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Faculteit Bedrijfseconomische Wetenschappen

master in de toegepaste economische wetenschappen: handelsingenieur

Masterthesis

Analysis of freshness of products:case studyAB Inbev

Udo Senden

Scriptie ingediend tot het behalen van de graad van master in de toegepaste economische wetenschappen: handelsingenieur, afstudeerrichting operationeel management en logistiek

PROMOTOR :

Prof. dr. Katrien RAMAEKERS

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2017

2018

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I. Prologue

This master thesis was the end of my master's degree in business engineering. During five years I learned a lot of valuable skills, not only to complete this thesis but also for the labour market. Business engineering made sure I had a broad background and understanding of the business world. When I chose the research subject of my thesis it was important that I gained business experience. Further was it important that I got international exposure and the subject would be related to operational management and logistics. I like to see how logistical processes get optimised and to know how everything is arranged. Getting the opportunity to get this experience within a true multinational was exactly what I was looking for. Furthermore I chose a broad subject so I could get an understanding of every department of the company. Because of this I now clearly know what I value in a job and which departments are interesting, which is very important to make a good job choice.

This master thesis was a success because of the support I got from everyone in my close environment. First I would like to thank my two promotors within UHasselt, Katrien Ramaekers and within AB InBev, Pepijn Raes. They helped me doing the research for my thesis, gave me valuable insights and gave me necessary feedback. Furthermore reviewed they thoroughly my thesis and gave me a critical review. Because of this critical review my thesis became something I am proud of. Secondly I would like to thank AB InBev for giving me the opportunity to do my thesis at their headquarters in Leuven and also for letting me go to Prague, where I got the necessary contacts and involvement in the project. In addition would I like to thank all employees of AB InBev who were always ready to answer my questions, explained all methods, and gave feedback. Next I would like to thank the employees of Katoen Natie who also helped me to collect and understand the data. Lastly I would like to show my gratitude for my parents and my brother, for their everlasting support and believe in me.

II. Samenvatting

Freshness is de tijd die verstrijkt tussen het bottelen van bier en het moment van laden. Het is als het ware de leeftijd van het afgewerkt product op het moment van laden. AB InBev is een bedrijf dat een groot gedeelte van zijn producten exporteert naar andere delen van de wereld. Om deze producten nog te verkopen in het geëxporteerde land moet er nog genoeg tijd zijn voordat de houdbaarheidsdatum van het product verstrijkt. Om dit te garanderen heeft AB InBev freshness regels opgesteld die eisen dat een product niet wordt verzonden nadat 30% van haar shelf-life is verstreken. Shelf-life is de periode tussen productie en houdbaarheidsdatum. Natuurlijk moet er worden geprobeerd ieder product zo snel mogelijk te exporteren zodat het product een lange shelf-life heeft op de bestemming. Dit wordt aangestuurd door de KPI (key performance indicator) freshness, een van de maatstaven waarop het export team wordt beoordeeld. Het doel van deze masterthesis is om freshness te verbeteren.

Opdat freshness verbeterd kan worden moet er eerst inzicht worden verworven in hoe processen worden aangestuurd in een bedrijf. Deze processen zijn beïnvloedt door veranderende marktomstandigheden zoals globalisering, intensifiëring van concurrentie en technologie. Deze omstandigheden hebben processen op voornamelijk vijf principes veranderd. Deze vijf principes zijn: snelheid, variabiliteit, vocalisatie, visualisatie en waarde creatie. Onder snelheid worden verschillende systemen voor het plannen en controleren van supply chain stromen uitgelegd. Dit kan op verschillende manieren zoals Kanban gebaseerd op de just in time theorie, material resource planning, drum buffer rope of constant work in proces. Bij variabiliteit worden de begrippen six sigma en flexibiliteit nader toegelicht. Als derde wordt het vocalisatie principe uitgelegd wat nauw gerelateerd is aan de theory of constraints. Het vierde principe, visualisatie, duidt op het creëren van visibiliteit voor managers. Met visibiliteit wordt bedoelt dat managers weten waar stock zich bevindt op ieder moment of wat de prestatie is van ieder departement. Hierdoor kan er snel worden gereageerd als er dingen dreigen mis te lopen. Een departement wordt beoordeeld aan de hand van KPI’s (Key performance indicators). Het laatste principe is waarde creatie, dit betekent dat iedereen in contact met de supply chain een voordeel moet hebben om in het supply chain netwerk te zitten. Indien er voor een partner geen waarde is om onderdeel van het netwerk te zijn, is het voor deze partner ook niet interessant om moeite te doen voor het netwerk. Cruciaal om waarde te creëren is een goede communicatie en samenwerking.

Vervolgens volgt een diepere analyse bij AB InBev. Eerst wordt besproken hoe processen gevisualiseerd kunnen worden via een flowchart of BPMN (Business process modelling notation). Flowcharts zijn een intuïtieve manier om processen te visualiseren zodat deze makkelijk kunnen worden verbeterd en gecommuniceerd. Het business process model opgesteld voor AB InBev omvat 6 departementen en twee bedrijven. De twee bedrijven zijn AB InBev en Katoen Natie. Katoen Natie wordt opgenomen in het model omdat zij de warehouse provider zijn van AB InBev. Zij zorgen dat producten worden opgeslagen en verzonden. De verschillende besproken departementen zijn: order taking, supply network planning, scheduling, inventory deployment, binnenlands en internationaal transport.

Ordertaking zorgt ervoor dat klanten weten wanneer ze hun producten krijgen en op basis daarvan berekenen ze wanneer de producten moeten aankomen in het warehouse van Katoen Natie. Bijvoorbeeld beloven ze aankomst van het product 1 februari bij de klant maar het duurt drie weken om het product te transporteren en één week om het product te laden. Hierdoor zal het product op 1 januari beschikbaar moeten zijn in het warehouse. Deze beschikbaarheidsdatum wordt MAD (made availability date) genoemd. Het volgende departement supply network planning (SNP) zorgt ervoor dat de producten geproduceerd kunnen worden. Aangezien er een beperkte capaciteit is moeten sommige orders eerder geproduceerd worden om aan de vraag te voldoen. Er moet een voorraad worden gemaakt om de vraag bij te houden in piekperiodes. Het volgende departement, scheduling, bepaalt wat en wanneer geproduceerd gaat worden. Om de hoeveelheid te bepalen wordt de output van SNP gebruikt. Om het moment van productie te bepalen wordt gekeken naar het beschikbare bier en verpakkingsmateriaal. Het schema wordt constant aangepast om het actueel te houden.

Als de goederen geproduceerd zijn moet worden beslist welke producten naar Katoen Natie worden getransporteerd. Voor producten die alleen maar nodig zijn voor export, is het eenvoudig aangezien deze producten onmiddellijk naar het warehouse worden getransporteerd. Voor producten die voor de lokale als internationale markt nodig zijn is er een ander systeem. Deze producten moeten het bevel krijgen getransporteerd te worden naar het warehouse. De tweede taak van inventory deployment is beslissen wanneer welke producten klaar zijn voor lading. Deze datum noemt de inventory availability date.

In opdracht van inventory deployment zorgt het binnenlands transport departement dat de producten van de brouwerij tot het warehouse geraken. Omdat push producten onmiddellijk getransporteerd worden is er geen bevel van inventory deployment nodig om de goederen te transporteren. Het laatste departement, internationaal transport, regelt de boeking van een container. Zij kijken naar inventory availability date en naar de vroegst toegelaten verzendingsdatum om een container te boeken .Verder kijken ze ook dat er geen kosten ontstaan omdat een container te lang in hun bezit is.

Vervolgens wordt gekeken naar welke data beschikbaar is. Voor iedere verzonden pallet worden verschillende gegevens bijgehouden. Aan de hand van deze gegevens kunnen analyses worden gedaan. Vooraleer er analyses kunnen worden gedaan moeten speciale gebeurtenissen en bieren in kaart worden gebracht. Als eerste wordt de stock build uit de data-analyse gehaald vervolgens ook Hoegaarden. Daarna wordt het effect van verschillende product categorieën geëvalueerd en wordt er gekeken hoe de brouwerijen en bestemmingen freshness beïnvloeden. Als laatste wordt er gekeken naar specifieke producten en wordt er geprobeerd te verklaren waarom er verschillen zijn tussen deze producten. Door deze analyse kwam onder meer aan het licht welke productcategorieën het beste presteren en dat sommige artikels andere beïnvloeden aangezien ze hetzelfde product verpakken in een ander materiaal.

In de analyse werd duidelijk dat het productieschema constant veranderd, hierdoor is het moeilijk om via het productieschema een inventory availability date te bepalen. Meestal werd er voor de veilige optie gekozen om MAD gelijk te stellen aan inventory availability date. Aangezien het niet mogelijk is zonder grote investeringen het productie proces betrouwbaarder te maken, moet er worden gekozen voor een andere systeem. Volgens de theorie kan het systeem op verschillende manieren verbeterd worden. Zo kan de productiebetrouwbaarheid voorspeld worden of kan gekozen worden om enkele dagen voor MAD te produceren in plaats van een week voor MAD. Verder zouden ze het verzendingsproces variabeler kunnen maken.

Om het verzendingsproces variabeler te maken is er een nieuw soort contract nodig tussen de verschepers en AB InBev. Een mogelijke oplossing hiervoor is een optie contract. Dit contract zorgt dat AB InBev een reservatie doet voor een aantal containers iedere week van het jaar. Om deze reservatie te doen wordt een voorschot betaald. En indien de reservatie gebruikt wordt, wordt de rest betaald, indien er te weinig containers gereserveerd zijn moet er een toeslag betaald worden. Door het contract wordt variabiliteit verminderd aangezien overcapaciteit en ondercapaciteit worden bestraft. Oftewel door het verliezen van de reservatie kost oftewel door het betalen van een toeslag.

