of a query in SAP.
	Relationship	D2-Opt1, D2-Opt2, D2-Opt3, D2-Opt4, D2-Opt5
	Status	Accepted for further research
	Evaluation	Cr1: process time will stay the same, but rework will disapear. Cr5,6: Implementation will take some time and cost of a SAP consultant, because he/she has to design a script in SAP.
	Rationale	The feasibility for this option depends on the research of SAP consultants. The company decided to spend a project of (40 hours) on this project, to check the possibilities.

Continues on next page.

Design issue		D2: How to implement available-to-promise?
Context		The second option is implementing available-to-promise in SAP, orders are handled one day before delivery in the current situations. ATP can make it possible to handle orders when they come in, make stock reservations and have an up-to-date overview of the availability position.
Quality attributes		Cr1: process time, Cr2: process costs, Cr3: process quality, Cr4: process flexibility, Cr5: implementation time, Cr6: implementation costs, Cr7: feasibility and Cr8: customer satisfaction.
Architectural options	Identifier	D2-Opt1: Solve inconsistencies between SAP & WMS by searching for the current problems and resolve these.
	Description	The inventory position in SAP that is used by CSD is not always equal to the inventory position in WMS and the actual inventory position. this option searches for the problems and tries to solve them.
	Relationship	D1-Opt2 and all options of D2.
	Status	Rejected after research by the WMS change-over team.
	Evaluation	Cr5,6: Implementation time and costs are low. Cr7: The feasibility is also low.
	Rationale	The feasibility is too low because the biggest problems that are reported are too difficult to change. For example: best before date is not stored.
Architectural options	Identifier	D2-Opt2: Solve inconsistencies between SAP & WMS by changing to another warehouse management system (for example SAP EWM).
	Description	The inventory in SAP that is used by CSD is not always equal to the inventory position in WMS and the actual inventory position.
	Relationship	D1-Opt2 and all options of D2.
	Status	Accepted for further research
	Evaluation	Cr3: Improves the quality because the information that is worked with are correct. Cr5,6: Implementation is high because changing to another warehouse system affects a lot of departmenst within the company.
	Rationale	The project will cause some risk because changing a warehousemanagement system changes a lot of processes within departments. Next to this, the implementation time and costs are high but acceptable for the company.

Continues on next page.

Architectural options	Identifier	D2-Opt3: Change process order data in SAP
	Description	Operations scheduling makes the production schemes one week ahead. All process orders are inserted in SAP if the production planning is finished. Process orders for more than 1 week ahead are inserted by tactical planning and all these orders are inserted in SAP on Friday. This is a problem in case of impending out-of-stock and would also be a problem for stock reservation in case of ATP.
	Relationship	D1-Opt2 and all options of D2.
	Status	Accepted for further research
	Evaluation	Cr1: The planning process time will increase for operations scheduling and/or tactical planning. Cr3: the process quality will increase because the data used will be complete. Cr7: Feasibility can become a problem because operational and tactical planning departments need to change their process.
	Rationale	This option should be investigated because it will change the process of adding and changing process orders in SAP for the operations and tactical planning departments. At the same time, it can decrease process time for CSD.
Architectural options	Identifier	D2-Opt4: Change order handling process.
	Description	Orders are handled one day before delivery at the moment. If ATP is used, orders need to be handled at the moment they come in. The handling process needs to be changed.
	Relationship	D1-Opt2 and all options of D2.
	Status	Accepted for further research
	Evaluation	Cr1: The process will stay almost the same, only the time for rework will decrease if the order handling is changed. Cr5,6: Implementation can take some time due to the switch to a ATP module in SAP. Cr8: This process can increase customer satisfaction because customers get their confirmation on the due date earlier in time.
	Rationale	Research will be done on the effect of changes. Most important is the cahnge in process results in a situation that makes it possible to do stock reservations in SAP.
Architectural options	Identifier	D2-Opt5 Prepare IT/SAP structure for ATP (decision/checking rules)
	Description	The SAP structure is not suitable for implementing ATP at the moment. Further research coudl show how much time and effort it takes to change the structure for implementing ATP.
	Relationship	D1-Opt2 and all options of D2.
	Status	Only accepted after approvalof D2-Opt2, D2-Opt3 and D2-Opt4.
	Evaluation	Cr5,6: Implementation will take some time because research in SAP needs to be done first. Reserch at other operation companies showed that the data cleanup and implementation of ATP can be huge.
	Rationale	This option is only started if the options 2, 3 and 4 are accepted after research. The reason for this is that if one of the other options is not posisble, research on this one could be useless.

