Universiteit Leiden

ICT in Business

Market specific processes in ERP systems

An explorative study on the bulb forcing process

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MASTER'S THESIS

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Preface

In front of you lies the thesis '*Market specific processes in ERP systems, an exploratory study on the bulb forcing process*'. This thesis has been written to fulfill the graduation requirements of the 'ICT in Business' master at Leiden University. I was engaged in writing this thesis from February 2016 to July 2016.

During the search for a subject for my master's thesis I got into contact with Keemink Design B.V.. I was delighted that I got the opportunity to work on a project regarding bulb forcing. Since bulb forcing originates from my place of birth, I was directly interested.

During the lectures of the master 'ICT in Business', I got interested in the application of IT in order to improve business processes. This project enabled me to explore how IT systems, ERP systems in particular, could support market specific processes like bulb forcing. Therefore, I'm glad that I got the opportunity to work on this project.

I would like to thank everybody who supported me while writing this thesis. Especially I want to thank Dr. H.T. Le Fever, who guided me through the whole process of writing the thesis. I also want to thank René Keemink and Fred de Vos, who were always willing to provide extensive and useful feedback. Last but not least I want to thank Pim Heemskerk and Lindsey van der Wijden, who were always willing to help me and provided educative feedback which brought my master's thesis to a higher level.

I hope you enjoy reading this master's thesis.

Kevin van der Wijden
Lisse, Saturday 30^{th} July, 2016

Abstract

Enterprise Resource Planning (ERP) systems are Information Technology (IT) systems that are designed to support most business processes. Making an ERP system suitable for supporting a market specific process is a complex task. In this master's thesis has been explored how market specific processes can be implemented into an ERP system. In order to relate this to practice, an implementation of the bulb forcing process in an ERP system has been analyzed.

The bulb forcing process is a market specific production process for bulbs. This process influences the blooming of the bulbs. In order to make the analysis broader applicable, the bulb forcing process has been generalized. Based on the generalized process, a comparison has been made with general production processes. Literature research and discussions with experts gave insight in the bulb forcing process. For this master's thesis the general production processes that were used were Make-To-Stock (MTS) and Make-To-Order (MTO). MTS means producing products based on expected sales. MTO means producing products after a customer order is placed. These two processes are taken as the general processes, because other production processes can eventually be related to those. Besides supporting the market specific process, it should also be considered how the production process should be re-scheduled once unforeseen events occur. In the bulb forcing process, these unforeseen events are mostly triggered by uncertainty introduced by the biological characteristics of the raw materials. In order to guide the re-scheduling, a re-scheduling policy has been suggested.

Based on the comparison between the generalized bulb process and the general production processes (MTS and MTO), a framework has been suggested. This framework can be used as a guideline for the customization of an ERP system to support market specific processes with similar characteristics as the generalized model. In order to determine the applicability of the suggested framework, it has been applied to practice using a case study. This case study is based on a major bulb export organization of the Netherlands. This company wants to implement the bulb forcing process in their ERP system.

Resulting from the comparison between the generalized bulb process and the general production process can be concluded that the generalized bulb model is strongly related to MTS and MTO. There are only minor differences. Therefore it is not necessary to completely adapt the ERP system to the market specific process. Creating a market specific layer around the ERP system is sufficient to support the process. In the case of the generalized bulb process, additional checks should be supported before raw materials go into production. These checks determine if the raw materials satisfy market specific characteristics. From the application of the suggested framework in the case study could be concluded that it was not required to adapt the framework to practical experiences.

Contents

List of abbreviations

ERP Enterprise Resource Planning.

IT Information Technology.

MC Mass Customization.

MC-ERP Mass Customization of ERP.

MRP Material Requirements Planning.

MRP II Manufacturing Resource Planning.

MTO Make-To-Order.

MTS Make-To-Stock.

SCM Supply Chain Management.

SME's Small and Medium-sized Enterprises.

SOA Service-Oriented Architecture.

UML Unified Modeling Language.

1 Introduction

Implementing an Enterprise Resource Planning (ERP) system in an organization is a complex task. ERP systems are developed to support all kind of processes within an organization. Because of the ability to support all kind of processes, the implementation of an ERP system is a difficult task.

Aligning an ERP system with market specific processes brings even more challenges. Since most market specific processes have specific characteristics, they are most of the time not supported by ERP systems. In order to make the ERP system capable to support a market specific process, customization is needed. For this master's thesis the bulb forcing process is taken as market specific process. The bulb forcing process is a production process of bulbs, which influences the bulbs to manipulate the time of blooming. This process will be analyzed in order to gather requirements for the customization of an ERP system.

This master's thesis focuses on the implementation of the bulb forcing process in an ERP system. Research will be performed to determine to what extent the bulb forcing process is similar to standard production processes, like Make-To-Stock (MTS) and Make-To-Order (MTO). Additionally, it will be explored how market specific processes should be implemented in an ERP system. This results in the following research question:

"How to implement market specific processes, with similar characteristics to the bulb forcing process, in an ERP system?"

1.1 Problem statement

The problem statement addresses the driving problem for this master's thesis. Based on the problem statement, sub-questions have been formed.

In the bulb sector of the agricultural industry, the exploitation of ERP systems is limited. Nowadays younger generations are taking over the management of organizations in the bulb sector. The change to younger management, results in a different view on the exploitation of ERP systems, or IT systems in general. This results in an increased need for market specific customizations of IT systems.

The bulb sector is an important sector in the Netherlands. The Netherlands accounts for 65% of the total production area of flower bulbs in the world (Buschman, 2004). Besides the production, the Dutch trading companies deal with 85% of the trading of bulbs around the world (ibu). The bulb production area in the Netherlands has grown from 20.921 hectares in 2004 to almost 25.000 in 2015 (Buschman, 2004; cbs, 2016). Nowadays, the export of flower bulbs is worth around €871 million (cbs, 2016). The Netherlands is the market leader in the bulb sector. This makes it interesting to see if the implementation of market specific processes improves the efficiency of organizations in the bulb sector. If these organizations become more efficient, because of the implementation of market specific processes, the Netherlands will be able to further exploit their market position. This will not be explored in this master's thesis since the focus is on the customization of ERP systems to support market specific processes.

To align the customization of ERP systems to support market specific processes with practice, a market specific process in the bulb sector of the agricultural industry will be used as case study. This specific process is the bulb forcing process. Bulb forcing is a market specific production process since it is only applicable to the bulb sector. Therefore the bulb forcing process will be generalized in order to make it applicable to processes with similar characteristics. This generalization will be used to suggest a framework. This framework can be used as a basis for the customization of ERP systems for supporting market specific processes. In order to determine how ERP systems should be customized, the generalization will be compared to standard production processes supported by ERP systems.

Sub-question 1: Which production processes are usually supported by ERP systems?

Sub-question 2: What is bulb forcing?

Sub-question 3: To what extent is a market specific process, like bulb forcing, similar to production processes usually supported by ERP systems?

Production processes require production planning because products have to be produced in time. Some processes, like bulb forcing, are influenced by uncertainty since it is a biological process. This uncertainty might force organizations to re-schedule the production. Re-scheduling policies have to be formed in order to structure the re-scheduling of the production.

Sub-question 4: How can re-scheduling be handled in a production process?

The case study is based on the implementation of the bulb forcing process within a bulb export organization in the Netherlands. The problem to be solved arises from the fact that the bulb forcing process is not supported by the ERP system of this specific organization. This results in a less efficient business process for the organization. This inefficiency results in two concerns within the organization. Firstly, since the bulb forcing specific process is largely depending on manual labor, a lot of time is lost. Secondly, besides the loss of time, the current implementation of the ERP systems supports only a small part of the process. Due to the minimal support of this process, the added value of the ERP system as currently implemented is questioned by the organization. In order to improve the perceived added value, the organization has to consider customization of the ERP system. The organization needs to determine if customizing the ERP system will have a positive impact on the business process. Customization that positively impact the business process, will increase the perceived added value.

The bulb forcing process is the differentiating factor for this specific organization to distinguish them from other organizations. This is the main reason for the organization to customize the ERP system. The organization has developed a lot of knowledge regarding bulb forcing, which gives them an advantage over their competitors. Making this process more efficient and effective, will make the whole organization more efficient and effective. Therefore it will be interesting to investigate if customization of the ERP system will positively impact the business process.

Sub-question 5: How to customize ERP systems to support the bulb forcing process?

1.2 Thesis outline

This master's thesis is structured as follows: Section 1.1 contains the problem statement in which the research (sub-)questions are defined. Section 2 provides the theoretical framework. This section contains a literature research based on the research questions. Section 3 provides a comparison between a generalized model of the bulb forcing process and the standard production processes MTS and MTO. In Section 4 a framework is suggested. This framework can be used as guideline for the customization of ERP systems for supporting a market specific process. Section 5 provides a case study in which the suggested framework is applied in practice. Section 6 provides the results. Section 7 and Section 8 respectively provide discussion and conclusion of the results. Section 9 ends with suggestions for future research.

The representation of processes will be done using Unified Modeling Language (UML), and in particular activity diagrams. Like the name suggests, activity diagrams are used to represent the flow of a process. Since we will focus on specific business activities, the activity diagrams are a logical choice for representing processes.

2 Theoretical Framework

This section is organized as follows. First, in Section 2.1 ERP systems will be theoretically defined, followed by Section 2.2 which handles ERP customization. Next, in Section 2.3, the process of supply chain management will be described. Then the sector specific process of bulb forcing will be generalized into a model in Section 2.4. Finally, Section 2.5 will cover re-scheduling, which is an important factor of supply chain management.

2.1 ERP systems

ERP systems have their origin in Material Requirements Planning (MRP) systems (Verdouw et al., 2015; Manthou et al., 1996). The following definition of MRP is given by Manthou et al. (1996): "MRP is a computer-based information system designed to control manufacturing activities within an organization" (Manthou et al., 1996). Over the years, MRP system expanded into Manufacturing Resource Planning (MRP II) systems (Verdouw et al., 2015; Yang et al., 2007; Mabert et al., 2001; Manthou et al., 1996). Compared to MRP systems, MRP II systems are extended systems in order to control other business processes like order processing and product costing (Verdouw et al., 2015; Yang et al., 2007; Mabert et al., 2001; Manthou et al., 1996).