De verlaging van variabiliteit is een voordeel voor de verscheper aangezien deze liefst zo min mogelijk variatie heeft. De verscheper moet namelijk de veiligheid garanderen en hiervoor moeten complexe berekeningen worden uitgevoerd. Hoe constanter het volume van goederen hoe makkelijker deze berekening. Het voordeel voor AB InBev is dat er geen boeking hoeft te worden gedaan. Hierdoor kan een product onmiddellijk worden geladen indien nodig. Om tot deze manier van werken te komen zal er echter nog het nodige onderzoek moeten gebeuren en zullen de processen in AB InBev moeten veranderen. Maar door een toename in flexibiliteit zal het wel mogelijk zijn een verser product te leveren.

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1. Introduction

1.1 Problem statement

Supply chain management is vital for today's companies. Because of a higher quality demand and increasing competition, supply chains need to be as lean and fast as possible. People want to have fresher products than before. These challenges get even bigger as supply chains get more global. Therefore it is vital for companies to improve their supply chain. (Weber, 2007)

These challenges are also present at AB InBev, a global beer brewing company and the partner for this thesis. They have over 500 beers brewed in over 50 countries and a revenue of 43 billion dollar. In this master thesis a case-study at AB InBev will be done. The focus of the study will be to deliver customers the freshest beers by minimizing the storage of finished goods at several production plants in Belgium and at the cross dock in the port of Antwerp. In order to improve the freshness of beers there needs to be an understanding of the concept stock and why a lot of companies keep stock. Then some important models and strategies about stock management are discussed. Lastly the real situation at AB InBev is described.

Stock are products that have not been sold jet. The principal reason stock is held, is for customer service and to cope with variability. If there was no stock, a customer would always have to wait until the product is produced and transported to the desired location. Because customers do not want to wait, stock is made so customers can get products immediately. If one moves further up the supply chain it is not possible anymore to receive products immediately, because stock levels would be too high. Higher in the supply chain customers actually need to wait until they receive their products. This waiting time is called lead time. Lead time is the time between the placement of an order and the actually receipt of the order. So if an order is placed in a web shop and the customer receives it the next day, the lead time is one day. Lead time gets bigger as a supply chain gets more global due to longer transportation. Customers prefer a short lead time, because this enables them to quickly alter or place orders if necessary. This altering or placing can be needed to react on an unforeseen demand drop or raise (Weber, 2007).

Because of lead time, production and demand variability it is necessary to make forecasts. When a customer places an order, the company will predict when the order will arrive at the customer. The lead time is forecasted because production is not constant due to malfunctions or defects and transportation can be longer than predicted because of weather conditions or traffic congestion. Another source of variability is demand. If demand is high it is possible that the production rate is just not high enough, this will cause the company to delay the order because they cannot produce the goods fast enough. These variabilities will have an important effect on stock higher in the supply chain (Weber, 2007).

According to Hopp and Spearman (2004) there are three possible effects or ways of handling variability: stock, capacity and time. If demand rises, it is natural to use stock to face this rise. In the case there is no stock, the production capacity will be raised in order to deliver the products on time, but this is only possible if there is excess capacity. When there is no excess capacity, the order has to be delayed. This last way to cope with the problem is called backordering. This is the cheapest way of coping with variability. A big disadvantage of backordering is that customer service is low, customers want their orders on time. Timely delivery is measured by service level. Service level is the percentage of products that is delivered on time. So if the service level cannot drop there are two possibilities left: having excess capacity or keeping stock. The disadvantage of capacity is that it uses a lot of resources, but production is flexible. Keeping stock has the risk that products can deteriorate or get obsolete but it is a fast and cheaper way to eliminate variability. So there are three ways of coping with variability, holding stock, having excess capacity or let the customer wait. Hopp and Spearman (Hillier & Lieberman, 2004) also added a fourth possibility, this is eliminating variability by forecasting. This way a rise can be anticipated.

An important way of coping with variability is by using stock (Hillier & Lieberman, 2004). There is a lot of literature about the subjects how to manage stock, how much to order and when to order. The most famous model is the economic order quantity model. There are several variants of this model but the basic idea of these models is to determine the optimal order quantity mathematically. In order to calculate the optimal order quantity several variable costs like holding cost, order cost and purchasing cost are included. Holding costs are costs that exist due to having goods in stock, for example the interest on money that is lost because it is spend on products in stock. Order costs are costs that are incurred every order and are not related to the quantity of products ordered, for example administrative costs and costs of bringing the order. It is possible to add some other costs like stock out cost, this is a penalty cost for not delivering the ordered products. Each model makes some assumptions, in the model of Figure 1 is assumed that ordered goods are received immediately. In the ideal case a company waits till all the stock is gone and then orders, this means an order gets placed on irregular moments but the quantity is fixed. This is pictured in Figure 1, with inventory level as a function of time, this gives the typical saw pattern for stock. Another assumption of this model is that demand is constant because you see a constant decline over time (Hillier & Lieberman, 2004).

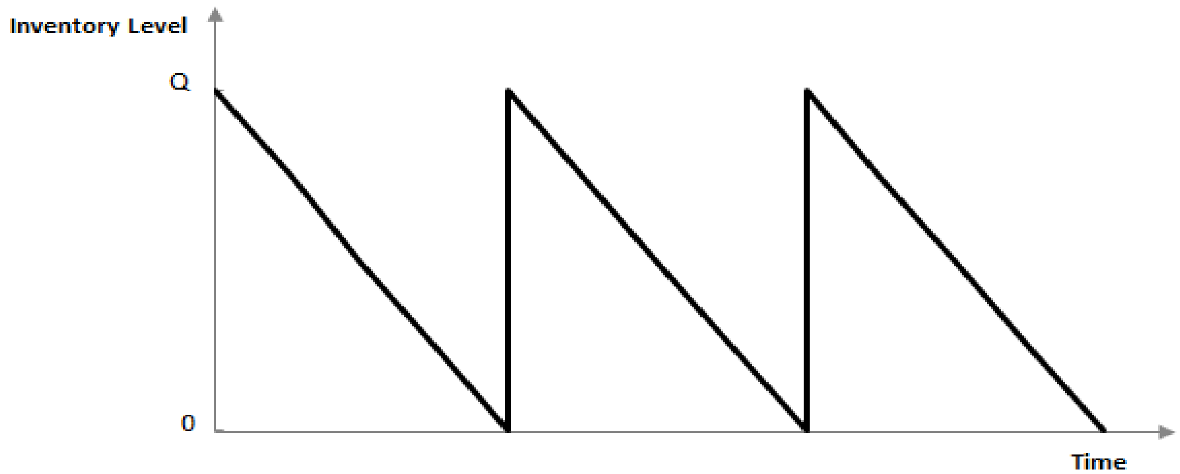

Figure 1: Saw pattern (Hillier & Lieberman, 2004)

In practice the assumption that an order is received immediately does not hold. Like discussed above there is a lead time that needs to be taken into account. This means an order needs to be placed in time so that a company does not run out of stock. On time means the moment stock will run out minus the lead time, see L in graph 2. For example if the lead time is ten days, goods are ordered ten days before stock-out. This point is called the reorder point s in graph 2 and is expressed in units, the number of products sold during the ten days before stock-out. For example a company sells 10 products a day, with a lead time of ten days, then the reorder point is going to be 100 units. But like mentioned before lead time cannot be perfectly predicted, as a consequence a security stock is made. This stock is used if lead time is longer than predicted, security stock is s–E(x) in the graph below. This security stock also gets used because of other variabilities (Liberatore, 1979).

Until now it is assumed that demand is constant over time, in real-life this is not the case. Therefore the graph in Figure 1 is in practice more like Figure 2. This figure gives an impression of the real situation instead of the purely theoretical situation (Hillier & Lieberman, 2004).

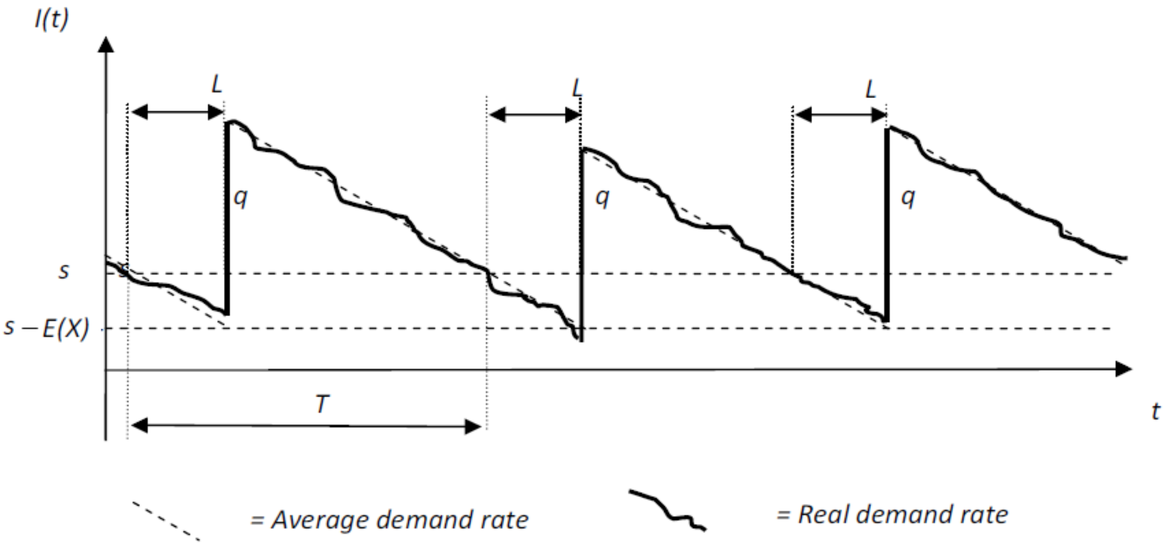

Figure 2: real situation (Hillier & Lieberman, 2004)

For the case of AB InBev the economic order quantity is not of much use because AB InBev is a production company. The EOQ model can be adjusted for a production company by giving the vertical line a slope. This way the products are not immediately available, but they are gradually produced. But even by changing the slope the EOQ does not fit the needs for AB InBev because AB InBev has products that are perishable. Because AB InBev does not want beers to deteriorate, they want to deliver the freshest products possible. The way to do is, is to have as less stock as possible. By consequence the cycle time will be short. Cycle time is the time till all old stock is used and new stock is needed represented by T in graph 2. A minimum cycle time is not the aim of the EOQ model but still the insights of the model can be used in this master thesis. Because the EOQ model does not really fit for AB InBev some important strategies will be discussed (Huang, He, & Li, 2017)

There are several strategies to get ordered products on the right place and time: make to order (MTO), make to stock (MTS), make to forecast or a combined strategy. In a make to order strategy the production of a good starts when that good is ordered. This rule implies having practically no stock of finished goods because the produced goods are already ordered. There are several advantages of this strategy: the product is fresher and there is less stock which also saves costs. There are also some disadvantages connected to this strategy, one of them is that the lead time is longer. Because the production still has to be executed when a product is ordered. Another disadvantage is that it is more likely to delay orders because they cannot be produced on time and as a consequence the service level is going to be lower (Kim, Fowler, Shunk, & Pfund, 2012).