Continues on next page.

Design issue		D3: How to use forecasts in SAP?
Context		The demand department calculates the forecast for every stock keeping unit (SKU) based on their own trends and the forecasts send in by customers. This customers' forecast is not bused by CSD to detect if customers order more thatn their own forecast.
Quality attributes		Cr1: process time, Cr2: process costs, Cr3: process quality, Cr4: process flexibility, Cr5: implementation time, Cr6: implementation costs, Cr7: feasibility and Cr8: customer satisfaction.
Architectural options	Identifier	D3-Opt1: Use forecasts in SAP (based on the forecast system of the operating company in Russia)
	Description	Use YWV00_RAVI to search for blocked stock keeping units, this can be done in case of lack of availability , credit control blocekd orders and sales over forecasted volume.
	Relationship	D1-Opt2 and all options of D2.
	Status	Only accepted after research and approval of D1 and D2.
	Evaluation	Cr3: Quality can improve because CSD can keep track of the orders per customer in relation to their weekly forecasts. Cr7: Feasibility is not very high because the start of this project depends on the reesearch and approval of D1 and D2.
	Rationale	This option is accepted after reserach and approval of D1 and D2. the reason is that it can only partly contribute to the goals (questions) of the QOC analysis.

Appendix B2

A link to the Google form, to go through the decision model of artifact iteration 2.

Appendix B3

Table 45 - Results of TOPSIS calculation for artifact 2.

Possible options				Step 1								
Option	DP1	DP2	DP3	Pr	Im	CS	Fea		Pr	Im	CS	Fea
1	X1	X3	X16	16	-6	6	0		256	36	36	0
2	X2	X3	X16	9	-5	5	-2		81	25	25	4
3	X1	X3	X17	12	-1	5	2		144	1	25	4
4	X2	X3	X17	10	0	4	0		100	0	16	0
5	X1	X4	X16	16	-4	5	1		256	16	25	1
6	X2	X4	X16	14	-3	4	1		196	9	16	1
7	X1	X4	X17	12	1	4	3		144	1	16	9
8	X2	X4	X17	10	2	3	3		100	4	9	9
9	X1	X5	X16	14	-4	4	1		196	16	16	1
10	X2	X5	X16	12	-3	3	1		144	9	9	1
11	X1	X5	X17	10	1	3	3		100	1	9	9
12	X2	X5	X17	8	2	2	3		64	4	4	9
13	X1	X6	X16	13	-6	5	0		169	36	25	0
14	X2	X6	X16	11	-5	4	0		121	25	16	0
15	X1	X6	X17	9	-1	4	2		81	1	16	4
16	X2	X6	X17	7	0	3	2		49	0	9	4
17	X1	X7	X16	13	-4	4	1		169	16	16	1
18	X2	X7	X16	11	-3	3	1		121	9	9	1
19	X1	X7	X17	9	1	3	3		81	1	9	9
20	X2	X7	X17	7	2	2	3		49	4	4	9
21	X1	X8	X16	11	-4	3	1		121	16	9	1
22	X2	X8	X16	9	-3	2	1		81	9	4	1
23	X1	X8	X17	7	1	2	3		49	1	4	9
24	X2	X8	X17	5	2	1	3		25	4	1	9
25	X1	X9	X16	10	-2	4	1		100	4	16	1
26	X2	X9	X16	8	-1	3	1		64	1	9	1
27	X1	X9	X17	6	3	3	3		36	9	9	9
28	X2	X9	X17	4	4	2	3		16	16	4	9
29	X1	X10	X16	10	0	3	3		100	0	9	9
30	X2	X10	X16	8	1	2	3		64	1	4	9
31	X1	X10	X17	6	5	2	5		36	25	4	25
32	X2	X10	X17	4	6	1	5		16	36	1	25
33	X1	X11	X16	8	0	2	4		64	0	4	16
34	X2	X11	X16	6	1	1	4		36	1	1	16
35	X1	X11	X17	4	5	1	6		16	25	1	36
36	X2	X11	X17	2	6	0	6		4	36	0	36
37	X1	X12	X16	13	-2	5	1		169	4	25	1
38	X2	X12	X16	11	-1	4	1		121	1	16	1
39	X1	X12	X17	9	3	4	3		81	9	16	9
40	X2	X12	X17	7	4	3	3		49	16	9	9
41	X1	X13	X16	13	0	4	4		169	0	16	16
42	X2	X13	X16	7	6	2	6		49	36	4	36
43	X1	X13	X17	9	5	3	6		81	25	9	36
44	X2	X13	X17	7	6	2	6		49	36	4	36
45	X1	X14	X16	11	0	3	3		121	0	9	9
46	X2	X14	X16	9	1	2	3		81	1	4	9
47	X1	X14	X17	7	5	2	5		49	25	4	25
48	X2	X14	X17	5	6	1	5		25	36	1	25
49	X1	X15		2	7	1	4		4	49	1	16
50	X2	X15		0	8	0	4		0	64	0	16