Nowadays MRP II systems are expanded into ERP systems. ERP systems include, in addition to MRP II systems, financial results, procurement, sales, manufacturing and human resources (Powell et al., 2013; Verdouw et al., 2015; Yang et al., 2007; Mabert et al., 2001). ERP systems are seen as a business solution rather than an IT solution (Mabert et al., 2001). Verdouw et al. (2015) introduced 'ERP II' which is based on Service-Oriented Architecture (SOA). ERP II is a more web-based and componentized structure for an ERP system. ERP II has therefore more flexibility than ordinary ERP (Verdouw et al., 2015). In short, ERP systems are a management tool for coordinating and guiding the enterprise-wide activities of a firm (Yang et al., 2007; Mabert et al., 2001).

ERP systems are supposed to be, or to become, the IT backbone of an enterprise (Yang et al., 2007). The research of Powell et al. (2013) concluded that production managers in Small and Medium-sized Enterprises (SME's) would like to exploit the possibilities of their ERP system. With the exploitation of the ERP system, the managers expect an improvement of the production process. The managers expect better control over the process and flow of information across different inter- and intra-organizational business departments (Verdouw et al., 2015).

Over the years organizations have invested heavily in IT (Mabert et al., 2001). Organizations are forced to make such investments due to the evolving pressure of global competition (Mabert et al., 2001). This master's thesis focuses on the agricultural industry, specifically on the horticulture. In the agriculture the usage of IT has expanded over the past decades (Verdouw et al., 2015). Nevertheless, the usage of IT in the horticulture is still limited. In the horticulture the applicability of ERP is considered as limited (Verdouw et al., 2015). Due to governmental rules, organizations within the bulb industry get forced to adopt IT solutions. These rules are created in order to track all flow of goods throughout the whole industry. The tracking of the flow of goods has to be done from harvesting till delivery to the end customer/consumer.

Resulting from experiences in other industries, ERP systems should be able to become the backbone of organizations in the agricultural industry (Yang et al., 2007). In order to support the agricultural industry, the ERP system should be able to handle a production process which is subject to uncertainty. In Ahumada et al. (2012), a stochastic tactical planning model for the production and distribution of fresh agricultural products is presented. The model handles the uncertainties that could encounter in the fresh produce industry, in particular to handle the uncertainties that could encounter during the development of growing and distribution plans.

Similar uncertainties are found in the bulb industry. Bulbs have to reach a 'G' stage, which means that the bulbs are ready for production (De Hertogh, 1974). Estimations can be made for bulbs when they are expected to get in this 'G' stage, but it will remain uncertain since it is a biological process (De Hertogh, 1974). Since the bulb industry has not broadly adopted IT systems yet (Verdouw et al., 2015), a lot of manual work is needed to cope with this uncertainty. In the case of the agricultural industry, the application of ERP systems is considered to be limited (Verdouw et al., 2015), since ERP systems are only able to support stable business processes (Verdouw et al., 2015). In order to support the uncertainty in the agriculture, ERP manufacturers have to overcome their shortcoming in the flexibility of the ERP systems (Verdouw et al., 2015).

2.2 ERP customization

Once an organization decides to implement an ERP system, they will encounter several hurdles. For example, it could be that there exists a gap between the business processes and the way the processes are modelled by the ERP system (Powell et al., 2013). Due to these gaps, the ERP systems do not meet the information processing demands and requirements of the organization (Huang et al., 2012). Davis (2005), introduces the term 'vanilla ERP' which means that no customization is done on the ERP system. Vanilla ERP systems cannot meet all functionalities or special business requirements (Huang et al., 2012). This introduces ERP customization as subject for research. Other researchers have investigated this subject (e.g. Powell et al., 2013; Verdouw et al., 2015; Davis, 2005; Yang et al., 2007; Rothenberger and Srite, 2009; Huang et al., 2012).

Davis (2005) defines the customization of an ERP system as follows: "Customization is a code change put into place because the ERP business process does not mirror the 'desired' business process" (Davis, 2005). This definition of ERP customization will be adopted in this master's thesis. Like described before, the business processes within the agriculture are uncertain and market specific (Verdouw et al., 2015). Verdouw et al. (2015) describe that with uncertain processes, like the processes in agriculture, the application of vanilla ERP systems is hard due to the lack of flexibility. In addition to the limited flexibility, ERP systems are not developed to contain market specific functionalities. Nowadays ERP manufacturers are aware of their lack of flexibility and are therefore adapting to the market needs, for example with ERP II (Verdouw et al., 2015).

Zhao and Fan (2007) list the following downsides for traditional ERP systems:

1. ERP systems should be tightly integrated with other systems. Particularly focusing on the integration of information sharing

2. Traditional ERP systems are based on MRP systems. Therefore the ERP systems are not able to analyze the combined information of all resources to support the complete business.

3. The traditional ERP systems are not as flexible as promised. They can only be configured according to predefined configurations and not freely.

In order to solve these points, Zhao and Fan (2007) introduce Mass Customization of ERP (MC-ERP). MC-ERP uses characteristics of Mass Customization (MC): rapid implementation and flexible customization (Zhao and Fan, 2007). MC-ERP customization consists of two parts. The first part consists of the customization of processes in the ERP system, according to the requirements of the organization. The second part is that the ERP system gets customized in order to match the product of the organization (Zhao and Fan, 2007).

Another option for customization is the creation of a market-specific layer around the ERP system (Verdouw et al., 2015). Such market-specific layers adapt the existing ERP business processes to the market specific application of the business processes. The customization of ERP systems can come with risks e.g.:

1. Customization will increase the complexity, which makes the implementation at the organization more difficult (Davis, 2005)
2. It will impact the maintenance/upgrades of the system (Davis, 2005; Huang et al., 2012)
3. Customizations will increase the ERP systems' costs (Yang et al., 2007; Huang et al., 2012)
4. High customization might lead to redevelopment of functionality that is already available in the system (Rothenberger and Srite, 2009)
5. Increase in complexity might negatively influence the systems' performance (Yang et al., 2007)

The need for customization always arises due to a gap between offered and required functionality. An important consideration that comes with such gaps is whether the ERP system should be adapted, or if the current business process should be adapted (Huang et al., 2012). Consultants can guide an organization during the decision making process to determine if customization is needed. Once a good relationship is created with consultants, they can exploit their capabilities. The better the relationship, the more knowledge the consultants will have about the required (specific) configuration. Therefore the consultants are more capable to give proper advice for decision making (Davis, 2005; Rothenberger and Srite, 2009).

According to Huang et al. (2012), there are three different types of gaps between offered and required functionality of the ERP systems:

1. Data (e.g. format, relationship)
2. Process (e.g. process procedures are different than business process)
3. Output (e.g. presentation format, information content)

These gaps are considered to be misfits. There are two options to solve those misfits: adapting or customizing. When a misfit is adapted, the business process is aligned with the process in the ERP system. Customizing, on the other hand, is the aligning of the software with the business process. ERP contents are aligned with the business for 70% (Huang et al., 2012). The other 30% requires consideration if customization or adoption is needed (Huang et al., 2012). Customization is the only way to meet all needs of the customer (Huang et al., 2012).

2.3 Supply chain management

The processes this master's thesis focuses on, can be summarized in Supply Chain Management (SCM). ElMaraghy et al. (2013) defines SCM as follows: "Supply Chain Management (SCM) deals with the coordination and integration of the interactions among various businesses involved in the provision of product and service packages required by the end customer in a supply chain" (ElMaraghy et al., 2013). Over the years the view on production/manufacturing processes has changed. This is due to the fact that the market has changed from 'one product fits all', to 'a product for all' (ElMaraghy et al., 2013; Su et al., 2010).

In this master's thesis the focus will be on MTO and MTS supply chain processes. These two supply chain processes are mostly characterized as the main processes, other supply chain processes have similar characteristics (Li and Womer, 2012; Rafiei and Rabbani, 2012; Meisel and Bierwirth, 2014; Harrod and Kanet, 2013; Ioannou and Dimitriou, 2012; Su et al., 2010). MTS is based on a forecast of future orders; production starts based on expected orders (Rafiei and Rabbani, 2012). MTO is an order driven supply chain process; production is triggered once an order is received from a customer (Rafiei and Rabbani, 2012). Table 1 and Table 2 list the positive and negative effects of MTO and MTS on the supply chain process respectively.

In order to be able to determine the necessary changes to the current supply chain processes, the current supply chain, and the expected supply chain will be described.

Table 1: Effects of MTO driven supply chain process

Positive effects	**Negative effects**
+ Avoidance of costly inventory of: raw materials, semi-finished products and final products (Meisel and Bierwirth, 2014)	- Customers must wait longer for their configured product (Su et al., 2010)
+ Externally determined finished good dates (Harrod and Kanet, 2013)	- Raises additional service requirements (e.g. on-time delivery) (Meisel and Bierwirth, 2014)
+ High customization (Ioannou and Dimitriou, 2012)	- Externally determined finished goods dates, requires methods for negotiating or setting job due dates (Harrod and Kanet, 2013)
+ High customer involvement during the process (Ioannou and Dimitriou, 2012)	

Table 2: Effects of MTS driven supply chain process

Positive effects	**Negative effects**
+ Lead time is shorter than with MTO (Huang et al., 2012)	- Forecast dependent which might lead to excessive inventory of stock outs

2.3.1 Current supply chain

Figure 1 is an abstraction of the supply chain as currently implemented in the ERP system at Company X of the case study in Section 5. This abstraction shows that the ERP system supports the most common supply chain processes like, MTO, MTS and (direct) reselling (Li and Womer, 2012; Rafiei and Rabbani, 2012; Meisel and Bierwirth, 2014; Harrod and Kanet, 2013; Ioannou and Dimitriou, 2012; Su et al., 2010). As stated, these are common supply chain processes and are therefore, most of the time, not able to handle market specific processes. In order to make them applicable to market specific processes, the existing processes have to be customized. In Section 2.3.2 the desirable processes will be described.

The supply chain represented in Figure 1, starts with the availability of raw materials. This can be triggered in two different ways: a customer can place an order or the organization can find a good offer. This already indicates the support for MTS and MTO, since MTS starts from stock, and MTO starts at the placement of a customer order. Once products are in stock there are several paths that can be taken till delivery. Raw materials can be crafted into a final product with a production order. Once a final product is produced, this product can be stored to be sold later (MTS) or it can directly be prepared for transport to the customer (MTO). Another path is the direct reselling of the products. When there is no need for production, the raw materials are directly transported to the final customer. The last path is for internal orders, which means that products (which can be raw materials) from stock are used internally.

Figure 1 is generally applicable on ERP systems. For example, SAP and Microsoft Dynamics support the same processes. The detailed execution of each path will be different, but the structure is the same. Therefore, during this master's thesis, Figure 1 will be considered as a general abstraction for the processes of the supply chain within ERP systems.