The next system is a make to stock strategy, in this strategy goods are produced without a specific demand. Production keeps stock at a constant level. A big disadvantage of this strategy is that there is a high stock which is costly, and there are risks connected to keeping stock. For example products can be damaged by vermin or they can deteriorate. A big advantage is that stock-outs are not likely and by consequence the service level will be high. Also production can be planned easier and in an optimal way (Kim, Fowler, Shunk, & Pfund, 2012).

The next discussed strategy is make to forecast. This means the production process produces on forecast. An advantage of this strategy is that it is easier to plan production. Another advantage is that the lead time is shorter, because the goods are already produced, only the delivery has to be done. The stock level is going to be lower than MTS because it will variate more. The service level in this systems is higher than in a MTO system, if the forecasts are reliable. There are also some disadvantages so is it more likely to run out of stock than a MTS strategy. It is also necessary to have reliable forecasts otherwise the strategy will look like a MTS or MTO strategy. It has to be noted that a good forecast is difficult to achieve because of uncertainties (Kim, Fowler, Shunk, & Pfund, 2012).

It is possible to combine a MTO and a MTS strategy. This is done by following a MTS strategy but change to a MTO strategy afterwards. The point where the system is changed is called the decoupling point. Because of the change in strategy there is stock at this point. This combined strategy can also be explained for beer. For this example the production of beer would be made to stock, but the bottling of beers would be on order. In this example there would be a stock of not bottled beer and no stock of bottled beer because this gets immediately delivered after bottling (Olhager, 2010).

For the case study it is important to notice that AB InBev has a slightly different strategy than the strategies discussed. For the last production stage, bottling, they use a mixture of the MTS and MTO strategies. They produce 80 percent of their products via a make to order strategy and 20 percent of their products via a make to stock strategy. This 20 percent is make-to-stock and is used for unforeseen demand or supply chain problems. The biggest difference with the combined strategy is that they do not have a real decoupling point. A normal decoupling point is where MTS changes to MTO. Assuming that before bottling everything was MTS it now changes to MTS and MTO.

As stated before the aim of the practical part of this master thesis is to deliver the freshest products by minimizing the stock of final goods. The final goods are beers in bottles, cans and kegs. By minimizing the stock of final goods, the cycle time of products is lower. The cycle time is the time products spend on average in storage. So the lower the cycle time, the fresher the beers delivered. Customers want fresh beers because old beers do not have the same taste. And to get top quality beers to the customer AB InBev made freshness rules. These rules are practical rules that put in order certain protocols at certain events. An important rule is that authorization is needed from the importing zone to ship products older than 28 days. AB InBev Belgium needs to ask permission because contracts promise beers fresher than 30 percent of the perishable date otherwise the customer could reject the goods or ask for a compensation. The aim of this master thesis is to minimize these events because they can be very costly.

As discussed stock is influenced by several variabilities like demand changes. And the sensitivity to these variabilities is determined by the strategy and processes of the departments and actors upstream and downstream in the supply chain (Hopp & Spearman, 2004). In this master thesis the focus is to change the strategy or processes of departments and not to reduce variability. Because most sources of variability cannot be influenced by AB InBev in a significant way. For example port authorities and customs can add variability by holding cargo longer than expected, but this cannot be influenced by AB InBev. The focus of this thesis will be on a strategy or process change. An example for a process change is the following: usually a signal from the production department is given to the transport department when goods are produced, this way transport can be arranged. The process change was that the signal was given one day before, this way there was more time to arrange transport and products become fresher. A disadvantage is that if something goes wrong in production, transport is arranged for nothing.

AB InBev has several benchmarks to evaluate their performance. One way they evaluate their performances is by the freshness of products that arrive at their customers, they want that their products are not past 30 percent of the shelf-life when the products arrive at the customer. Shelf life is the time a product can be sold which is equal to the time between production and expiry date. AB InBev has this rule because the taste of beer deteriorates and a customer has more time to sell the products because the expiry date is later. Another reason is that AB InBev has to pay a fine or compensation if products arrive too late. There are some events that cannot be influenced by AB InBev that is why the 30 percent benchmark is translated into a freshness benchmark of 10.5 days for the exporting country. This means that products are send at an average age of 10.5 days. Freshness is measured as follows: freshness starts at the moment a product is bottled and the expiration date is printed on the bottle. This expiration date is one year from the date of bottling. The freshness benchmark stops if the products are packed in a sea container, ready for shipment. At this moment the freshness of shipped products is on average 14 days. In these 14 days the product gets transported from several breweries in Germany and Belgium to the cross dock in Antwerp, and put in a sea container. There are several days needed to plan and transport products from the brewery to Antwerp, then there are several days needed to plan a sea container and to put the products in the container. It is unclear for AB InBev why this process takes on average 14 days which is quite a long time to transport and to put products in a container not that far from the production site. Because AB InBev set the target that no products arrive after the 30% benchmark, they need to make sure this process goes faster. This way costly events can be avoided, and customer satisfaction will rise.

In order to achieve these targets all activities of AB InBev are divided into several departments, where each department has its own purpose. The most important department for this paper are: order taking, supply network planning, scheduling, inventory deployment and transport planning. The use of those different departments is discussed down here.

Order taking is responsible for the incoming orders. They make sure orders are ready on the right time by setting MAD's. MAD is the abbreviation for made availability date, this means that at this date the product needs to be produced and transported to the cross dock. Ten days later the product needs to be in a sea container ready for shipment. This MAD is set using a material resource planning system (MRP-system). This system uses an arrival time at the client and determines the MAD via backpropagation. Next is an example how to calculate the possible MAD for goods that need to arrive in China the first of January. For this example one should know that it takes 45 days to transport a container to china. Further there are 10 days needed to transport and load products in a container in Antwerp. And there are 42 days needed to brew and bottle the beer. This means that for goods arriving the first of January production starts 97 days earlier, being the 25 of September. The MAD is 42 days later being the 6th of November this is when they are produced and bottled. Next the products are transported and arrive at the first of January in China. It should be noted that this example is a simplification of the real calculation of the MAD-date. This is why a possible research question specific for this department could be: "How is the MAD calculated exactly?".

The next department is supply network planning, this department makes sure production is guaranteed even with capacity constraints. They determine production quantities for every week and look ahead for spikes in demand. They need to make plans on a long time horizon in order to bottle products efficiently and to guarantee supply.

The scheduling department is closely related with the supply network planning department, with the distinction that they make the production plan that is executed, they convert the quantities into an hour plan. The scheduling department determines what has to be produced each hour, they make necessary last minute changes. For example if one bottling machine is defect, they make sure a new plan is made. If a machine is defect some orders have to be delayed, this department searches to delay the right orders so the minimum amount of orders is too late.

The next department is inventory deployment, this department manages a part of the inventory levels at the different breweries. This department decides when goods are ready to leave. In order to understand this department there needs to be a distinction between two order categories. These are MTO (make to order) and MTS (make to stock). The MTO orders are arranged by the inventory deployment department and the MTS orders are arranged by the different breweries. MTS orders are orders from clients nearby, MTO orders are for clients further away. Especially the data analysis can be important to evaluate performance of this department.

The last department that gets discussed is transport planning, they are responsible for the transport in the process. In this department there are also two divisions domestic and international. The shuttling process between the different breweries and Antwerp is arranged by the domestic transport department. Overseas container shipments are arranged by the international transport department. An important benchmark for this department is TPA, transport planning accomplished. This is the percentage of transports that are executed according to the plan that is made by the department. If this is 100% everything goes according to plan. A side note is that the execution in Antwerp is outsourced to Katoen Natie. So if the TPA is not 100% it can be the fault of Katoen Natie or the international transport planning department. Katoen Natie is a partner of AB InBev and manages the cross dock of AB InBev in Antwerp. A possible point of interest for this department could be the difference between reality and plan.

1.2 Research plan

This problem statement leads to the following central research question of this paper.

"How can the cycle time of finished products between brewery and container shipment be lowered for AB InBev?"

This central question can be divided in several subquestions.

- Which methods or systems are mostly used in a department according to the literature? What are the most common challenges or problems in these departments?
- How does the supply chain of AB InBev look in detail, more specifically how and why do departments upstream influence the stock of final goods?
- Does the analyzation of the available data reveal any problems or irregularities for a specific product, destination or plant? How do the departments treat these problems or irregularities? What is the cause of the problem?
- What are possible points of improvement? How should the process be improved??