Continues on next page.

	Step 2				Step 3					Step 4			
Option	Pr	Im	CS	Fea	Pr	Im	CS	Fea		Pr	Im	CS	Fea
1	0,203	-0,076	0,076	0,000	0,051	-0,019	0,019	0,000	Ab (tbj)	0,051	0,025	0,019	0,019
2	0,114	-0,063	0,063	-0,025	0,028	-0,016	0,016	-0,006					
3	0,152	-0,013	0,063	0,025	0,038	-0,003	0,016	0,006	Aw(twj)	0,000	-0,019	0,000	-0,006
4	0,127	0,000	0,051	0,000	0,032	0,000	0,013	0,000					
5	0,203	-0,051	0,063	0,013	0,051	-0,013	0,016	0,003					
6	0,177	-0,038	0,051	0,013	0,044	-0,009	0,013	0,003					
7	0,152	0,013	0,051	0,038	0,038	0,003	0,013	0,009					
8	0,127	0,025	0,038	0,038	0,032	0,006	0,009	0,009					
9	0,177	-0,051	0,051	0,013	0,044	-0,013	0,013	0,003					
10	0,152	-0,038	0,038	0,013	0,038	-0,009	0,009	0,003					
11	0,127	0,013	0,038	0,038	0,032	0,003	0,009	0,009					
12	0,101	0,025	0,025	0,038	0,025	0,006	0,006	0,009					
13	0,165	-0,076	0,063	0,000	0,041	-0,019	0,016	0,000					
14	0,139	-0,063	0,051	0,000	0,035	-0,016	0,013	0,000					
15	0,114	-0,013	0,051	0,025	0,028	-0,003	0,013	0,006					
16	0,089	0,000	0,038	0,025	0,022	0,000	0,009	0,006					
17	0,165	-0,051	0,051	0,013	0,041	-0,013	0,013	0,003					
18	0,139	-0,038	0,038	0,013	0,035	-0,009	0,009	0,003					
19	0,114	0,013	0,038	0,038	0,028	0,003	0,009	0,009					
20	0,089	0,025	0,025	0,038	0,022	0,006	0,006	0,009					
21	0,139	-0,051	0,038	0,013	0,035	-0,013	0,009	0,003					
22	0,114	-0,038	0,025	0,013	0,028	-0,009	0,006	0,003					
23	0,089	0,013	0,025	0,038	0,022	0,003	0,006	0,009					
24	0,063	0,025	0,013	0,038	0,016	0,006	0,003	0,009					
25	0,127	-0,025	0,051	0,013	0,032	-0,006	0,013	0,003					
26	0,101	-0,013	0,038	0,013	0,025	-0,003	0,009	0,003					
27	0,076	0,038	0,038	0,038	0,019	0,009	0,009	0,009					
28	0,051	0,051	0,025	0,038	0,013	0,013	0,006	0,009					
29	0,127	0,000	0,038	0,038	0,032	0,000	0,009	0,009					
30	0,101	0,013	0,025	0,038	0,025	0,003	0,006	0,009					
31	0,076	0,063	0,025	0,063	0,019	0,016	0,006	0,016					
32	0,051	0,076	0,013	0,063	0,013	0,019	0,003	0,016					
33	0,101	0,000	0,025	0,051	0,025	0,000	0,006	0,013					
34	0,076	0,013	0,013	0,051	0,019	0,003	0,003	0,013					
35	0,051	0,063	0,013	0,076	0,013	0,016	0,003	0,019					
36	0,025	0,076	0,000	0,076	0,006	0,019	0,000	0,019					
37	0,165	-0,025	0,063	0,013	0,041	-0,006	0,016	0,003					
38	0,139	-0,013	0,051	0,013	0,035	-0,003	0,013	0,003					
39	0,114	0,038	0,051	0,038	0,028	0,009	0,013	0,009					
40	0,089	0,051	0,038	0,038	0,022	0,013	0,009	0,009					
41	0,165	0,000	0,051	0,051	0,041	0,000	0,013	0,013					
42	0,089	0,076	0,025	0,076	0,022	0,019	0,006	0,019					
43	0,114	0,063	0,038	0,076	0,028	0,016	0,009	0,019					
44	0,089	0,076	0,025	0,076	0,022	0,019	0,006	0,019					
45	0,139	0,000	0,038	0,038	0,035	0,000	0,009	0,009					
46	0,114	0,013	0,025	0,038	0,028	0,003	0,006	0,009					
47	0,089	0,063	0,025	0,063	0,022	0,016	0,006	0,016					
48	0,063	0,076	0,013	0,063	0,016	0,019	0,003	0,016					
49	0,025	0,089	0,013	0,051	0,006	0,022	0,003	0,013					
50	0,000	0,101	0,000	0,051	0,000	0,025	0,000	0,013					