2.3.2 Expected supply chain

Creating a market specific layer around general processes, like the ones described in Figure 1, requires careful consideration. The desirable processes are shown in Figure 2. The desirable process differs only at one point from the current supply chain, which is the market specific process; the bulb forcing process. The bulb forcing process is a process that is subject to uncertainty due to biological processes. The bulb forcing process will be further explored in section 2.4. During the initial implementation of the ERP system no customization was applied since it was considered that manual labor would enable the ERP system to provide sufficient support for the bulb forcing process. Additionally, a factor limiting the customization of the ERP system is the limited adoption of ERP systems within the horticultural industry (Verdouw et al., 2015). The organization did not see the advantages of a supporting IT system. They were therefore not willing to take the most out of the system. Since the usage of ERP systems has been expanding over the last years, it has become obvious that automating business processes can provide a lot of advantages when applied properly. This is the reason why it is important to customize the ERP system in order to properly support market specific processes.

Combining the knowledge of the organization and the ERP manufacturer leads to a vision on the process which satisfies both organizations. Figure 2 is created in consultation with the organization and the ERP manufacturer. Market specific knowledge of the organization leads to requirements, e.g. the flow of the process, market specific constraints, etc. The requirements are categorized according to the MoSCoW principle (Van Vliet et al., 1993). The MoSCoW principle will be further explored in Section 4. The IT related knowledge of the ERP manufacturer gives insight in the technological possibilities to overcome certain problems, like

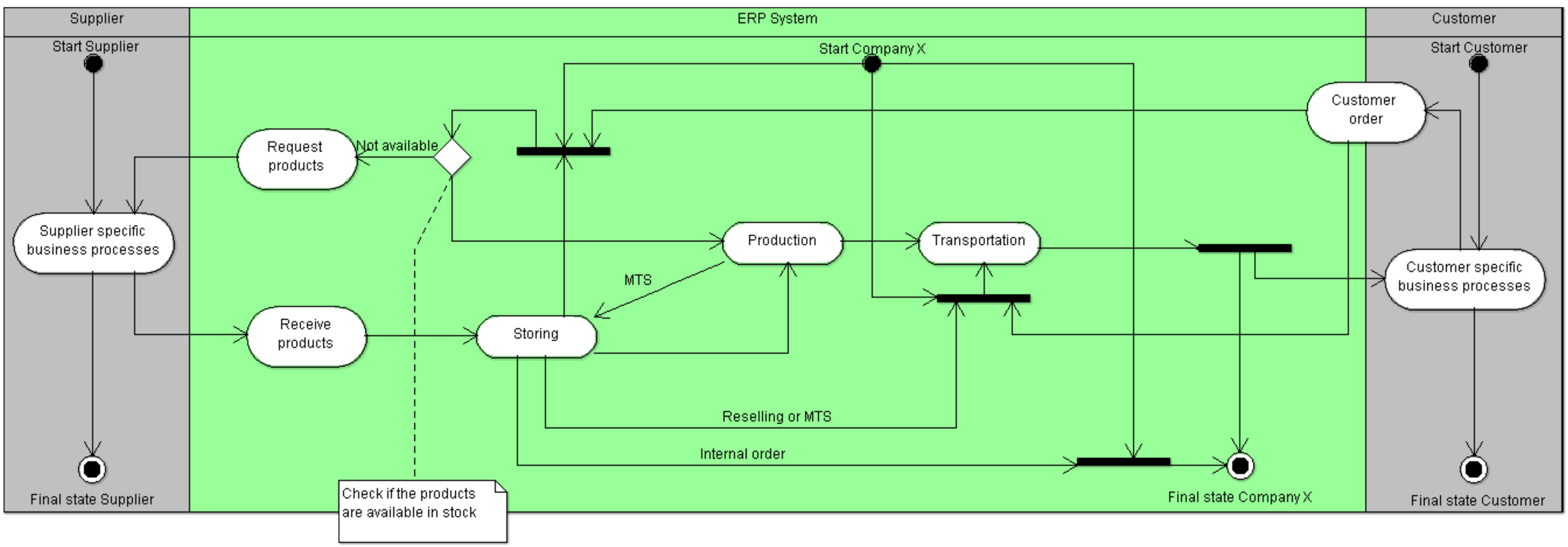

Figure 1: Current Supply Chain, as implemented at Company X of the case study

limitations of the used components of the ERP system. Combining the knowledge of the two organizations will therefore eventually lead to an improved business process, which will be properly supported by the ERP system.

The forcing process in Figure 2 can be replaced with similar market specific processes, like the forcing process in the fruit sector or the handling of fresh products since they comprise similar characteristics (Ahumada et al., 2012; Sønsteby et al., 2013). The details of the bulb forcing process will be given in Section 2.4. The same section will also give an abstraction of this process, which gives the possibility to compare similar processes with the forcing process. This will lead to the possibility to apply the same customization process to processes with similar characteristics.

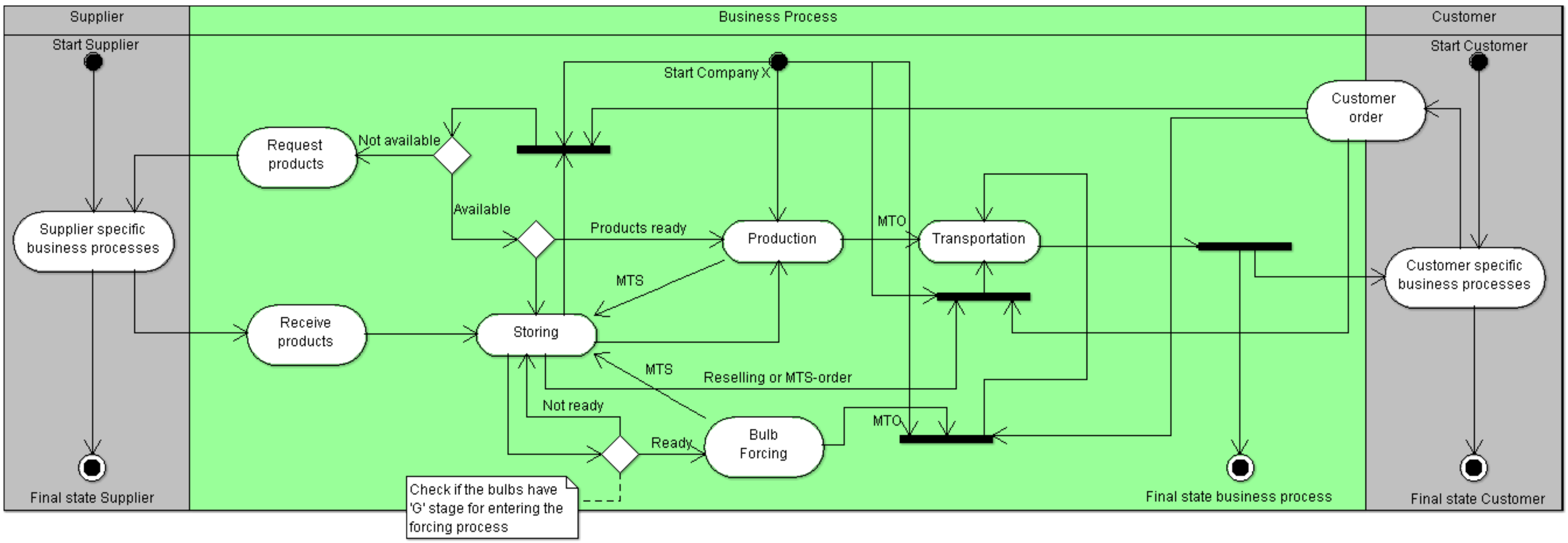

Figure 2: Desirable Supply Chain

2.4 Bulb forcing

Bulb forcing is a specific type of forcing process in the bulb sector of the horticulture. The forcing process is also found in other sectors, e.g. the fruit sector(Sønsteby et al., 2013). De Hertogh (1974) defines bulb forcing as "the system by which the potted plant or cut flower is produced from a storage organ" (De Hertogh, 1974). In short, bulb forcing means that environmental conditions, particularly temperature, of the bulbs (storage organ) are influenced to produce potted plans or cut flowers which satisfy the required characteristics at the right time.

The forcing of bulbs requires knowledge about the morphological changes of the different bulb species and cultivar (De Hertogh, 1974). The species and cultivar determine the exact forcing technique (De Hertogh, 1974). Forcing is based on environmental control, in the case of bulb forcing particularly temperature control (De Hertogh, 1974). As stated by De Hertogh (1974), it is also possible to use chemicals to influence the storage organ. De Hertogh (1974) introduces standard forcing. In standard forcing the major controlling factor is the temperature (De Hertogh, 1974). For this master's thesis the focus will be on standard forcing. In Sections 2.4.1 and 2.4.2, the 9°C forcing schema and the 5°C forcing schema respectively, will be explored. Those schemas are examples of standard forcing, since the temperature is the major controlling factor.

Low temperature treatments are the most common treatments in bulb forcing (De Hertogh, 1974). Most bulbs require a warm-cool-warm post harvest temperature treatment, also called a low temperature treatment (De Hertogh, 1974). This means that the bulbs are stored at a relatively warm temperature after harvesting in order to increase the floral development. This floral development consist of seven stages of which the last, the 'G' stage, is the most important. This 'G' stage indicates that the bulb is ready to be stored under a relatively cool temperature. For each bulb cultivar the optimal amount of weeks is for this cooling period is defined. It is almost impossible to determine the exact date that a bulb reaches the 'G' stage, due to the following factors as stated by De Hertogh (1974):

1. Differs each year
2. Differs for each cultivar
3. It might even differ per region of production of the bulb

These factors force yearly sampling of each cultivar (De Hertogh, 1974).

Once the 'G' stage is reached, a so called 'inbetween' temperature starts (De Hertogh, 1974). The 'inbetween' temperature is a cultivar specific period which ensures that the most of the bulbs in the batch will reach the 'G' stage. This 'inbetween' temperature is beneficial for the development of the flowers (De Hertogh, 1974). Once the 'inbetween' temperature has been reached, the bulbs are ready to be placed in controlled temperature environment (De Hertogh, 1974). These are storage units in which the temperature can be controlled. There are optimal temperatures and durations described for the cooling of each cultivar. Deviating from these optima can result in less quality potted plants and/or cut flowers, e.g. abnormal coloration and wrong stem length (De Hertogh, 1974).