1.3 Research methodology

In this part the approach to answer several subquestions is discussed. The subquestions are discussed in the order they are mentioned above. To gather the needed information for the first subquestion, a literature study will be done. This will clear out which methods are used according to the literature and eventually if these strategies are suited for AB InBev. Then the advantages and disadvantages of the different strategies will be discussed. The information for this literature review will come via the website of Hasselt University, ebscohost or google scholar. For the second subquestion open interviews will be done with people who know what happens exactly in their department. These interviews are open interviews, but are highly dependent on what the interviewer wants to say. Questions that have risen during the literature study will be asked. If any other important questions rise after the interviews, these question will be asked by mail and added. In order to answer the third subquestion, it is needed to analyse the available data. Which will be provided by AB InBev. This analysis will try to identify parts of the process that are done in an ineffective or inefficient way. Sometimes department leaders do not know or want to withhold these problems. Further will the data-analysis try to measure the negative and positive factors mentioned in the literature or the interviews. This data-analysis will also clarify the processes that are time consuming in terms of freshness and the processes that are not. Processes that consume a lot of time and therefore influence freshness negatively, will easier improve freshness when their problems are solved. The last subquestion will give a conclusion about the paper. The possible points of improvement will be discussed and if possible ways of treating the problem.

2. Literature review

Supply chains are very specific for each company. Therefore there is a lack of literature covering the whole supply chain in detail. By consequence more general principles and theories will be covered in the literature review. In the end there will be a broad understanding of trends in supply chain management and ways to optimize whole supply chains without going into detail for each specific department.

According to Walker (2005) the five most important supply chain principles are: velocity, variability, vocalize, visualize and value principles. These principles are caused by changing market conditions like globalization, intense domestic competition, fickle consumer demand and technology. Globalisation is now common for companies, they are spread out geographically, it is common for big companies to have service centres outsourced to India, China or Eastern Europe. These service centres are only possible because of improved software, hardware and information technology making it possible to efficiently outsource activities (Dossani & Kenney, 2007). Also trade agreements like GATT (general agreement on tariffs and trade) or NAFTA (north American free trade agreement) reduce economic barriers to make international trade possible. Intense domestic competition and fickle consumer demand raised the need for ERP systems with complex algorithms and better communication in the whole supply chain, instead of easy rules of thumb used before. As identified by Walker (2005) there are five main principles in supply chain architecture. In the next sections, each of the principles will be discusses in more detail.

2.1 Velocity

The first principle is velocity. Velocity focuses on the speed of the whole network. This means how fast is a product through the whole network of partners and processes from raw materials to consumer. It focuses on eliminating stock through the whole chain, both in perspective of accounts receivables as actual stock. Production planning and control strategies (PPCS) are strategies that determine the speed of product flow through a supply chain. The four most important ways of managing a supply chain flow are: Material resource planning (MRP), Drum buffer rope (DBR), Constant work in process (CONWIP) and kanban. Kanban comes from the Just in Time (JIT) theory, the most important theory focusing on the velocity principle (Walker, 2005).

2.1.1 Just In Time (JIT) / Kanban

JIT is a theory coming from Mr. Taiichi Ohno (2007), the inventor of the Toyota production system (TPS). JIT's core elements are setup time reduction, small lot production, the use of kanbans, level production scheduling and preventive maintenance (Kannan & Tan, 2005). TPS is based on the principle of reducing the production cost by eliminating waste. This means that everything exceeding the minimum amount of workers, material, parts and equipment that are necessarily needed to keep production running is a surplus that raises costs. Specifically these costs should be minimized (Sugimori & et al., 1977).

The first requirement to implement JIT but the most important one is to have processes that quickly gain accurate knowledge of timing and quantity required. By having a backward information flow stock can be eliminated. In other systems the way of doing this is to plan everything carefully. If a part is needed the delivery is carefully planned and will be executed according to schedule. Of course this is not very flexible; if something goes wrong or if there is a change in schedule this will cause problems. Toyota solves this problem by an information flow from the end of the chain up to the front of the chain. The second requirement to produce JIT, is to have piece production and transportation. This way there is no need to keep stock because you have to transport or produce in lots. Toyota did this by reducing setup time and changing production methods. The last important requirement is to be able to change production schedules, in order to react fast on changing market conditions (Sugimori & et al., 1977).

In order to attain these requirements a special Production planning and control system (PPCS) is used. Kanban is a non-computerized system that facilitates the planning of a supply chain. It ensures that there is always enough stock and there is no overproduction. Kanban is Japanese for card, and in fact they use cards attached to a container. There are two types of cards; conveyance kanban and production kanban. The conveyance kanban goes from one process to the proceeding process. The production kanban stays within one process, and follows the product. At the moment a final product is needed, a production kanban is made. Next a worker will go to the stock point at the beginning of the process with an empty container, attach the production kanban to the container and take all the goods needed to produce the product. As follows the container is pushed through the production process and the product is assembled, with the items in the container, the production kanban keeps following the product through the whole process. The production kanban lets the workers know what they are producing. To fill the container with products, products are taken from the stock point at the beginning of the process. In case a new container has to be opened the conveyance kanban attached to this container is brought back to the end of the preceding process. Here a container at the stock point at the end of the proceeding process is taken, the conveyance kanban is put on the container. The conveyance kanban and the container are brought back to the begin stock of the following proces. The production Kanban which was on the container acts as dispatching information. In this process the same cycle happens, the production kanban is used to collect the necessary parts to start producing as fast as possible to replenish the stock taken. By limiting the amount of cards in circulation, work in process is kept under control. In a kanban system products are produced when needed, without over producing or using difficult measures. Because there is only produced what needed this is a pull system, it only produces at the moment something is ordered (Kouri, Salmimaa, & Vilpola, 2008).

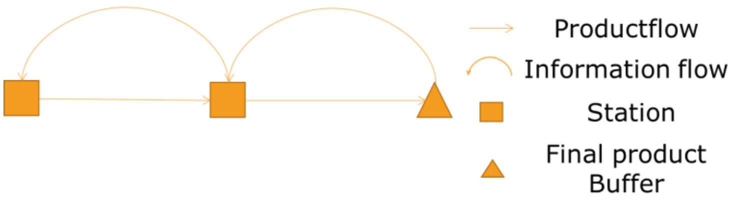

Figure 3: Kanban System (Jodlbauer & Huber, 2008)

2.1.2 Material Resource Planning

In conventional western systems, companies work with material resource planning (MRP). The big difference between MRP and JIT is that MRP is a push system. MRP is a computerized system which tries to plan everything. It releases raw material according to a master production schedule and determines release dates and times through the backpropagation of planned lead times. In this backpropagation, set-up time and lot production is taken into account. There can be uncertainties in time or quantity like set-up issues, transportation issues et cetera. This is why a safety stock and safety lead-time is implemented in the chain. Next is an example to illustrate this a little further. An order has to be delivered September 30, it takes 3 days to transport it, 3 days to produce it and it takes 4 days till you have the raw materials needed for production. As the order has to be delivered September 30, this means the product has to be produced on September 27 at the latest. Because of variability and in order to be safe the deadline of production is put September 26. Three days before September 26 you should start producing at the latest. Depending on the variability of the process the release of the order for production is somewhere around September 22. In case production has to start around September 22, the order should be passed before the September 18 Depending on the variation of the lead-time of your supplier, you pass the order sometime before the 18th of September (Jodlbauer & Huber, 2008).

2.1.3 Constant Work In Process

The next two PPCS systems are a more hybrid version of pull and push systems. Frist CONWIP will be discussed. CONWIP stands for constant work in process. This is the system that has the most in common with the KANBAN system. Where a Kanban process controls the WIP for each station and pulls products from the preceding station, the CONWIP system controls the WIP over a whole chain of stations. In a CONWIP system raw materials are released at the moment the final product is needed, as long as the amount of WIP is under a constraint, called WIPCAP. WIPCAP is the maximum amount of WIP allowed on the floor, by introducing this constraint stock will be kept under control. Another element of CONWIP is the work-ahead window, this is the amount of time allowed to produce a product before it is needed. By introducing a work-ahead window, too much stock and deterioration is avoided. In Figure 2 the CONWIP process is visually explained. As seen on the figure CONWIP is the same as Kanban, only a CONWIP has an information flow that does not include every single station, only the first and the last station. Because of this information flow there is a push process between the stations and a pull process over the whole chain. Combinations of Kanban and CONWIP are possible for example by taking several stations together (Gstettner & Kuhn, 1996).

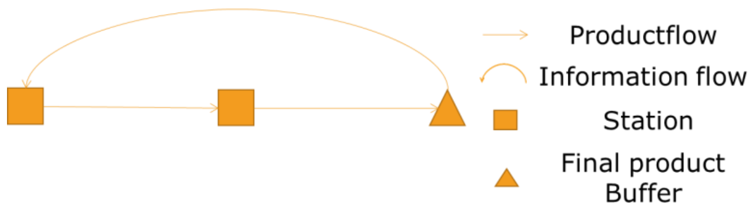

Figure 4: Constant work in process (Jodlbauer & Huber, 2008)

2.1.4 Drum Buffer Rope

The last PPCS discussed is the Drum buffer rope (DBR) system. This system is coming from the theory of constraints introduced by Goldratt (1990). The Theory of constraints will be treated in more detail in the vocalize principle. The general idea in the theory of constraints is to identify the bottleneck and adjust all the processes in order to elevate that bottleneck. In a production system this bottleneck is called a capacity constraint resource (CCR). In case the highest throughput has to be achieved CCR is the resource limiting this throughput. In order to make sure the resource produces the maximum possible it has to be made sure this resource is used all the time. The constraint resource will set the pace of the whole production process, the CCR is the drum. In order to make sure the CCR keeps running, there is a buffer before the resource, this way there are always products to be processed by the CCR even when there are uncertainties before the constraint. The time when raw materials are released is determined by the backpropagation of the lead time between start of the process and the buffer (Sirikrai & Yenradee, 2006).