Continues on next page.

	Step 5											Step 6		
Option	Pr	Im	CS	Fea			Pr	Im	CS	Fea		Dib	Diw	Siw
1	0,000	0,002	0,000	0,000		(tij-twj)^2	0,003	0,000	0,000	0,000		0,048	0,054	0,530
2	0,000	0,002	0,000	0,001			0,001	0,000	0,000	0,000		0,053	0,033	0,381
3	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,034	0,046	0,576
4	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,037	0,040	0,514
5	0,000	0,001	0,000	0,000			0,003	0,000	0,000	0,000		0,041	0,054	0,568
6	0,000	0,001	0,000	0,000			0,002	0,000	0,000	0,000		0,039	0,048	0,550
7	0,000	0,000	0,000	0,000			0,001	0,000	0,000	0,000		0,028	0,048	0,634
8	0,000	0,000	0,000	0,000			0,001	0,001	0,000	0,000		0,030	0,045	0,597
9	0,000	0,001	0,000	0,000			0,002	0,000	0,000	0,000		0,042	0,047	0,530
10	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,041	0,041	0,500
11	0,000	0,000	0,000	0,000			0,001	0,000	0,000	0,000		0,032	0,043	0,571
12	0,001	0,000	0,000	0,000			0,001	0,001	0,000	0,000		0,035	0,040	0,528
13	0,000	0,002	0,000	0,000			0,002	0,000	0,000	0,000		0,049	0,045	0,475
14	0,000	0,002	0,000	0,000			0,001	0,000	0,000	0,000		0,048	0,038	0,438
15	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,039	0,037	0,490
16	0,001	0,001	0,000	0,000			0,000	0,000	0,000	0,000		0,041	0,033	0,446
17	0,000	0,001	0,000	0,000			0,002	0,000	0,000	0,000		0,043	0,045	0,511
18	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,042	0,039	0,476
19	0,000	0,000	0,000	0,000			0,001	0,000	0,000	0,000		0,034	0,041	0,543
20	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,038	0,038	0,500
21	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,045	0,038	0,456
22	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,046	0,032	0,411
23	0,001	0,000	0,000	0,000			0,000	0,000	0,000	0,000		0,039	0,036	0,475
24	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,044	0,034	0,437
25	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,041	0,038	0,480
26	0,001	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,042	0,033	0,436
27	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,038	0,039	0,507
28	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,043	0,038	0,470
29	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,034	0,041	0,546
30	0,001	0,000	0,000	0,000			0,001	0,000	0,000	0,000		0,037	0,038	0,504
31	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,036	0,046	0,564
32	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,042	0,046	0,523
33	0,001	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,039	0,037	0,493
34	0,001	0,000	0,000	0,000			0,000	0,000	0,000	0,000		0,042	0,035	0,453
35	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,001		0,042	0,045	0,516
36	0,002	0,000	0,000	0,000			0,000	0,001	0,000	0,001		0,049	0,046	0,487
37	0,000	0,001	0,000	0,000			0,002	0,000	0,000	0,000		0,037	0,047	0,560
38	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,037	0,041	0,530
39	0,000	0,000	0,000	0,000			0,001	0,001	0,000	0,000		0,030	0,045	0,604
40	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,034	0,043	0,558
41	0,000	0,001	0,000	0,000			0,002	0,000	0,000	0,000		0,028	0,051	0,640
42	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,001		0,032	0,051	0,616
43	0,000	0,000	0,000	0,000			0,001	0,001	0,000	0,001		0,026	0,052	0,670
44	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,001		0,032	0,051	0,616
45	0,000	0,001	0,000	0,000			0,001	0,000	0,000	0,000		0,033	0,044	0,572
46	0,000	0,000	0,000	0,000			0,001	0,000	0,000	0,000		0,035	0,040	0,532
47	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,033	0,047	0,591
48	0,001	0,000	0,000	0,000			0,000	0,001	0,000	0,000		0,039	0,047	0,546
49	0,002	0,000	0,000	0,000			0,000	0,002	0,000	0,000		0,048	0,046	0,491
50	0,003	0,000	0,000	0,000			0,000	0,002	0,000	0,000		0,054	0,048	0,470