The forcing process has two basic goals (De Hertogh, 1974). The first goal is to create bulbs that flower on the earliest possible date. The second goal is to ensure delayed or retarded flowering at the latest possible date. Having the earliest and/or latest flowering bulbs will give a competitive advantage since customers want to have flowering bulbs as long

Table 3: Phases of bulb forcing

Phase	Characteristics
1. Production	The production process consists of the following five steps: 1. Harvesting & pre-planting storage 2. Planting, rooting and low temperature mobilization for flowering and/or bulbing 3. Bolting (prematurely producing a flowering stem) 4. Flowering 5. Increasing bulb weight/size
2. Programming	All procedures executed from harvesting to placement in the greenhouse
3. Greenhouse	Placement in the greenhouse till the bulbs are developed into potted plants or cut flowers

as possible. Limits to these goals are determined by the genetic characteristics of the different cultivars (De Hertogh, 1974). For example, the genetic characteristics of cultivars results in slower development of the bulbs. Therefore specific cultivars require later harvesting than other cultivars with faster development. The possibility of an early date of flowering of the bulbs with slower development is for this reason limited. The two goals are achieved using three phases. In Table 3 the three phases of bulb forcing are explained De Hertogh (1974). Phase one is the initial creation of an storage organ. Phase 2 is the development of the bulbs until they reach the 'G' stage till the completion of the cooling period. Phase 3 is the actual blooming of the flowers, which is beyond the scope of this master's thesis.

The following sections (2.4.1 and 2.4.2) describe the specific forcing schemas that are relevant for this master's thesis.

2.4.1 9°C forcing schema

The most simple schema, and therefore the least complex one, is the 9°C schema. This schema is represented in an UML diagram, see Figure 3. This schema represents a supply chain process with similar characteristics to MTS. Once the bulbs have arrived at an organization, and once they have reached the 'G' stage, they are stored in controlled temperature rooms at 9°C for a cultivar specific amount of weeks. This schema is based on the forecasting of an organization; the organization judges that there will be enough market demand at the moment of the completion of the cooling period.

The only uncertain variable in this schema is the date on which the bulbs reach the 'G' stage: $Date_{`G'stage}$. The 'inbetween' temperature and cooling period are set per cultivar and therefore known in advance (De Hertogh, 1974). If the date of the 'G' stage is determined, the earliest possible delivery date can be determined using Equation 1.

$$Date_{Delivery} = Date_{`G'stage} + Days_{`inbetween'temperature} \quad (1)$$

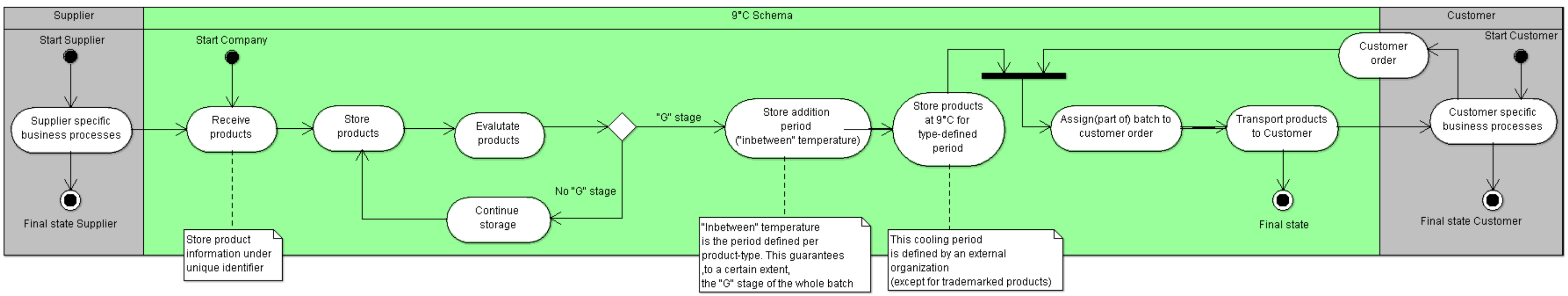

Figure 3: Representation of the 9°C schema

2.4.2 5°C forcing schema

The 5°C schema is the reverse of the 9°C schema. The 5°C schema is represented in Figure 4.The main difference with the 9°C schema is that the cooling period is determined by the forcer. There are, like with the 9°C schema, given cooling periods per cultivar. The forcer determines the cooling period manually, to adapt it to customer specific demands and customer specific environmental conditions. For example, if the customer demands potted plants with short stems, the cooling period should be shorter. The environment in which the bulbs will be planted is also taken into account in this schema. If the customer lives in a cold environment the cooling period at the forcer could be reduced and vice versa. Therefore, the order is placed firstly to set the demanded delivery date, and after this is determined when the bulbs should have reached the 'G' stage. This date of reaching the 'G' stage is determined using Equation 2. Equation 2 comes with two uncertain variables: $Days_{cooling}$ and $RequiredDate_{`G'stage}$. These two variables can not be determined before the order is placed. Like with the 9°C schema, the 'inbetween' temperature is set per cultivar.

$$RequiredDate_{`G'stage} \leq Date_{Requesteddelivery} - Days_{`inbetween'temperature} - Days_{cooling} \quad (2)$$

The 5°C schema is an order driven process, the forcing starts after the placement of the order. Therefore, the 5°C schema represents a supply chain process with similar characteristics to MTO. This 5°C schema is uncertain due to a couple of factors:

1. The $Days_{cooling}$ is only known when an order is placed
2. The $Date_{Requesteddelivery}$ is only known when an order is placed
3. Once the $RequiredDate_{`G'stage}$ is known, it is possible that this cannot be satisfied since it is highly uncertain when bulbs get to this stage (De Hertogh, 1974)

Like stated earlier, determining the 'G' stage of a bulb cannot be done in advance. Therefore the 5°C schema requires a lot of knowledge of the different cultivars. Experts are capable of estimating when the earliest 'G' stage date will be. Since it is an estimation, it is possibly not entirely accurate. Therefore a situation can occur in which the requested delivery date is postponed.

2.4.3 Generalized process model

In order to make the processes of Sections 2.4.1 and 2.4.2 broadly applicable they have been generalized, see Figure 5. During this generalization, information about several types of supply chains have been used to determine general characteristics of supply chains (Li and Womer, 2012; Rafiei and Rabbani, 2012; Meisel and Bierwirth, 2014; Harrod and Kanet, 2013; Ioannou and Dimitriou, 2012; Su et al., 2010). From this exploration MTS and MTO turned out to contain all general characteristics of supply chains, since all other supply chain processes are based on them. Therefore, the generalized model is able to support general processes like MTS and MTO, as well as the specific processes.

The process as represented in Figure 5, starts with the placement of a customer order. This can be handled in three different ways. The first one is (direct) reselling. This means that the products are received and directly stored. After storing the products they are directly sold, without the need for production. The second way is the selling of products which are produced in advance. This is the MTS process. Final products are produced based on forecast. Once a

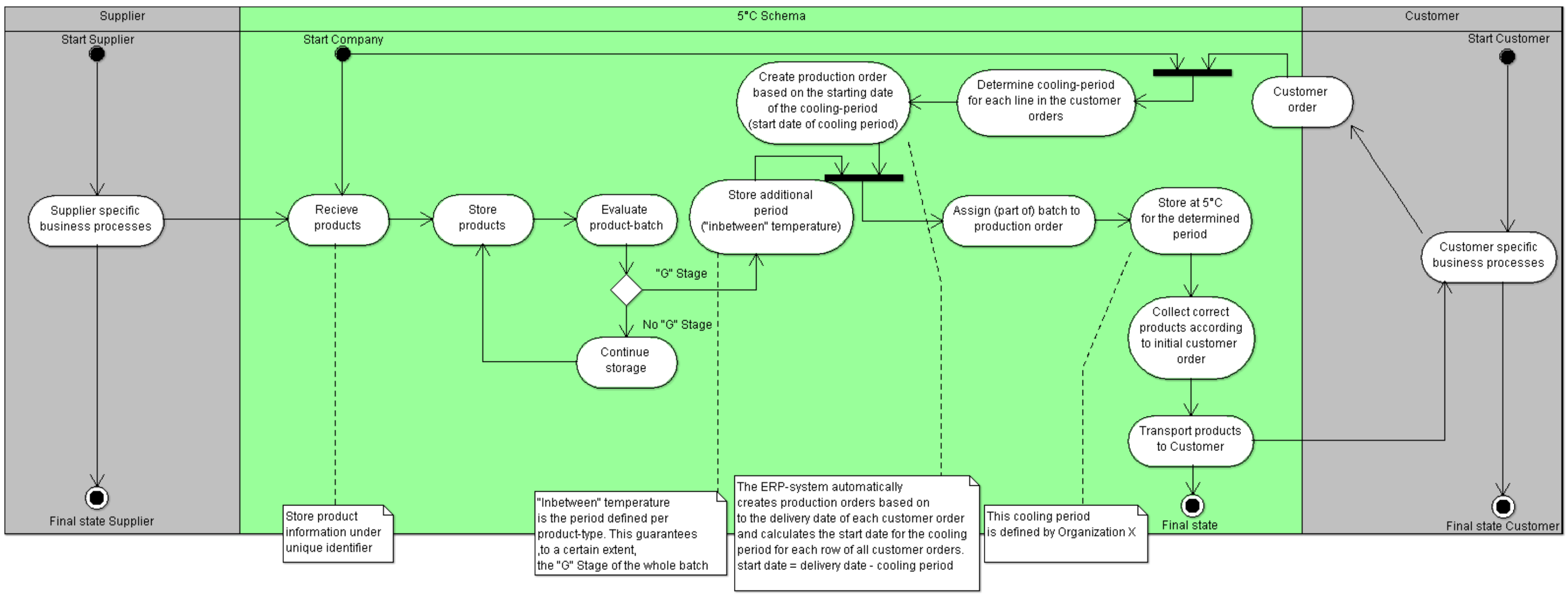

Figure 4: Representation of the 5°C schema

customer order is placed, the product can be directly sold from stock. The last way is based on MTO. Once a customer order is placed, the availability of the required products is checked. If the products are not available they are requested at the supplier. Once the products are received they can be used for production. Before the products go into production, it is checked whether their properties satisfy the required properties (e.g. 'G' stage, expiration date, etc.).

In Section 3 the generalized bulb forcing process of Figure 5 will be compared to the general model of supply chains in ERP systems of Figure 1.

2.5 Re-scheduling

Since the generalized process of Figure 5 is subject to uncertainty due to the biological nature of the raw material, re-scheduling needs to be considered. First an initial schedule of the process is set. This initial schedule is determined using the schemas as defined in the previous section. Re-scheduling is needed once the schedule of the process differs from the expected schedule (Gomes et al., 2013). Gomes et al. (2013) introduce this as predictive-reactive scheduling. Predictive-reactive scheduling consists of two steps (Gomes et al., 2013). The first step is the generation of the (initial) production schedule. The second step is the updating of the production schedule in response to a disruption or other event.