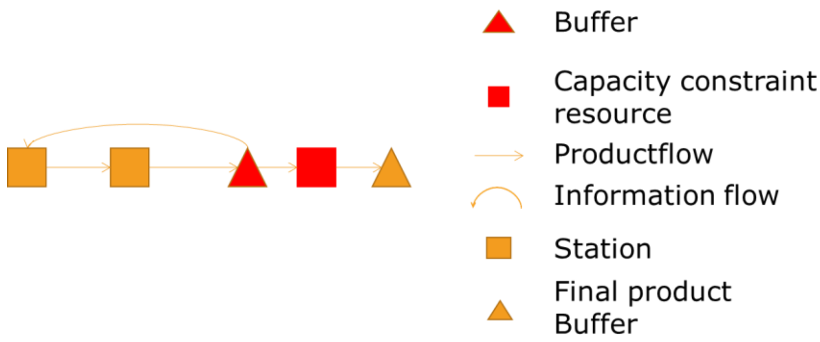

Figure 5: Drum Buffer Rope (Jodlbauer & Huber, 2008)

2.1.5 Conclusion

H. Jodlbauer and A. Huber (2008) reviewed all these production planning and control strategies (PPCS) on several evaluation criteria and discussed the advantages and disadvantages of the strategies. There are several criteria to be discussed for each system: WIP, service level, robustness and stability. Service level is the percentage of products that are delivered on time. A supply chain's main objective is to reach a high service level. Of course costs have to be taken into account, this is why there should be a low level of work in process or stocks and a high utilisation of workers. For some businesses it is more important to have a high service level than other businesses. In a fast moving consumer goods business, service level is crucial. In the case products are not available sales are lost. If a consumer wants a beer and his favourite beer is not available, he will take another beer. In the case of the automotive industry or typical pull supply chains, service level is perceived less crucial. If a consumer wants a car, and the car arrives one week late, he will probably not be tempted to change the car he buys. There is a connection between WIP and service level, a high degree of WIP automatically results in a higher service level. When a company has a lot of stock, it is always possible to deliver on time because there is enough stock to correct for uncertainties. The speed of a product going through the whole supply chain is slowed down by increasing stocks, by consequence the products are older at delivery. The third evaluation criterion is robustness, robustness is the stability of the system if the environment changes. For example a fifty percent demand increase or an increase in scrap rate by twenty percent. The last criterion is stability. Each PPCS has parameters that have to be determined. For example in a Kanban system the number of cards, for MRP and DBR the lead-times and for CONWIP the WIPCAP. All these parameters have to be determined optimally to get the best performance out of a system. Some parameters are more difficult to determine than others. In practice it is difficult to determine the different parameters exactly because of imperfect information. Stability measures the effect of wrong parameters on performance. It determines the connection between the error on parameters and the effect on service level.

As explained there is a relationship between WIP and service level. Therefore WIP and service level should be discussed together. First a basic scenario is discussed, without robustness and stability. In this scenario the parameters are determined optimally and there are no sudden changes in the environment. In order to determine which PPCS is better, several simulations have been made. In Figure 6 each dot is a simulation. One simulation is for example MRP with 200 units WIP with the corresponding service level on the Y-axis. Each line is the combination of the best simulations. The line visualizes the best possible service level for each level of WIP. One can clearly see the relationship between service level and WIP for each PPCS. This figures concludes that CONWIP has the best possible performance followed by MRP and DBR. The lowest performance is achieved by Kanban, where service level is lower for comparable levels of WIP (Jodlbauer & Huber, 2008).

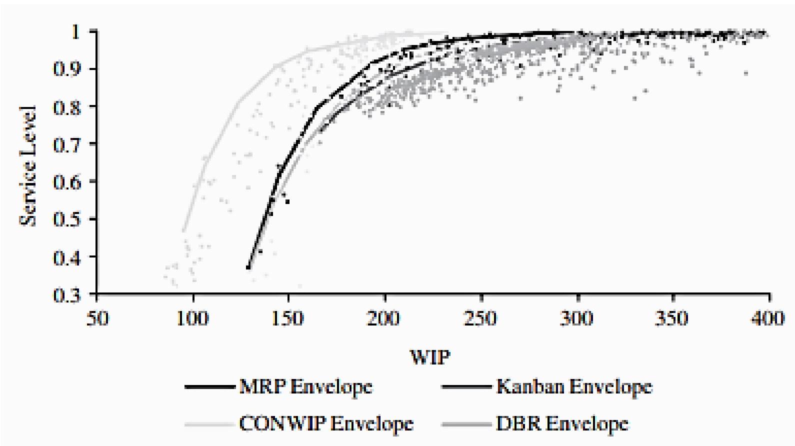

Figure 6: Service level, parameters optimized (Jodlbauer & Huber, 2008)

The next topic is robustness. The robustness determines how the systems reacts if the environment of the supply chain changes. In the study five elements changed: the mean time to repair (MTTR), set-up time, machine availability, scrap rate and demand. The first four elements all affect supply chain internal variation. In the case internal variability decreases all systems except Kanban benefit the reduction by a higher service level with lower WIP. Kanban does not benefit the reduction in variability because the other strategies better handle the reduction in internal variability with the same parameters. In the case internal variation increases there is a split in sequence for low WIP and high WIP. For low levels of WIP Kanban and CONWIP outperform the push systems MRP and DBR. This is because push systems tend to accumulate stock in the chain, where pull systems automatically control for this effect. For high levels of WIP this disadvantage is not as strong anymore making them better than Kanban or CONWIP. When the variability of demand changes nothing changes the ranking of the PPCS (Jodlbauer & Huber, 2008).

The last topic to discuss is stability, this has been researched by changing the parameters of each PPCS. The conclusion is that MRP is the most stable system followed by Kanban and DBR. The least stable system is CONWIP. DBR and CONWIP have as advantage that these systems do not have a lot of parameters. Therefore they are easy to use but less stable. If there are not a lot of parameters it is very important to determine them very exact because a small error could have a big influence on the performance of the system (Jodlbauer & Huber, 2008).

2.2 Variability

The next discussed principle is the reduction of variability. Because of lower transport rates, worldwide logistical networks have become normal. Companies outsource production activities to where they are the cheapest. But in order to still deliver on time all variability should be reduced. Variability is an important reason to hold stock. If there is high variability stocks increase to cover insecurity. In order to keep control of stock in a global network it is needed to reduce variability throughout the whole supply chain. This means any transit time variability, production time variability or customs clearance time variability should be reduced in the network. Another problem in modern supply chains is that customers expect more choice which also raises variability. In case variability is driven out, the network is able to reduce stock while keeping the same service level. Closely related with variability is flexibility. Flexibility is the ability of a supply chain to quickly change processes. Flexibility means that there are short term alternative ways to fulfil demand. For example if a supplier located in Mexico does not deliver in time, you are able to buy the same product in Eastern-Europe which arrives one day later. By changing supplier on short term, variability can be driven out (Walker, 2005). First, an important strategy to cope with variability is discussed, Six Sigma. Second flexible supply chains will be discussed as this is also a way to cope with variability.

2.2.1 Six sigma

Six sigma is a project management method focussed on reducing variability. Six Sigma originated by Motorola Inc. in the US. Motorola was having trouble to compete with the Japanese JIT strategies. In order to face the Japanese threat they had to make drastic improvements in their quality levels. Quality in a production company is determined by lower and upper limits that are acceptable. For example a specific beer has to have an alcohol percentage between 5,19% and 5,21%. This is respectively the lower specification limit (LSL) and the upper specification limit (USL). The LSL or USL are mostly determined by law, internally or by a service level agreement (SLA). A SLA is a contract between supplier and client that determines which specifications the products has to have and how payment and distribution should be arranged. In order to produce between LSL and USL, there has to be a target. This is the percentage you aim to produce, in the example this should be an alcohol percentage of 5,2%. Of course there is going to be variation on the process, but as long as it is between LSL and USL the product can be sold. If the product is not between LSL and USL the product cannot be sold and is by consequence waste. In statistics, sigma (σ) is the symbol for standard deviation. Six sigma stands for a stable process where the distance between target and LSL or USL is more or equal to six times the standard deviation. This is a lot less variation than most production processes and results in a low level of waste and defects. For example a 3 sigma process results in 66.810 defects per million products, a 4 sigma process results in 6.210 defects and a 6 sigma process results in only 3 defects per million. As can be deducted from these numbers there is an exponential relationship between the effort and a higher level of sigma process. It is relatively easy to go from a 3 sigma process to a 4 sigma process but it is very difficult to get form a 5 sigma process to a 6 sigma process. By consequence more sophisticated statistical tools and following investments will be needed in order to achieve this goal. Therefore one should always ask the question if the effort is worth the benefit (Linderman, Schroeder, Zaheer, & Choo, 2003).