Appendix B4

Table 46 - Steps of the focus group of iteration 3.

Steps of a Focus Group	Execution
Research questions	- What is your opinion on the decision model? - Do you have improvements for the decision model? - What do you miss in the decision model? - Which of the three options of ATP do you prefer? - Do you think there is another option for using ATP? What do you think about the effect for customers?
Select focus group participants	Employees functions: - Inventory management (CSD) - Order processing retail (CSD) - Team manager (CSD) - Market business partner - Account management retail Account assistant retail
Plan & Execute the session	Give a short presentation on the subject, let employees go through the decision model in google forms and let them have a discussion on the research questions. Field notes are made by the researcher during the session.
Plan & Execute the session	Improvements for the model: - Batch management. - Define customer as HNL and end-customer. - Combination with zero-touch ordering & VMI. - Potential for the future. - Timeframe of for the decision model. Opinion on the ATP options: - Preference of employees.
Report on results	The results are analyzed with help of the framework for architectural design decisions (ADDs) (Gu et al., 2010).

Appendix B5

Table 47 - Framework for architectural design decisions (ADDs) of artifact iteration 3.

Design issue		Iteration 3, D1: Batch management in SAP.
Context		Production batches including best-before-dates are only accurately stored in the warehouse management system at the moment. It is important that these production batches are included in SAP to make use of available-to-promise and to make SAP the leading software system.
Quality attributes		Cr1: process time, Cr2: process costs, Cr3: process quality, Cr4: process flexibility, Cr5: implementation time, Cr6: implementation costs, Cr7: feasibility and Cr8: customer satisfaction.
Architectural options	Identifier	It3-D1-Opt1: Batch management in SAP.
	Description	Research with a SAP consultant will be done on the possibilities of batch management in the current SAP systems and which improvements are needed to make the system ready.
	Relationship	All options of D2.
	Status	Accepted for further research.
	Evaluation	Cr1: Process time for CSD can decrease. Cr3: Process quality can increase due to the fact that all information is stored in one system.
	Rationale	It can be a very big project, which leads to an easier way of working for CSD (inventory management).

Continues on next page.