Predictive-reactive scheduling requires a re-scheduling policy to determine the initiation and the boundaries of the re-scheduling (Gomes et al., 2013). According to Gomes et al. (2013), there are three different kinds of re-scheduling policies. Those three policies will be described to show their characteristics. Based on those characteristics a re-scheduling policy for the generalized process of Section 2.4.3 will be introduced in Section 2.5.1.

The first policy is the so called event-driven re-scheduling policy (Gomes et al., 2013). This policy bases the re-scheduling of the production on events (e.g. order cancellation, delay in arrival of materials, etc.) (Gomes et al., 2013). However, when a high number of events occurs, the system can end up in a permanent state of re-scheduling, showing the pitfall with this policy (Gomes et al., 2013). This will make the system very instable. Therefore the events that are taken into account should be thoroughly considered, in order to prevent such a permanent state of re-scheduling (Gomes et al., 2013).

The second re-scheduling policy is the periodic re-scheduling policy (Gomes et al., 2013). This policy is an interval based policy. The production is checked on a specific interval to consider whether re-scheduling is needed (Gomes et al., 2013). This prevents the system from getting into a permanent state of re-scheduling since re-scheduling is done on set intervals instead of based on events. In order to apply the periodic re-scheduling policy it is relevant to determine the optimal re-scheduling period (Gomes et al., 2013). If this period is not well defined, the process might stall for a long period of time because the planning is not revised until the next period (Gomes et al., 2013). Therefore the third policy is introduced: the hybrid re-scheduling policy. This policy combines the interval of the periodic re-scheduling policy with the triggers of the event-driven re-scheduling policy (Gomes et al., 2013). This means that re-scheduling is done at a determined interval and at special and/or major events (Gomes et al., 2013).

According to Gomes et al. (2013), re-scheduling can be done using three general methods: right shift scheduling, partial re-scheduling and complete re-scheduling. Right shift scheduling is 'shifting' the remaining production to the right until it is feasible (Gomes et al., 2013). This means that the production is postponed until it is possible to be executed (Gomes et al., 2013). Partial re-scheduling is re-scheduling the production in such way that only the

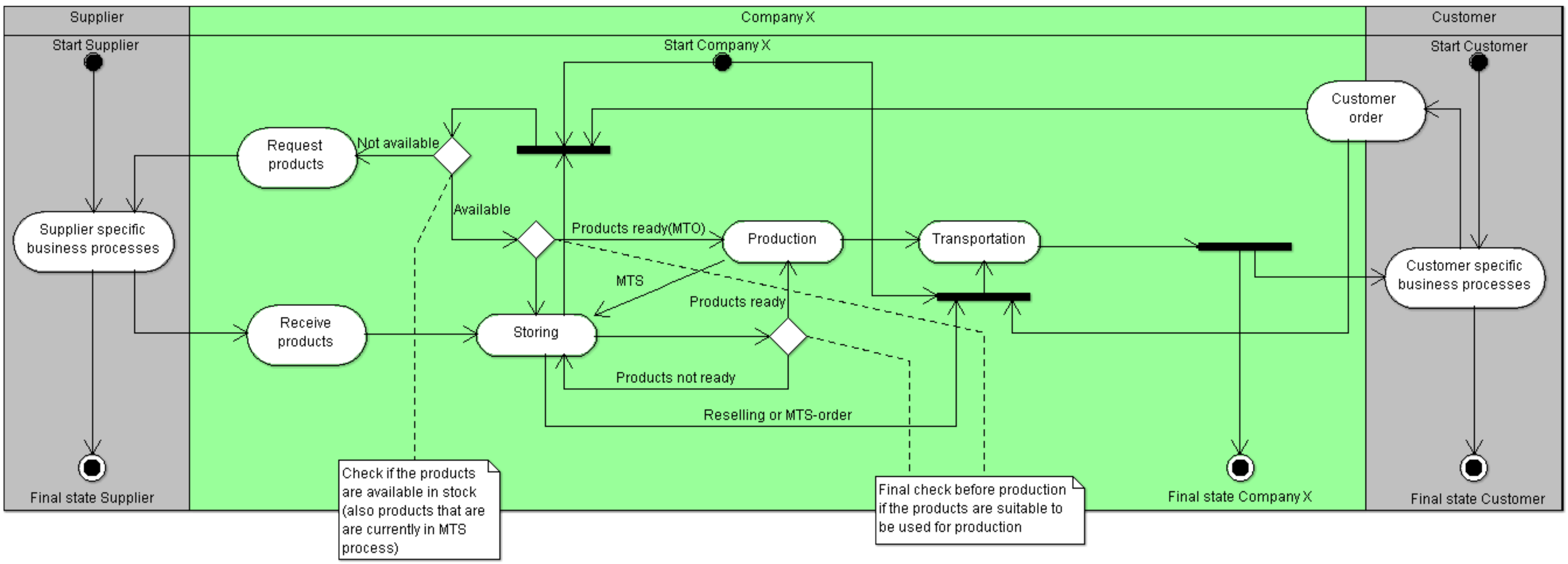

Figure 5: Generalized process model

affected productions are changed (Gomes et al., 2013). The productions that were not affected will remain planned according to the initial schedule (Gomes et al., 2013). The last method is complete re-scheduling, which completely reschedules each planned production (Gomes et al., 2013).

2.5.1 General model re-scheduling policy

For the process described in Section 2.4.3, a hybrid re-scheduling policy will be introduced. Hybrid re-scheduling is chosen because of the occurrence of events and constraints that have to be checked regularly. First of all, there are several triggers that require re-scheduling:

1. **New order:** A new order impacts the schedule. The schedule of related orders (e.g. same raw materials, same production period, etc.) should be reconsidered. This is in alignment with the partial re-scheduling method.

2. **Order cancellation:** If the order gets cancelled, either by the customer or by the organization, it should be considered if the schedule requires a change. This is only relevant for related order (e.g. orders that require production in the same period). Therefore the partial re-scheduling method can be used to determine a new schedule.

3. **Change in the order:** Once the order gets changed the schedule should be reconsidered to check if the schedule is still in accordance with the new demands. This can be done using the partial rescheduling method. Only the affected productions are adapted to the changes if needed.

4. **Raw materials not available**: This can be overcome by applying the right shift scheduling method. The production should be delayed until the raw material is available. Additionally, the order can, in agreement with the customer, be changed. In this case a change in the order (trigger 3) will occur. Once the order cannot be changed, the remaining solution is covered in the second trigger; order cancellation. The customer should get notified that the order could not be completed according to their preferences and that their order therefore will be cancelled.

5. **Raw material not in 'ready' state:** This is similar to the previous trigger: raw materials not available. In order to overcome this the right shift scheduling method should be used. The production should be shifted to another moment in time in which the raw material is in the 'ready' state.

The first three triggers are events that might cause re-scheduling. Once the events do not interfere with the current planning, they can be added to the current planning. Otherwise, re-scheduling is needed in order to plan the production to ensure that all products are produced in time. The last two triggers can occur as event and they can be checked regularly. These triggers occur as event once a production has to be started. In order to prevent the occurrence of those two triggers, they can be checked regularly. On a regular base it can be checked if there is sufficient raw material to supply the (expected) demand. Additionally, estimations can be made to determine when the raw material will get in the 'ready' state.

3 Comparison

In this section the general models of Figure 1 and Figure 5, representing the standard way of handling the supply chain and the generalized supply chain for processes like bulb forcing respectively, will be compared.

3.1 General

In the models of Figure 1 and Figure 5, no major differences can be found. The most impacting difference, is the additional check executed before products enter the production phase of the whole business process. The flow of internal orders, as shown in Figure 1, is not taken into account since this master's thesis focuses on customer orders.

Additional checks before products enter the production phase, are usually done without the interference or support of ERP systems. Since ERP systems are developed to support all kind of markets they usually do not (completely) support market specific checks. Customization enables ERP systems to support market specific checks. Therefore, it should be considered if the customization of ERP systems will lead to an improved business process. In order to determine if implementing the market specific checks in an ERP system would be profitable, the impact of the checks on the complete business process should be determined. In order to determine the impact of the checks on the business process, the following factors are considered before and after the implementation of market specific checks:

1. Impact on process continuation
2. Amount of manual labor time (before and after implementation)
3. Risk of errors
4. Occurrence of the check(s)

These factors are considered to be important to determine the necessity of customizing the ERP system to support market specific checks.

The first factor, impact on process continuation, requires a thorough analysis of the impact of the checks on the continuity of the whole business process. It should be determined to what extent the checks can improve, stop or delay the whole business process. This directly determines the importance of the checks. Once the checks are required for the continuation of the whole business process, it is highly recommended to implement such checks in the ERP system. The checks can, in such case, be implemented as a constraint in the ERP system. Without satisfying this constraint, the business process will not continue. If the market specific checks are recommended but not required, one or more of the other factors will determine if the implementation of the checks in the ERP system is necessary.

The second factor is the amount of time spending on manual labor that is required to execute the market specific checks. The amount of time that could be saved after the implementation of the check in the ERP system should be considered. If no or minimal improvement is made in the amount of time spending on the checks, it should be considered if it is worth to implement the checks in the ERP system. One consideration could be the availability of information.Crucial information might be gathered during the checks, which can be valuable for the rest of the business process.

The third factor is the error chance. Since market specific checks are usually not supported by the ERP system, these market specific checks are dependent on manual labor. Manual labor results in a higher error chance. Data might be lost or checks might not be performed in accordance with the required characteristics. Errors might lead to faulty products, which might lead to a decrease in customer satisfaction. Therefore it is recommended to consider the reduction in error chance.

The last factor is the occurrence of the checks. It should be considered if it is profitable to implement the checks in the ERP system regarding the occurrence of the checks. Since customizing ERP systems is costly, it should be determined if the investment is worth the return. Checks with a high occurrence will relatively have a shorter payback period. This means that the implementation of checks will become profitable over a shorter period of time.

3.2 Handling uncertainty

The model from Figure 1 is applicable to most production processes. Due to the occurrence of uncertainty, some market specific processes are not (completely) supported by the model of Figure 1. In order to handle the uncertainty introduced by these market specific processes, the model should be adapted. An example of such market specific processes is the bulb forcing process, described in Section 2.4. In order to support this process, processes that are represented in Figure 3 and Figure 4 are needed. In order to make these specific processes more broadly applicable, a general model is created, in Figure 5.