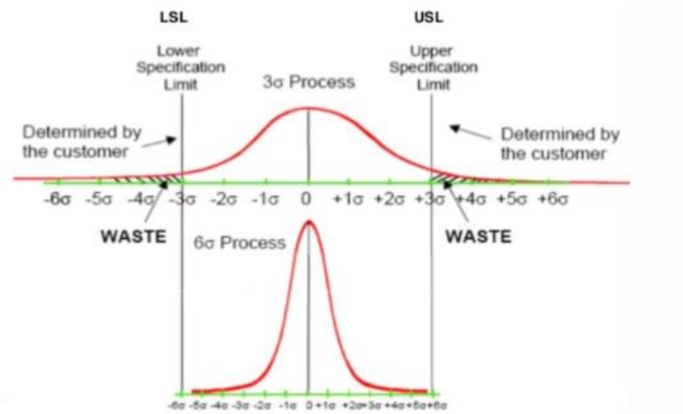

Figure 7: Six Sigma (Linderman, Schroeder, Zaheer, & Choo, 2003)

Six sigma is more than just a way to define how stable a process is. Schroeder et al (2008) formulated the following definition: "Six Sigma is a parallel-meso structure to reduce variation in organization processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives." There are several elements in this definition that need further explanation. The first element is the parallel-meso structure. This is a structure within the organization for a specific six sigma project. Six sigma has three hierarchical levels: champion, black belt and green belt. These three levels are not connected with the organizational hierarchy, therefore it is called parallel structure. The leader of different projects is the champion, who provides support and reviews the projects. A champion is mostly someone from senior management. The black belts serve as project leaders and mentor green Belts in problem-solving efforts. Black belts are selected people with leadership skills and technical knowledge. Black belts play a crucial role to communicate between the team and senior management. The next important part of the definition is improvement specialists. Almost all people within the project have had a specific training about six sigma. This training serves to educate all members of the six sigma project and has a psychological side effect which will cause members to believe they can solve the problem because they are trained for it. The following element in the definition is a structured method, for all Six Sigma projects a structured method is used named DMAIC. DMAIC stands for define, measure, analyze, improve and control. This structured method is known to get to the root cause of problems by using several tools. In each phase some people are more important than others, the champion will have an active role in the define phase, but a more supporting role in the other phases. Black belts will be active in every phase of the project and green belts will be more active during the measure, analyze and implement phases. An advantage of this structure is that everybody in the team knows what is expected of him. Another aspect of six sigma is the use of performance metrics, metrics used are for example the process sigma as explained above. All the metrics can be divided into two categories: customer-oriented metrics and financial metrics. Customer-oriented metrics identify the needs of the customer and determines targets based on customer requirements. Therefore when customer-oriented metrics are improved there is a direct effect on the satisfaction of the customers. It makes sure priorities are right. The other metrics are financial metrics, these are very important in order to evaluate a project. It also helps to determine the way the team has to go. The last part of the definition is strategic objectives, this means that every project should have a strategic or financial implication. When there is no strategic objective, projects should not be done. It also means that the power to start a project is with the senior management, a champion is the only one who can initiate project. This way it is avoided that only convenience projects are executed what is sometimes the case in the bottom-up approach. In this approach workers can initiate projects without permission of senior management (Schroeder, Linderman, Liedtke, & Choo, 2008).

2.2.2 Flexible supply chains

Instead of trying to reduce variability, it is also possible to cope with variability by making a supply chain more flexible. According to Sinh and Acharya (2014) a supply chain can be flexible in twelve dimensions. These dimensions are: manufacturing, sourcing, coordination flexibility, information system, logistics, access, market, expansion flexibility, physical distribution flexibility, demand management flexibility, transhipment and new product development flexibility.

The first dimension is manufacturing, a flexible manufacturing processes allows that production levels are quickly raised and reduced in order to react on a changing environment. It also allows rapid introduction of new products. Sourcing flexibility is the ability to have several suppliers thereby reducing risk of being dependent on one supplier. Coordination flexibility focusses on the possibility to change partners and built new relationships with partners. Flexible coordination means that partners are quickly integrated into company processes. Information system flexibility is the opportunity to change processes in the information system because of changing requirements. For example a new production process that has to be implemented into the company's IT system. Next is logistics flexibility this means that it is easy to advance or delay orders. Access flexibility is an external flexibility, it is the ability to sell products everywhere by an intensive and widespread distribution coverage. Market flexibility is the possibility to quickly react on needs of the market. Expansion flexibility focusses on the capacity of the whole network, the ability to raise production, transport, supply et cetera all at once. Physical distribution flexibility is the possibility to effectively and efficiently change the distribution processes so direct as well as indirect customer expectations are met. Demand management flexibility is the degree of which a company is responsive for customer needs. Next is transhipment flexibility which is more common for companies with several stocking locations, it is the ability to transfer stock from one stock location to another one. By having transhipment flexibility discrepancies can be corrected. The last dimension is new product development flexibility, which means it is easy to introduce new products into the process. (Singh & Acharya, 2014).

By changing something in the structure mostly more dimensions are influenced, and not always in a good way. There are a lot of ways to increase flexibility of a supply chain, but flexibility comes often with a cost. For example if you have lots of suppliers this increases sourcing flexibility but it becomes more difficult to integrate them in the processes lowering coordination flexibility. There are several ways to increase flexibility mostly very company specific. This is why only postponement is discussed as an example how a supply chain can be more flexible. Postponement is a strategy where specific characteristics are determined the last moment. For example the colour of a car is determined the moment it is ordered this way there is no need to keep stock for each colour of car. The example given is product customisation postponement. It is also possible to postpone on other places in the supply chain, for example in the product development phase. Here decisions about design can be postponed, this way suppliers can give their opinion about the parts and the most advantageous design can be chosen. Postponement adds flexibility to market, transhipment and demand flexibility (Boone, Craighead, & Hanna, 2007).

2.3 Vocalize

The vocalize principle tries to synchronise supply and demand. In order to synchronize there should be continuous communication and collaboration about network constraints, demand patterns inventory levels and cash positions. If the vocalize principle is followed in a supply chain there is a heavy focus on throughput. The vocalize trend in supply chains causes that organizations alongside the edges of a company can easily get information, they can easily plug and play. The vocalize principle is heavily based on the drum buffer rope concept from the theory of constraints. Which will be explained in more detail in the next paragraphs (Walker, 2005).

Theory of constraints is the theory behind the production planning and control strategy (PPCS) Drum-buffer rope(DBR). The theory of constraints exists out of the believe that constraints should be identified and elevated. By elevating something that is limiting performance, the level of performance should go up. A constraint is more than only capacity constraints. Other constraints can be supply, demand or even policy constraints. With this understanding of constraints it can be concluded that every system should have at least one constraint (Watson, Blackstone, & Gardiner, 2007).

The theory of constraints follows five simple steps: "Identify the system's constraints", "Decide how to exploit the system's constraints", "Subordinate everything else to the decision taken in the step before", "Elevate the systems constraints" and last "If a constraints has been broken, go back to step one". The first step is quite straightforward. It can be challenging to identify constraints because they are mostly not that clear. Sometimes stocks, rules, policies, communication issues or measures trouble the identification of a constraint. A manager focussing on a high utilisation rate could forget the focus of a company. In the end, value has to be delivered to the customer. The customer does not pay to keep workers busy who produce unnecessary stock. If utilisation rates are high, it does not necessarily mean you are working efficiently. In most cases machines have different capacities, if a high capacity machine works on full capacity before a low capacity machine, intermediate stocks would start to explode which in turn would disturb the processes. So focussing on utilisation rates would not be optimal in this case (Goldratt, 1990).

Once the constraint is identified the next step is to decide how to exploit the system's constraints. The main question is how to manage the non-constraints. Mostly all non-constraints should be managed according to the constraint. This means the consumption of the constraints should be covered but not more. When a non-constraint produces/supplies more than the constraint can consume, there is unnecessary stock. In the example above this would mean the high capacity machine should not work on full capacity. The next step is to subordinate everything else to the decision taken before. In our example this would mean to let purchasing of raw materials and delivering of finished products be determined by the low capacity machine. The fourth step is to elevate the system's constraint. In the example this can be done by introducing a new machine, but there are also other possibilities like introducing an extra shift. The fifth step is to start over if a constraint is broken. Moreover there is an important remark if the constraint is broken by use of rules. When specific rules are not updated they tend to hold down the process. In our example a rule could be: "keep the low capacity machine on full utilisation". This rule can influence the process if something else changes in the system. The conclusion of the TOC is to communicate bottlenecks and problems throughout the whole supply chain, this way everything can be optimised (Goldratt, 1990).

2.4 Visualize

A critical issue in gaining competitive advantages in supply chains is by getting visibility on all processes. Performance management lies at the heart of every competitive supply chain network. Managers need to know how current processes are going. Without visibility it is impossible to manage a supply chain efficiently. There are several ways of managing processes. Mostly key performance indicators (KPI's) are used. The data for the different KPI's can be gathered from sensors, RFID, GPS, barcodes, ERP et cetera (Walker, 2005).

Visibility has increased a lot by implementing technologies like sensors, RFID, GPS, barcodes and ERP. By using these techniques in combination with IT it is possible to efficiently track and trace products throughout the supply chain. Sensors can for example track temperatures. RFID and barcodes are used to track products throughout the supply chain. This way it is known where a specific product has been scanned or passed. RFID distinguishes itself from barcodes, because there is no need to scan each individual product. GPS can locate products real time giving perfect visibility of products or resources. In order to keep track of what these systems register, events have to be kept in logs. These logs in combination with IT deliver possibilities to calculate measures of performance. This way success can be identified and the understanding of the process is improved (Akyuz & Erkan, 2010).

Key performance indicators can be retrieved using different techniques. There are two classes of indicators: financial and non-financial. The most known financial measures are traditional measures like revenue or total production cost. Unfortunately traditional financial measures are mostly too aggregated to review supply chain processes. Another way of calculating a financial KPI is by using activity based costing. Activity based costing tries to determine costs of activities and products based on budgets. By using budgets instead of actual prices it is possible to exclude price fluctuations in financial measures. For example the cost of treating a box in a warehouse. The treatment costs exist out of different cost components. One cost component is the time needed to retrieve the box. In order to determine this cost component the budgeted price of one workhour and the average time needed to pick a box is used. Non-financial KPI's are for example service level or freshness (Schulze, Seuring, & Ewering, 2012).