Design issue		Iteration 3, D2: Combination of ATP and current modules zero-touch ordering (ZTO) and vendor managed inventory (VMI)
Context		Some concerns about available-to-promise are about the relation between ATP and zero-touch ordering system (ZTO) and the vendor management inventory (VMI)
Quality attributes		Cr1: process time, Cr2: process costs, Cr3: process quality, Cr4: process flexibility, Cr5: implementation time, Cr6: implementation costs, Cr7: feasibility and Cr8: customer satisfaction.
Architectural options	Identifier	It3-D2-Opt1: Zero-touch ordering
	Description	The zero-touch ordering module connects full truck load orders automatically to a shipmetn.
	Relationship	
	Status	Rejected
	Evaluation	No effect on quality attributes.
	Rationale	Research on this topic with a SAP consultant shows that zero-touch ordering (ZTO) is nota problem in combination with available-to-promise. This module can use ATP in the same manner as normal orders handled by CSD.
Architectural options	Identifier	It3-D2-Opt2 Vendor management inventory
	Description	Vendor management inventory is used for the biggest customer, the best way of using VMI is to make decisions based on the latest availability overview. This is in contrast with available-to-promise, which works optimal if the customers send in their orders on time.
	Relationship	
	Status	Accepted for further research
	Evaluation	Cr5,6: Research has effect on the implementation time and costs.
	Rationale	Research on this topic is a requirement for the implementation of ATP. VMI is a module that makes an order one day in advance based on the stock and forecasts. Research must be done on dummy orders; orders that make a reservation of stock based on the forecast which is deleted when the actual order is made.

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Design issue		Iteration 3, D3: Improve concept understandability.
Context		Users of the decision tree where a bit confused on how to use the decision tree. For this reason the concept understandability for first time users must be improved.
Quality attributes		Cr9: Clarity Cr10: Consistency
Architectural options	Identifier	It3-D3-Opt1: Design usage & utility instructions.
	Description	The usage and utility instructions must include all descriptions of factors of the model. Including the goal, the decisions that must be made and effects that the decision has on the end solution. It must include: timeframe for ATP and must define customer.
	Relationship	
	Status	Accepted
	Evaluation	Cr9: Clarity, all aspects of the decision tree must be clear to first time users. Cr10: The information in the decision tree must be consistent for example use the same words for all definitions.
	Rationale	This is a good improvement for the model, because it will help to fulfill the artifact requiremens as easy-to-use, usefulness, completeness and understandability.
Architectural options	Identifier	It3-D3-Opt2: Decision tree redesign
	Description	The model looks complicated, try to design a new decision tree with colors which makes the clarity better.
	Relationship	It3-D3-Opt1 & It-D1-Opt1
	Status	Accepted
	Evaluation	Cr9: Improves clarity, and makes using the model easier.
	Rationale	This option can help to make the model easier to read for first time users, which is one of the artifact requirements.