Although the two models of Figure 1 and Figure 5 look very similar, the standard integrated processes of ERP systems are only capable to partly support such market specific processes. In order to make the ERP systems completely support such processes, market specific layers should be developed (Verdouw et al., 2015). There is no need to completely redesign the processes in the ERP systems, since they are capable to support most parts of the market specific process. The main difference between the standard processes and the process of Figure 5, is the fact that there is an additional check before products enter the production phase. Normally, ERP systems work according to the following principle: once products are on stock they can be used for the production without the need for an extra check. Once uncertainty is involved in the process, the products should be checked according to specific characteristics. These characteristics can vary from market to market. For example, in the bulb industry bulbs should have the so called 'G' stage before they can enter the production phase (De Hertogh, 1974), and in the fresh product industry products should not be perished (Ahumada et al., 2012). So the model of Figure 5 is applicable to the processes in which the raw materials require certain characteristics before they are accepted in the production phase.

There are several general characteristics related to the raw materials:

1. **Quality** (e.g. no damage, not perished (Ahumada et al., 2012))
2. **Material changes** (e.g. morphological characteristics as stem length and coloring (De Hertogh, 1974; Sønsteby et al., 2013)).
3. **Customer requirements/satisfaction**

The first two point can be programmatically handled, because these are characteristics that can be determined using mathematics. Therefore they can be integrated into an ERP system. The third point is based on the organizations knowledge of their customers. Once an organization has good knowledge about a specific customer, they will be capable to determine to what extent a customer is willing to accept less quality or (slightly) different products for on-time delivery. It can also be the other way around, the customer might be willing to accept a delayed delivery for the right products at the right quality. The ERP system is only able to support this third point by storing information related to the customer for reference. However, the system will not be able to exactly determine the balance between customer requirements and customer satisfaction.

The first characteristic; quality, is logically derived from production processes. Because the quality is subconsciously checked, a faulty raw material will not be used for a product because this will lead to faulty products. Material changes are changes that need to occur or to be applied to the raw materials before they can enter the production phase. These changes can also been seen as a production process on itself; it is similar to the production of parts of the final product. The production of computers can be taken as an example, because computers are assembled from standard components (Dellaert Benedict et al., 2004). These standards components also need to be produced, which is called 'subassembly' (Li and Womer, 2012).An example of subassembly is the morphological transformation of bulbs: the biological process within the bulb continues while in stock (De Hertogh, 1974). Another example is the creation of standard components for computers within the same organization.

The processes integrated in ERP systems handle products that are in stock, as available for usage in any other process. This is due to the fact that once products are received, checks have to be performed to accept the delivered materials. Once those materials are accepted, they are seen as available without the need for further checks. Some materials, especially biological materials like food or plants, decay over time (Ahumada et al., 2012) or require time to continue their development in stock (De Hertogh, 1974; Sønsteby et al., 2013). This introduces the need for a process which is able to cope with uncertainty.

In the process of Figure 5 uncertainty is covered with the check if the products are ready for production. This check will be performed as a trigger in the re-scheduling policy described in Section 2.5.1. Once the products are not ready in time, the production planning has to be revised. If the delivery date changes, this has to be done in consultation with the customer, or with the third characteristic (customer requirements/satisfaction) related to the raw materials as described before.

4 Framework

In order to handle similar processes, a framework will be proposed for the implementation of such a process. First of all, it should be considered if the custom processes should be implemented. This consideration can be guided by the factors listed in Section 3.1. These factors will determine if the implementation will be needed for the organization: impact on the further process, amount of manual labor time (before and after automation), error chance, and occurrence of the process. The last three factors are the most easily determined, since this can be done mathematically. Determining the impact on the further process is a more complex task. Since these processes are market specific, it should be considered what the impact is on the whole business process.

Secondly, the market specific process should be discussed with the ERP manufacturer in order to determine the requirement of the ERP system for the implementation of the process. The determined requirements should be ordered according to their necessity. This ordering can be done using the MoSCoW acronym (Van Vliet et al., 1993). The acronym stands for the following prioritization (Van Vliet et al., 1993):

1. **Must haves** – requirements must be implemented.
2. **Should haves** – requirements are not absolutely needed, but highly desirable.
3. **Could haves** – requirements are nice to have.
4. **Won't haves** – requirements are not needed.

This prioritization will determine which requirements have to be implemented and which do not have to be implemented. During the iterative discussions between the organization and their ERP manufacturer there should eventually be a clear and demarcated list of requirements. During the determination of the requirements, the market specific characteristics should be guiding in the prioritization of the requirements.

Thirdly the representation in the ERP system should be considered. This should again be settled during iterative discussions between the organization and their ERP manufacturer. Since it is a customization, the characteristics determined by the user should be guiding. Since there could be limitations in the applicability of those characteristics in the user interface of the ERP system, alternatives can be determined in consultation between customer and ERP manufacturer.

Next the initial implementation of the market specific process should be tested. A specific testing environment should be created in which the organization can test if the implementation satisfies their needs. This testing will result in some adjustments to the initial implementation. Before the testing phase it should be determined what the criteria for acceptance are. These criteria determine when the testing period can be completed. Until acceptance is reached, the implementation will be revised in an iterative way. In each iteration the implementation will be revised in order to satisfy the criteria for acceptance.

Once the testing phase is done, the process should be transferred into production. This is when the organization actually starts to use the newly implemented process. During this phase it is still possible that the organization finds out that choices made during the previous steps are negatively influencing the process and should therefore be revised. Customizations are usually not included in the updates of the ERP system. Due to this it might occur that the process requires continuous checks if it still fits with the other processes of the ERP system. Due

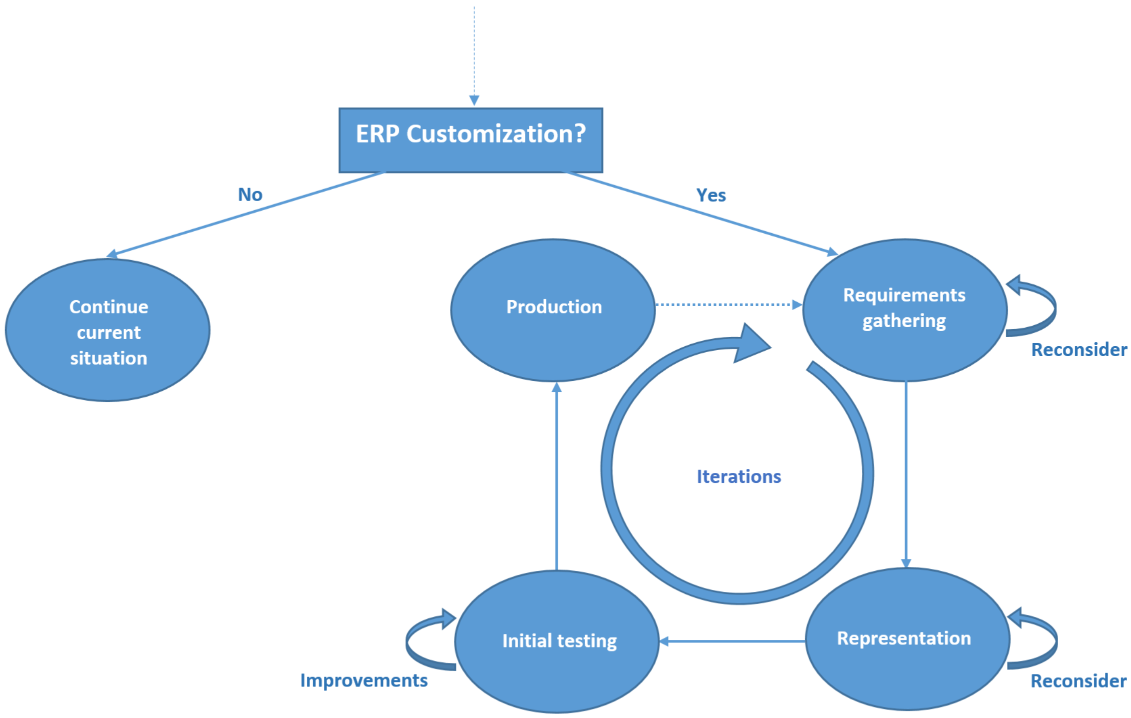

Figure 6: Framework

to this, customizations always turn out costly, because it requires continuous reconsiderations. Therefore the consideration if the customization is necessary should be thoroughly done.

Once a company has decided that the ERP system has to be customized for supporting the market specific process, the steps, as described in the previous paragraphs, are iteratively repeated. These steps are represented in Figure 6. This iterative way of working is similar to the way of working in SCRUM method. SCRUM is a method for agile software development (Permana, 2015). The SCRUM process is represented in Figure 7.

During the creation of the framework of Figure 6 some similarities with SCRUM were noticed. Therefore the suggested framework is briefly compared with SCRUM. Since the implementation of a market specific process is in fact the development of new software, the similarities with SCRUM are not exceptional. Since SCRUM has been proven as successful software development method (Van Vliet et al., 1993), we consider that the fundamental of the proposed framework is suitable to be applied to similar processes like described in Section 2.4. The iterative way of working will allow the process to be fine-tuned with each iteration. Therefore it is possible that pitfalls that where not recognized in an early stage will be solved in a later iteration.

The first step of the suggested framework is similar to the product backlog of the SCRUM process. The product backlog is a list of requirements. These requirements are ordered according to importance.

The next step in the suggested framework is the representation. This step considers how the flow of information, that results from the requirements, should be represented in the ERP system. In the SCRUM process this is done during the 2 weeks sprint. There the requirements determined in the product backlog are implemented and formed into a shippable product.

Figure 7: SCRUM process, taken from (Permana, 2015)

During the sprint review of the SCRUM process is reviewed what is or what is not done during the current run. In the suggested framework this is done in the testing step. That is where the created functionalities are tested. Once problems are recognized the product backlog is reconsidered and the process starts again. If there are not further problems, the product can be transfered into production.

The sprint retrospective of the SCRUM process is a review on the complete process. In the suggested framework this happens once the product has been implemented after testing. There might still be some additional demands from the organization which should be implemented. As long as the product is not considered to be complete the process will start over in a new iteration.