Key performance indicators are a valuable tool to get visibility in a supply chain. In order to manage a supply chain one should look out for certain problems with KPI's. So is it important that KPI's are consistent and complete in the performance measurement. Furthermore financial and non-financial KPI's should be used, focussing respectively on financial and operational measures. A big problem with KPI's is that too much KPI's get defined. This makes it unclear which KPI's are important for the management. Besides KPI's should align with the strategy in the company. The last problem with KPI's is that they can be too much focused on financial metrics or too much inward looking. In order to determine which KPI's are important, a balanced score card is used. A balanced scorecard is a way to grade performance of managers by determining a weight for a hierarchical set of financial and non-financial KPI's in line with top management strategy. A balanced scorecard should be a good representation of performance of a manager. This is why several dimensions should be included. The measures should be as well on long term as on short term. This way it can be avoided that managers only go for short term gain. Further the KPI's should have an external as well as an internal focus. This way the perspectives of multiple stakeholders in different levels of the organisation can be reflected and taken into consideration. Lastly a balanced scorecard should give insight in the four views of business: learning and growth, internal processes, customer and financials. In companies where a balanced scorecard is used, KPI's improve processes and managers know which KPI's are the most important because they know the strategy of the company and the weights connected to each KPI which grades them. The hierarchical relationship between KPI's is needed because KPI's can overlap or influence each other. For example wanting to have a low stock level and a high service level works against each other. By having visibility on the supply chain with KPI's it is possible to set targets and thereby influence the behaviour of managers. (Akyuz & Erkan, 2010)

2.5 Value

The last principle is value. Value means that every stakeholder should have an advantage by being in the network, this way the network value gets optimised. If a stakeholder does not have an advantage to be in a network, the network will be not valuable to the stakeholder and the stakeholder will do no effort for the network. The most important way to get an advantage is by collaboration between the four classes of stakeholders: customers, owners, employees and suppliers. First the importance of communication and collaboration is explained. Next a broader understanding of communication and collaboration will be discussed (Walker, 2005).

2.5.1 Importance of communication

As show by the theory of constraints in the vocalize principle, it is important to share information through the supply chain. A lot of studies also show that by sharing information, supply chain coordination can be improved, the bullwhip effect can be reduced and supply chain costs can be decreased. The bullwhip effect is defined as the distortion of demand information as one moves upstream in the supply chain, causing severe inefficiencies. Because a supply chain exists out of different players including suppliers, manufacturers, distributors, retailers and customers, demand information can be unclear. In the case there is no coordination between the different parties, it results in inefficiencies. The bullwhip effect is such an inefficiency where demand variability is amplified as one moves upstream. This is visualized in Figure 8 where the order quantity has more variability up in the chain even though the customer demand does not change. There are two main classes of causes: behavioural and operational causes (Constantino, Di Gravio, Shaban, & Tronci, 2013). Behavioural causes are for example human biases in adjusting optimal solutions, like smoothening inventory, overreacting on inventory levels and underestimating the quantity of stock available in the supply chain (Udenio, Vatamidou, Fransoo, & Dellaert, 2017). Some operational causes are non-zero lead-time, order batching, price fluctuations and shortage gaming. Non-zero lead-time means that the lead time can differ and therefore stock is needed. Order batching is for example that orders are all delivered on the same day. Price fluctuation effects happen if actors in the supply chain increase or decrease stock levels in order to profit from price fluctuations. The last example is shortage gaming, in this phenomenon a factory has only limited amount of stock and cannot deliver everyone. Here a customer orders more than actually needed in the hope to get the quantity he needs. Because the supplier cannot fulfil demand. The way to tackle the bullwhip effect is to coordinate more between the different players in the supply chain this way the right conclusions about demand can be drawn and stocks can be reduced (Constantino, Di Gravio, Shaban, & Tronci, 2013).

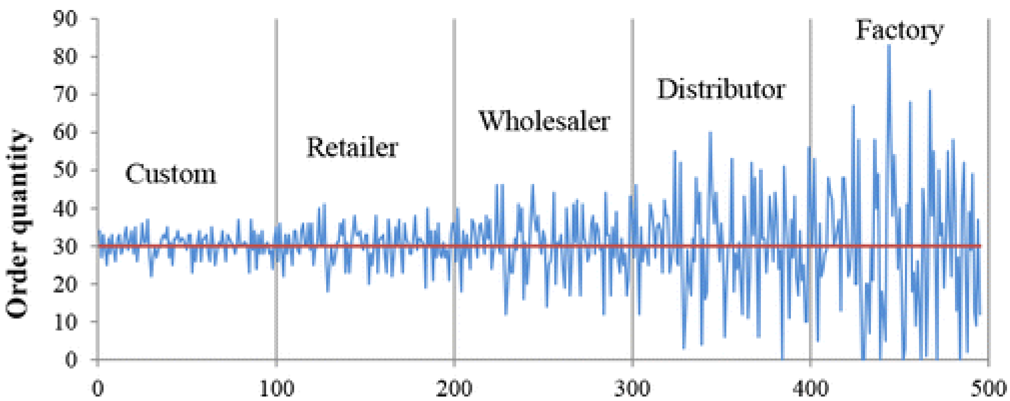

Figure 8 Bullwhip effect (Constantino, Di Gravio, Shaban, & Tronci, 2013)

2.5.2 Collaboration

The previous paragraph explained why it is important to share information and collaborate. In order to collaborate there has to be communication. The set-up of such a communication is determined by three characteristics: level of information sharing, information quality and medium. There are three levels of information sharing. The first level is the sharing of production status and planning processes, this level of collaboration is aimed at operational efficiency. The second level is to communicate changes in business environment or goals. The third level communicates future prospects for the company, here the aim of collaboration is about matching and sharing objectives.

There are many studies about collaboration. In order to explain the ways of collaboration a framework by Cao and Zhang (2011) is used. This framework defines 7 interacting components: information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communication, and joint knowledge creation.

Information sharing is the extent to which information is shared and is the "key requirement" (Cao & Zhang, 2011) for supply chain collaboration. It is the willingness to make strategic and tactical data like stock levels, forecasts, promotions, and strategies available to firms. This is also called the quality of the information, quality is aimed at clear data that both parties understand. There are six dimensions of information quality: Accuracy, reliability , frequency, currentness, completeness and appropriateness. If the quality of the shared information is high on these six dimensions the other party perfectly understands the data and it can be used to improve performance (Vanpoucke, Boyer, & Vereecke, 2009).

Goal congruence is how partners of the supply chain perceive objectives of the supply chain. In order to collaborate partners should feel that company objectives coincide with the objectives of the supply chain or at least that the objectives of the supply chain are a way to attain the company's objectives.

Decision synchronisation means that decisions throughout the supply chain are orchestrated in a way the supply chain is adapted to it. If decisions are synchronised, the decisions taken are communicated to the whole supply chain before it is executed. As a consequence the supply chain can prepare itself and plan for the effect of the decision, a negative effect will be reduced and a positive effect will be optimised immediately. In supply chain management there are several categories of decision making like operations, strategy, demand, production and scheduling, procurement, promise delivery, balancing change and distribution management. By making a joint planning in all of the categories, supply chain operations can be optimised (Cao & Zhang, 2011).

Incentive alignment refers to the process of sharing costs, risks and benefits among supply chain partners. Effective supply chain collaboration requires that each participant shares gains and losses equitably. In order to share gains and losses mechanisms are required. Resource sharing is the process of leveraging capabilities and assets or investing in new capabilities or assets together. An example of this is vendor managed inventory (VMI) or the sharing of actual equipment (Cao & Zhang, 2011).

Collaborative communication exist out of different parts: frequency, medium, direction and influence strategy. A close collaboration has open, frequent, balanced, two-way and multi-level communication. Mediums are telephone, e-mail, written and face–to-face contact. More high-tech mediums are EDI (Electronic data interchange), computer link or ERP. These high-tech systems of communication allow transaction costs to decrease drastically making collaboration cheaper and help collaboration between two parties (Vanpoucke, Boyer, & Vereecke, 2009).

The last component is joint knowledge creation, this component is the degree to which supply chain partners work together to get a better understanding of the market and competitive environment. There are two kinds of knowledge creation one is knowledge exploration and the other is knowledge exploitation. Exploration is about the capture, exchange and assimilation of knowledge like process technology or market knowledge. Exploitation is to exploit the knowledge to get a competitive advantage (Cao & Zhang, 2011).

2.6 Conclusion

As discussed by Walker (2005) there are five important principles on which a supply chain is designed. The velocity principle is determined by the production planning and control strategy the four strategies discussed were: Kanban from JIT, MRP, Conwip and DBR from the TOC. Each of them being advantageous in specific situations. The next principle is variability. As discussed one option is to reduce variability another option is to increase flexibility. An important theory to reduce variability is six sigma from Motorola by using a structured approach called DMAIC and specific tools like the process sigma. On the other hand flexibility can embrace variability by foreseeing short term solutions to reduce variability in several dimensions. The vocalize principle is heavily correlated with the TOC which tries to communicate problems throughout the supply chain and gives insights to guarantee demand is fulfilled. The TOC tries to identify and elevate constraints using a five step plan. The next discussed principle is the visualize principle which is about understanding and managing processes. This is done by the use of financial and non-financial KPI’s, possibly calculated by activity based costing. Next these KPI’s are put on balanced scorecards to grade the performance of managers and helps managers to send the supply chain in the right way. The last principle is value. This principle is the cultural shift from focusing internally to focussing on the supply chain as a whole to avoid problems like the bullwhip effect and to have other advantages of close collaboration. The five principles give understanding of how a supply chain works and why specific decisions are made. Furthermore gives it insights in trends and challenges of supply chains.

3. Case study AB InBev: As-is Situation

As done in the six sigma method DMAIC, the problem should first be defined. In order to define the problem of AB InBev, the processes have to be understood. Business process modelling is a way to visualize and understand complex processes. First the business process modelling literature will be consulted. Afterwards a business process model will be made and explained for all the processes directly related with freshness in AB InBev.

3.1 Business process modelling literature

Business process modelling is a technique to visualize the way organizations conduct their processes. Originally it was a way to facilitate the development of software for business processes (Williams , 1967). Now it is getting used by managers for integrating and managing the supply chain, because a successful system starts with the understanding of the system. According to Chinosi and Trombetta (2012) a business process is a set of one or more linked procedures or activities executed following a predefined order which collectively realizes a business objective or policy goal. There are several techniques to model a business process, each with its own advantages. Two techniques will be discussed in this thesis: flowchart and business process modelling notation (BPMN). The flowchart technique is explained first seen this is a very intuitive and easy way to visualize processes. Second the BPMN technique is explained this technique is more complicated but still based on the flowchart. It is understandable and it can handle more complexity than a flowchart.