Appendix B6

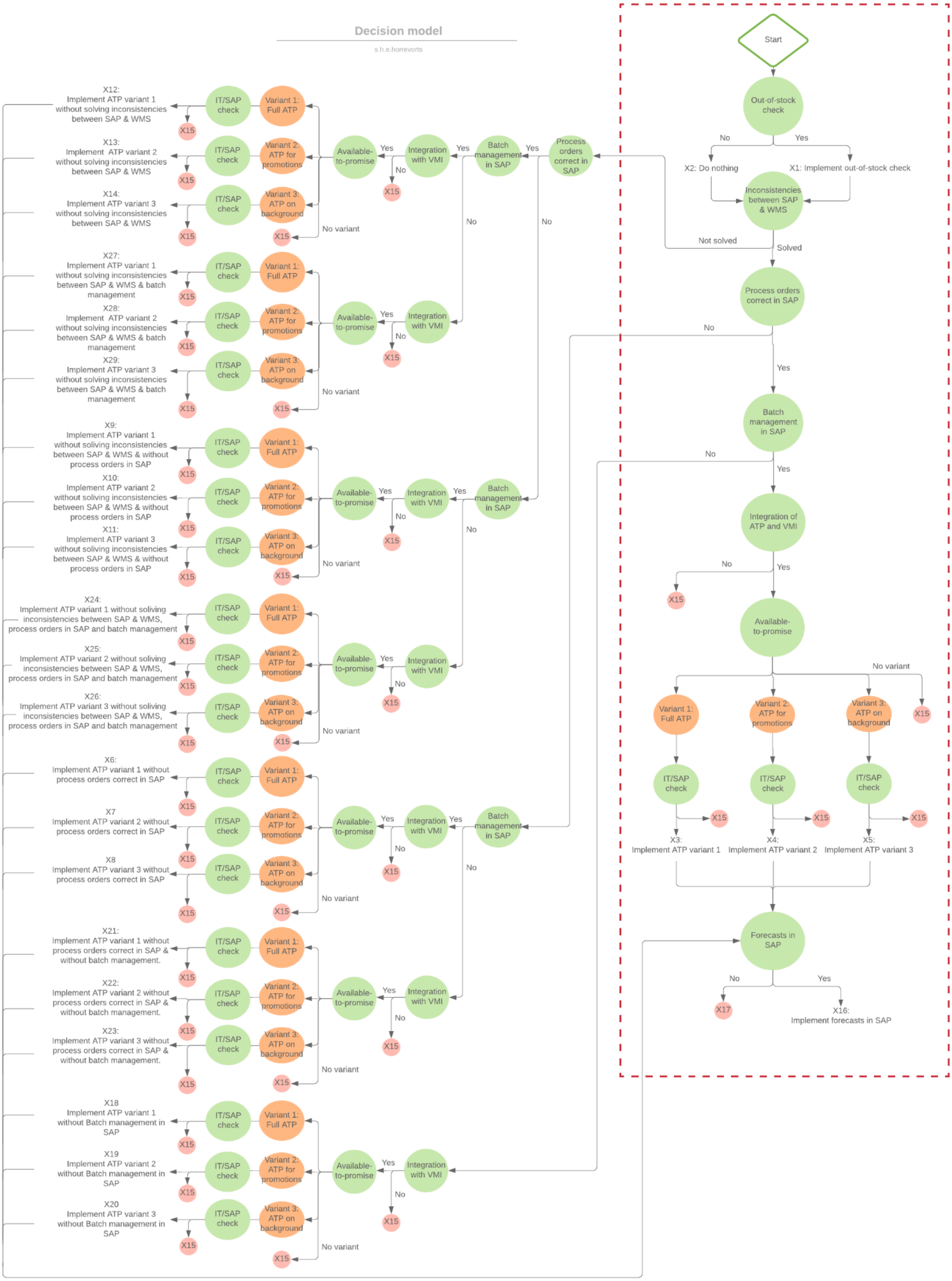

Figure 26 - Decision tree artifact 3 (with all possible solutions)

Appendix B7

1. Interactive presentation of the decision tree.

2. The Results of TOPSIS calculation for artifact 3 are shown in this link.

Appendix C: Additional tables and figures Chapter 4.3

Appendix C1

Table 48 - Research design validation part 1

Research design	Execution
Goal	Validate the artifact requirements: easy-to-use, usefulness, completeness and understandability.
Participants	Employees functions: - Inventory management (CSD) - Order processing retail (CSD) - Team manager (CSD)
Reponse rate	100%
Method of analysis	- Calculate average score per question - Calculate average score per requirement. - Design a graphical representation of every requirements' average score. - Discuss average scores per requirement.

Table 49 - Validation questions & scores for artifact requirements

Issues	Participants			Scores	
Preceived ease-of-use	Participant 1	Participant 2	Participant 3	Score	Total
1. I become confused when using the ATP model. *	2	4	2	3.33	
2. I make frequently errors when using the ATP model. *	2	3	2	3.67	
3. Iteractig with the ATP model was frustrating. *	1	4	4	3.00	
4. The ATP model often behaves in unexpected ways. *	3	3	3	3.00	
5. The interaction with the ATP model is easy to understand.	4	4	3	3.67	
6. The ATP model provides helpful guidance in performing tasks.	4	4	4	4.00	3.44
Preceived usefulness					
1. The ATP model helps me to accomplish the decision making more quickly.	4	3	4	3.67	
2. Using the ATP model makes the decision making easier.	4	4	4	4.00	
3. I find the ATP model useful.	4	5	4	4.33	
4. Using the ATP model enhances my effectiveness in decision making.	3	4	3	3.33	
5. THe decision would be difficult without the ATP decision model. *	3	4	4	2.33	3.53
Completeness					
1. Some important aspects are missing in the ATP model. *	3	2	3	3.33	
2. The model includes all requirements for implementing ATP.	4	4	3	3.67	
3. The ATP model is complete.	4	3	3	3.33	
4. The ATP model consists of too much information. *	2	3	2	3.67	3.50
Understandability					
1. It is easy to go through the ATP model.	4	5	2	3.67	
2. I knew what was expected after the ATP model presenation and description.	3	4	2	3.00	
3. I had to start over because I made a mistake during the process. *	2	3	1	4.00	
The ATP model is understandable.	4	4	4	4.00	3.67

Appendix C2

Table 50 - Research design of validation part 2

Research design	Execution
Goal	Validate if the possible solutions provide a valid advice that helps to reach the stakeholder goals: order-status transparency, time spend on out-of-stock and detect out-of-stock earlier in time.
Participants	Employees functions: - Inventory management (CSD) - Order processing retail (CSD) - Team manager (CSD)
Reponse rate	100%
Method of analysis	- Calculate average score per question - Design a graphical representation of the effects from the options on the goals. - Discuss average scores.