5 Case study

This case study will be based on one of the largest flower bulb export companies in the Netherlands, for this research called Company X. Even though Company X is one of the largest flower bulb export companies in the Netherlands, it is still categorized in the SME's. Company X was founded in 1898, in the middle of the flower bulb region in the Netherlands. They started off in France and Belgium and expanded to Scandinavia, Eastern Europe and Germany. In the beginning of the 20st century they started to sell flower bulbs to a few customers in the Middle East. The products vary between pre-packed and loose bulbs to a lot of different customers, like town halls in France and wholesalers in China. The particular point of interest for this case study is the breeding of bulbs. Breeding of bulbs enables Company X to determine the blooming of the bulb. This determination gives certainty for the customer that they will have flowers at a specific moment in time. For example, for a special event a customer is required to have flowers, but normally they do not bloom at that specific moment. Due to the breeding of bulbs, the customer will be able to have flowers at that specific moment. This is because the biological process of the bulbs is manipulated in such way that they will grow at the required time.

5.1 Current situation

Figure 1 represents the current flow of processes within Company X. Since the implementation of ERP systems is still limited in agriculture (Verdouw et al., 2015), Company X has been restrained in exploiting the possibilities of the ERP system. Resulting from this, the initial implementation of the ERP system within Company X has been relatively simple. Over the years, the importance of exploiting the possibilities of the ERP systems has been recognized. Time and money are (eventually) saved by supporting business processes with the ERP system. Therefore, the ERP system has been customized more and more in order to support the market specific processes of Company X.

The current lack in exploiting the possibilities of the ERP system has two causes. The first one is a change in management as explained earlier; a younger generation has become part of the management of Company X. This younger generation has more knowledge about the importance of IT within the organization. The second cause is the rising governmental demands in the agriculture. The government requires organizations in the agriculture to strictly register all proceedings done with products within the industry. ERP systems can be used for the registration of all proceedings with products. In this way, the export of the products can be executed better, because there is precise administration of the origin of each product. Another advantage of this is that eventually the quality of the products can be guaranteed. In this way, the organizations in agriculture are forced to implement or exploit IT systems.

5.2 Customization consideration

Currently the most general business processes are supported by the ERP system of Company X. The management of Company X realizes that the ERP system enables the business processes to become more effective and efficient. Less time is for example spent on administrative tasks. Therefore, more time can be spent on the more profitable tasks. The management recognizes that the process that gives Company X a competitive advantage, has the least support from IT. This particular process is the bulb forcing process as described in Section 2.4.

Since bulb forcing is a market specific process, thorough consideration is needed to determine the way this process should be implemented in the ERP system. Company X first considered what the optimal implementation would look like. After they determined the optimal implementation, they discussed this with the manufacturer of their ERP system. Since the ERP manufacturer's perspective was more technical, some pitfalls were recognized. Therefore the suggested implementation had to be revised several times in order to find a proper compromise for both sides. The ERP manufacturer wanted a compromise, which might be reusable later on for other applications. The management of Company X was looking for a solution that tightly fits their process. The actual solution was a compromise of those two considerations.

The most important reason for the management to decide that the process of bulb forcing should be implemented in the ERP system, is the amount of time spent on the process. The amount of manual tasks should be reduced and administration should be kept in the ERP system. In the current situation all information is manually written on sheets of paper and kept in a folder. The ERP system has no availability to this information and is therefore not capable to support the process. The first step is to move this information into the ERP system. This ensures an easier retrieval of information for the employees, since they do not have to browse a complete folder to find the correct information. Next to that, the ERP system will be able to give recommendations for the forcing of the bulbs. These recommendations are nowadays performed manually. Based on the date of the 'G' stage of the bulbs, it can be determined which batch of bulbs can be used for a particular customer order. This can be done by using equations like Equation 1 and Equation 2. These equations can be implemented in the ERP system to give recommendations to the user without the need of manual labor.

Since bulb forcing is based on biological products, the ERP system will not be able to directly assign a batch of bulbs to a customer order. Specific market knowledge is needed in order to assign the correct batch of bulbs to a customer order. Company X has a couple of employees who have gained knowledge over the years. They are capable to estimate the characteristics of the bulbs based on the supplier and the place where the bulbs initially grew. They also know the environmental conditions at the customer, which has an influence on the bulbs. Since this is such specific and complex knowledge, the user of the ERP system has to determine which of the recommendations generated will be assigned to a customer order.

Information that should be stored is based on Equation 1 and Equation 2. This means that the date of reaching the 'G' stage should be stored per batch of bulbs. Next to that, the amount of required cooling weeks for the 9°C schema should be stored per specific cultivar. These cooling weeks can be found in an online database which is accessible by Company X. Last, the 'inbetween' temperature period should be stored per culitvar. These 'inbetween' temperature periods can be found in the same online database. Based on these three characteristic, recommendations can be created and represented to the user. The user of the ERP system then has to decide which of the recommendations fits the best with a particular customer order based on their knowledge. For example, it might be that two batches of bulbs fit a customer order equally well, but one batch is from clay and the other from soil. If the customer prefers clay over soil, and this is known by the employee of Company X, the batch from clay will be assigned to that specific order.

The recommendations given by the ERP system provide a lot of support to Company X. Especially in the beginning of the season when there is a very limited amount of batches of bulbs with the required 'G' stage. Later in the season there will be more batches available with the 'G' stage and therefore it will be less complex to assign batches to customer orders.

Competitive advantage is gain by being able to sell batches of bulbs earlier than the competitors. Therefore, if the ERP system is capable to clearly represent which batches are in the 'G' stage, Company X will be able to sell those batches as early as possible.

Storing the information about 'G' stage date, cooling weeks and 'inbetween' temperature period will save a lot of manual tasks within Company X. Equation 1 and Equation 2 are performed manually. Besides the fact that computers can do this faster, the error chance is lower. The only point where there might be an error is at the entering of the data. Entering data will remain a manual task and is therefore still error prone.

Besides the reduction of manual calculations, the amount of time spent on information retrieval is also reduced. Since all data is stored centrally in the ERP system there is no need for the user to browse folders. Besides that, only the necessary data is shown at the point where batches have to be assigned to a customer order. Now the user has to browse all batches to see if there are batches with the required characteristics. Once the process is implemented in the ERP system, the user only has to make a choice from preselected batches from which is certain that they match (within a certain range) the required characteristics. So by implementing this process in the ERP system, the whole manual search for satisfying batches can be eliminated.

Additionally, the central storage of information about the batches of bulbs provides better support for customer service. Company X will be more capable to serve their customers with information. Once the information is stored in a database it will be available until deleted. This means that information about a particular batch, also historical information, can always be found. Resulting from this, Company X can provide their customers with specific information about the batches. This means that once a customer has a complaint, it will be possible to find back the cause of the complaint. With the use of manual stored information it will be very hard to lead back to the cause of the complaint, since most of the time the information is not available anymore. With this information in the database, the company can find out if an error occurred in the process of Company X, or if the customer made mistakes during the further handling of the batch(es) of bulbs.

5.3 Application of the framework

In this section, the suggested framework of Section 4 will be illustrated using the previously introduced case. This will show how the framework has been developed from practice to a generalized framework. For each step in the framework the considerations will be explained using the practice from the case.

5.3.1 Considering ERP customization

The first step in the framework is the consideration if the ERP system should be customized or not. Since the bulb forcing process is one of the main processes in Company X, there was little consideration needed because too much time is lost in the current situation, due to manual labor, in the existing situation. Organization X recognizes that once the ERP system would get customized the amount of manual labor would decrease.

There would still be need for manual labor, since the employees have specific knowledge that would be too complex to integrate effectively into an ERP system. This knowledge is mostly based on experiences of the past years. Employees can determine to what extent a particular customer will be satisfied with slightly different products, or how bulbs from a specific supplier react on the environmental circumstances at the customer.

Since Company X realized that supporting the bulb forcing process with the ERP system would improve the whole business, they have decided to implement a customization of their ERP system. This decision is made in accordance with their ERP system manufacturer. The ERP system manufacturer functions as a consultant for Company X, since they have a thorough understanding of the business. Additionally, the customization can be combined with other requests for customizations, e.g. representation of batch specific characteristics like origin and acidity. In this way the customization will not only impact this market specific process, but a broader spectrum of market specific demands.

5.3.2 Requirements gathering

The requirements for the process were quickly defined. As seen in Section 2.4, the process is clearly defined. That makes it easier to transform it into an abstraction. This abstraction will be translated to business logic in the ERP system. The most complex part is the correct administration of the required information. For each particular batch of bulbs the following information should be stored: date of reaching the 'G' stage, cooling weeks for the particular temperature and the 'inbetween' temperature.

Once the information is stored correctly, it can be used for calculations. The calculations will determine if a batch of bulbs will be usable for a particular customer order. Since it is possible that multiple batches might be suitable for a customer order, the explicit knowledge of the employees of Company X is deciding. So the ERP system will make recommendations, not the actual decision. Based on these recommendations the employees can make their decision.

5.3.3 Representation

Making an ERP system suitable for a market specific process is not only about functionality of the system. It is also about the representation of the information needed and used for the process. Therefore the representation of the information of the process within the ERP system should be considered.

Since Company X already partly uses the ERP system to support the bulb forcing process, they had a clear view on the representation of the relevant information. Just like the functional requirements this was discussed with the ERP system manufacturer. In this case the ERP system manufacturer directly agreed with the suggested representations. This was due to the fact that most of the suggested representations could also be used for other customization requests.

Considering the representation will not always be as easy as in the case of using the ERP system to support the bulb forcing process in Company X. For example, the suggested representations might not be possible due to limitations of the used components in the ERP system. Therefore this step is suggested as iterative in the framework. Then it will be possible for a company and ERP system manufacture to come to an agreement which will be the best possible for both.

6 Results

This section will be organized as follows. First the findings of the comparison between the generalized model of the bulb forcing process with MTS and MTO will be described. This will be followed by an analysis of the application of the suggested framework (Section 4) to the case study of Section 5.

6.1 Comparison

The comparison executed in Section 3 showed that no major differences can be found between the generalized model, based on the bulb forcing process, of Figure 5 and MTO and MTS as modelled in Figure 1.

The differentiating factor in the generalized model is the additional check stage before products enter the production stage. These checks are required to determine if the products satisfy market specific characteristics. The specific characteristic is that bulbs should have the 'G' stage in the particular case of bulb forcing, but this differs per market. Since there is only a minor difference there is no need to completely revise theERP system. Creating a market specific layer to support the additional checks is sufficient.

The introduction of the additional checks comes together with the introduction of uncertainty. In this case the uncertainty is related to characteristics of the raw materials used in the process. In Section 3.2 there are three main characteristics defined: quality, material changes and customer requirements/satisfaction. The first two points can be based on characteristics and mathematical approaches. But the third, customer requirements/satisfactions, is the one that is based on specific knowledge that is available in the company. This is information and knowledge that cannot be programmed in an ERP system. Due to this, the process can never be fully supported by the ERP system. Therefore the ERP system will only be capable to give suggestions. Those suggestions have to be analyzed by an employee. This employee has got the capabilities to interpret market specific knowledge. Based on this market specific knowledge, the employee will determine which suggestion of the ERP system will be used.

In order to determine if an ERP system should completely be revised or that a market specific layer is sufficient, the impact of the differences from the standard processes should be determined. Section 3.1 suggests four factors which should be considered to determine the impact on the business process. The type of customization should be determined based on the impact.

6.2 Application of the framework in practice

Applying the suggested framework to practice resulted in some insights. For each stage of the suggested framework the experiences will be described.

6.2.1 Customization consideration

As described in Section 5.3.1, there was limited need for considerations. The bulb forcing process is one of the main processes of Company X. Too much time was lost, due to manual labor, in the existing situation. Therefore, Company X decided, in consultation with their ERP manufacturer, that customization would improve the process in such way that it would be beneficial.

Determining if customizing the ERP system is beneficial will not always be this clear. Therefore some factors are described in Section 3.1 which helps determining the impact of the process on the complete business process.

6.2.2 Requirements gathering

The gathering of the requirements for the customization of the ERP system to support the bulb forcing process, was done in a short time. This is due to the fact that the process is well documented (e.g. De Hertogh, 1974). Based on this documentation the characteristics of the bulb forcing process could be described in Section 2.4. Besides the documentation, Company X had internally discussed how the bulb forcing process should be supported by the ERP system. This resulted in requirements which could be prioritized using the MoSCoW acronym.

Setting the initial requirements is an essential step in the process. Since market specific processes are mostly not documented, they should be thoroughly analyzed before the requirements can be determined. Since the process is iterative, requirements that are overlooked can be added in a later stage.

6.2.3 Representation

Once the requirements have been set, the flow of information of the process is known. Not all of this information is relevant for user of the ERP system. Therefore the representation of the information should be considered. It should be decided what information is relevant for the user, and how it should be represented.

In the particular case of Company X, the representation was settled after a couple of meetings with the ERP manufacturer. Company X had considered what information would be relevant for them and how that could be represented in the ERP system. Based on that view, the ERP manufacturer checked what they could do within the restrictions of the used components in the ERP system. After several conversations both parties agreed on a joint representation of the information.

7 Discussion

Using the knowledge from the theoretical framework, the suggested framework and the application of the framework in the case study, the research questions will be discussed.

The main research question of this master's thesis is: "*how to implement market specific processes, with similar characteristics to the bulb forcing process, in an ERP system?*" The exploratory study executed in this master's thesis suggests that market specific processes, with similar characteristics to the bulb forcing process, require a market specific layer. This market specific layer will contain the minor differences between standard production processes supported by ERP systems and the market specific process. In Section 4 a framework is suggested, which can be used as a guideline for the implementation of a market specific process.

The bulb forcing process is similar to MTS and MTO. Therefore the generalized model of the bulb forcing process (Figure 5) has no major differences with MTS and MTO. MTS and MTO are considered to be the general production processes, which are supported by most ERP systems.

Processes with similar characteristics will have a similar approach when they have to be implemented in an ERP system. Since the suggested framework is only applied on one case the framework should be applied to more cases in order to determine if it is broadly applicable to all kinds of market specific processes.

In the following subsections the sub-questions will be discussed.

7.1 MTS & MTO in ERP systems

Based on the knowledge gained during the literature review in Section 2, it could be concluded that MTS and MTO are broadly supported by a wide variety of ERP systems. MTS and MTO are the most normal production processes known. Other processes are eventually based on (one of) these two. Therefore MTS and MTO were chosen as the standard production processes in this thesis. This was also recognized during the case study, since the ERP system supports both MTS and MTO.

MTS and MTO function as the standard production processes in the comparison, since their characteristics apply to a lot of production processes. The general applicability of these two processes simplifies the comparison between them and any market specific process. Since they are broadly applicable they are not biased towards any market or industry. Therefore any difference between them and a market specific process will identify the market specific part of the process.

7.2 Market specific process: bulb forcing

The case study of Section 5 is based on implementing bulb forcing in an ERP system. Bulb forcing is a market specific process in the agricultural industry. In short, this process covers the preparing of the bulbs in order to make them bloom at exact the right time. A more detailed description can be found in Section 2.4.

Using the characteristics of this process a generalization is made in Figure 5. This general model was used to determine the differences between the bulb forcing process and the standard production processes. From that differentiation can be concluded that the process of bulb forcing is mostly similar to the standard production processes.

There is one difference between the bulb forcing process and the standard production processes. This difference is the additional check before the products go into the production phase. This check is needed because the bulbs have to be in a so called 'G' stage before they can enter the production process. This 'G' stage can only be estimated in advance. The actual determination of the 'G' stage is a manual task. Due to the fact that the 'G' stage can only be estimated in advance, it introduces uncertainty in the process.

In order to handle the uncertainty introduced by the 'G' stage a general re-scheduling policy is suggested in Section 2.5.1. Based on this re-scheduling policy the uncertainty can be handled in the production process. Once the bulbs do not reach the 'G' stage in time, an event for the re-scheduling policy is triggered and the schedule of the production process will be adapted according to the determined rules in the re-scheduling policy.

7.3 Similarities between market specific processes and known production processes

In order to be able to determine what the customization of an ERP system should look like, the differences and similarities between a market specific process and the supported known production processes should be determined. In the specific case of bulb forcing, the additional check before products enter the production phase is the differentiating factor. The knowledge gained of the differentiating factors of the market specific process have to be used to determine the way the customization of the ERP system should be executed.

The differentiating factors determine the requirements of the ERP customization. These factors are not yet supported by the standard implemented production processes within ERP systems. Based on the amount and impact of the differentiating factors it should be determined if the ERP systems requires a complete rework, or the implementation of a market specific layer.

7.4 Re-scheduling a production process

Besides the fact that a customization of an ERP system should support the particular market specific process as good as possible it is also important to take re-scheduling into account. Re-scheduling occurs when certain conditions are met or certain events are triggered. For example, the shortage of inventory, which has an impact on the production process. A re-scheduling policy determines how the schedule of the production process is adapted to the event or condition.

The re-scheduling policy has to take into account the whole business process. Therefore it is important that the impact from the market specific process is on the business process, and vice versa. Customizing an ERP system goes behind just adding functionality in order to make it capable to support the market specific process. The whole business process should be considered and supported. Therefore it could be worth considering to do business with an consultant. Consultants are skilled to get insight in the business and might therefore be able to determine the characteristics of the re-scheduling policy.

The specific triggers for the re-scheduling policy have to be determined for each market specific process, since those have their own characteristics. In Section 2.5.1, a general re-scheduling policy is suggested which can be used as base to determine a re-scheduling policy for a market specific process.

Implementing a market specific process in an ERP system is not only about supporting the process, but also about considering external factors that could have an impact on that process.

7.5 Customizing an ERP system for supporting the bulb forcing process

The comparison in Section 3 and the experiences from the case study of Section 5 show that there are relatively small differences between the processes at hand and the bulb forcing process. Therefore, the customization of an ERP system for supporting the bulb forcing process is less complex than initially thought. The bulb forcing process is well documented, which makes the determination of requirements also less complex. Market specific processes are seen as 'common sense' within the market. The bulb forcing process is an exception, usually market specific processes are not (well) documented.

Based on the documentation, an abstraction of the bulb forcing process has been made, see Section 2.4.3. Based on this generalization it can be concluded that most of the generalized process is already supported by ERP systems. This is due to the fact that the general model of the bulb forcing process has only minor differences with MTS and MTO. Therefore, creating a market specific layer in order to cover these minor differences is sufficient for the customization of an ERP system for supporting the bulb forcing process.

In the case of the bulb forcing process, the market specific layer consists of supporting specific checks. These checks are executed before batches of bulbs enter the production phase of the process. These checks are dependent on specific characteristics of the bulbs. Once all characteristics are satisfied, the particular batch of bulb is considered to have the 'G' stage. The further execution of the bulb forcing process is based on this 'G' stage. The market specific layer for supporting the bulb forcing process is fully dependent on administrating this 'G' stage. Once this 'G' stage is known, the rest of the process is based on the equations in Sections 2.4.1 and 2.4.2. These equations should also be implemented in the market specific layer. These equations will determine the suggestions that the ERP system will give to support the employees of the organization. The rest of the bulb forcing process is similar to MTS and MTO. Therefore no further customization is needed.

8 Conclusion

ERP systems are developed to support organizations to their full extent. Since different organizations operate in different markets, ERP systems support standard processes. In order to support market specific processes, customization of ERP systems is needed. Implementing market specific processes can be done in two ways: complete customization or creating a market specific layer. The impact of the market specific process on the whole business process, will determine which way will be used for the customization of the ERP system.

In this master's thesis the focus is on SCM, in particular production processes. For production processes, production planning is important. Therefore re-scheduling is considered in order to handle uncertainty within production processes. Re-scheduling policies guide production planning once unforeseen events occur and the planning has to be revised. This is important because producing products is not only about creating the right products, but it is also about delivering the product in time.

MTS and MTO are supported by most ERP systems, therefore they are considered as the standard production processes. In order to determine how market specific production processes should be implemented in an ERP system, they should be compared to MTS and MTO. With this comparison the differences can be considered, and it can be determined how the ERP system should be customized.

The market specific production process analyzed in this master's thesis is the bulb forcing process. The generalized model in Figure 5 shows that there is only a minor difference with the standard production processes MTS and MTO. Due to this minor difference, a market specific layer is sufficient for the customization of the ERP system. Therefore, in the case of market specific processes with similar characteristics to the bulb forcing process, a market specific layer is sufficient. This market specific layer will cover the gaps between the integrated process in the ERP systems and the market specific process.

Since customizing ERP systems is somewhat similar to developing a new software system, the suggested framework for customization consists of steps similar to the software development method SCRUM. The suggested framework can be applied to either complete customization or to the creation of a market specific layer.

It is concluded that market specific processes that can be abstracted into the process as modelled in Figure 5, have minor differences with MTS and MTO. Therefore, a market specific layer is sufficient for the customization of ERP systems for supporting the market specific process.

9 Future work

Since the framework is applied on only one case, it might be worth for future work to apply it to several other market specific processes.

Due to limitations in time, the process has not reached the testing and production stage in the case study of Section 5. Since the framework is based on the expected execution of the customization in the case study, this does not have a major impact. Nevertheless, it is more interesting to see if the suggested framework is applicable to a broad range of market specific processes. Therefore future work should be done to see if the framework is applicable to a broad range of ERP customizations.

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