Table 51 - Validation questions & scores for stakeholder goals

Questions	Participant 1	Participant 2	Participant 3	Average
1. Expected effect of out-of-stock check on order status transparency.	3	4	4	3.67
2. Expected effect of out-of-stock check on time spend on OOS*	4	4	5	4.33
3. Expected effect of out-of-stock check on early detection of OOS.*	4	4	4	4.00
4. Expected effect of ATP variant 1 on order status transparency	5	5	5	5.00
5. Expected effect of ATP variiant 1 on time spend on OOS.*	5	5	5	5.00
6. Expected effect of ATP variant 1 on early detection of OOS.*	5	4	5	4.67
7. Expected effect of ATP variant 2 on order status transparency.	4	4	3	3.67
8. Expected effect of ATP variant 2 on time spend on OOS.*	4	4	3	3.67
9. Expected effect of ATP vairant 2 on early detection of OOS.*	4	4	4	4.00
10. Expected effect of ATP variant 3 on order status transparency	3	4	3	3.33
11. Expected effect of ATP variant 3 on time spend on OOS.*	4	4	4	4.00
12. Expected effect of ATP variant 3 on early detection of OOS.*	4	4	4	4.00
13. Expected effect of Forecasts in SAP on order status transparency.	4	2	5	3.67
14. Expected effect of forecasts in SAP on time spend on OOS.*	2	2	4	2.67
15. Expected effect of forecasts in SAP on early detection of OOS.*	4	4	5	4.33

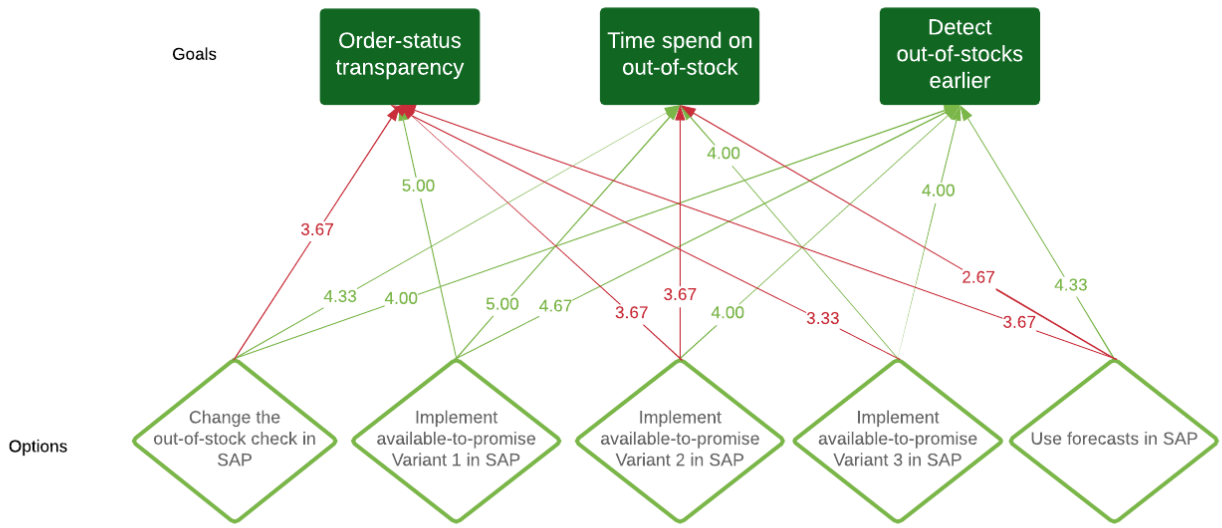

Figure 27 - Results validation options vs. stakeholder goals