3.1.1 Flowchart

The oldest technique of the two is explained first. It is defined as a formalized graphic representation of a program logic sequence, work or manufacturing process (Aguilar-Saven, 2004). It uses symbols to represent operations, data, flow direction and equipment for the definition, analysis or solution of a process. A flowchart is very flexible: a single process can be represented in several ways because there is no standard how to model a process. There are only standard building blocks with its own interpretation. The way they are put together is up to the designer. Furthermore is a flowchart very easy to use, interpret and communicate. A disadvantage of the technique is that it is too flexible, which can make it difficult to interpret the process if processes get more complicated. A second disadvantage is that processes tend to get to big to understand. Thirdly there is no difference between sub-activities and main activities making the chart hard to read. A flowchart is ideal to model processes with a high level of detail. In Figure 9 an example of a flowchart is shown (Aguilar-Saven, 2004).

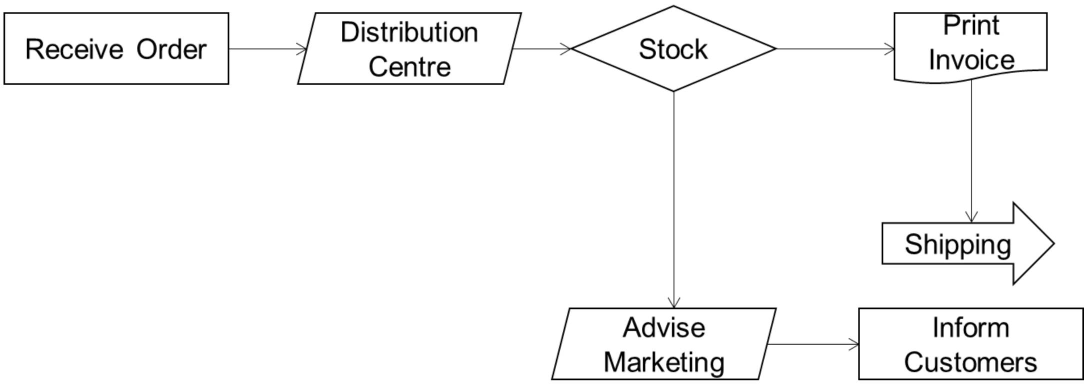

Figure 9: Example flowchart (Aguilar-Saven, 2004)

3.1.2 Business process modelling notation

Business process modelling notation (BPMN) aims to get a standard way of modelling business processes (Chinosi & Trombetta, 2012). A standardized way improves communication between business analysts who sketch the process as well as technical developers who develop software and business staff deploying and monitoring the process. BPMN has four graphical elements to build processes with: flow objects, connecting objects, swimlanes and artifacts. Flow objects represent all actions which happen in a business process determining its behaviour. Several kinds exist: events, activities and gateways. Connecting objects determine the sequence and the ways of connecting various objects to each other. Swimlanes or pools group activities, mostly a group is one department or company. This way the performer and responsible are clear. A pool is used for the biggest group for example a company, a swimlane is used for elements of a company for example departments or teams. The last element are artifacts, artifacts are additional information that do not affect the flow. Figure 10 gives an overview of the different elements of BPMN. And in Figure 11 is an example of a BPMN. The advantage of the BPMN technique in comparison to the flowchart is that the BPMN technique is better to visualize complex processes. The use of rules and the different elements of BPMN make a more complex structure clear (Chinosi & Trombetta, 2012).

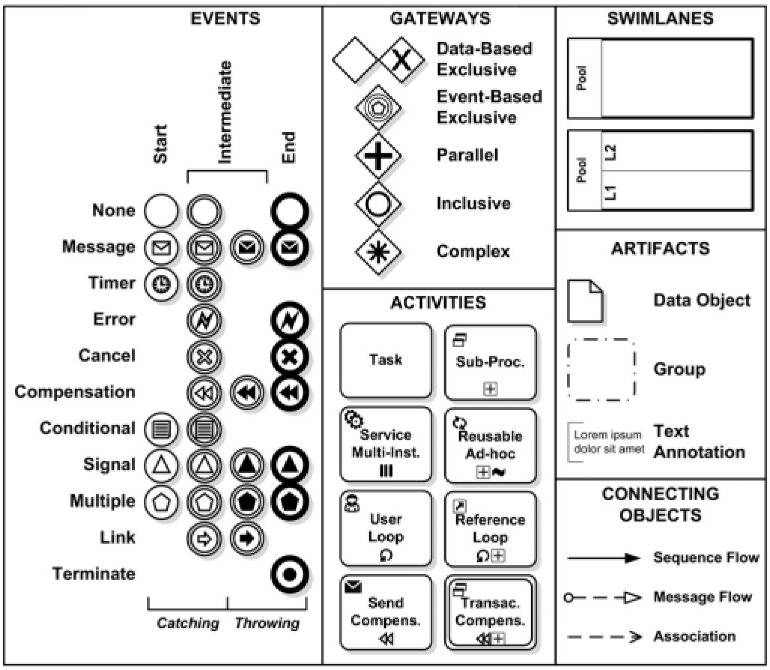

Figure 10: Elements Business process modeling notation (Chinosi & Trombetta, 2012)

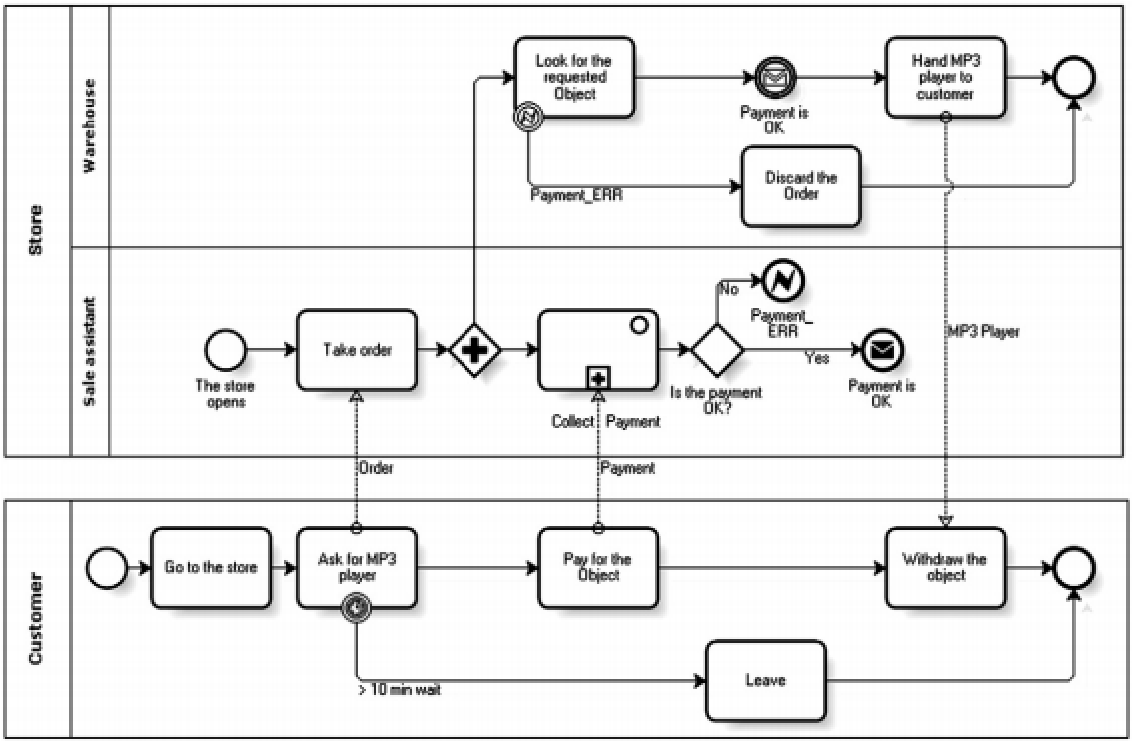

Figure 11: Business process model example (Chinosi & Trombetta, 2012)

Because of the clear intuitive structure and the general rules BPMN is a great tool to analyze processes. It can also be used to communicate processes between departments or companies, this way collaboration can become easier.

3.2 Business process model AB InBev

Now the business process model for AB InBev can be discussed. All the information of the processes mapping was retrieved by doing interviews with employees in Prague and Leuven. A BPMN approach has been used to model the process. The whole business model can be found in Appendix 7.1. There are three pools in the model: the customer, AB InBev and Katoen Natie. AB InBev is divided into different lanes, each lane representing a department: order taking, supply network planning, scheduling, inventory deployment domestic transport planning and international transport planning. Katoen Natie is the warehouse provider of AB InBev and does the actual loading of the containers. Each swimlane will be discussed separately.

3.2.1 Order taking

Order taking receives orders and compares them with the forecast, next they determine a promised delivery date. AB InBev uses an MRP system. As discussed this is typical for a push product like beer. The promised delivery date is determined differently for three groups of products. These groups are: minimum order quantity, make to stock and make to order. The first group, minimum order quantity (MOQ), is a group of low volume products. They are not ordered a lot. Therefore, the order taking department waits until they have a quantity which is big enough to start production. By waiting until enough is ordered it is beneficial to produce the product and excess stock is avoided. The disadvantage is that you cannot promise your customer when a product is going to be delivered. It should be noted that this group is really small and therefore has a negligible effect on freshness. The second group is MTS. This group contains mostly products shared by a lot of customers and have a high production quantity. The third group is MTO, this are products made on order for a specific customer. Because AB InBev has a lot of different SKU's (stock keeping units) a lot of products are produced on customer request.

As explained AB InBev uses an MRP system. A characteristic of this system is that intermediate dates are calculated and carefully planned. The first date which is calculated is the promised delivery date which is calculated differently for each group. The calculation always has two elements: the shipping time and lead time. The shipping time is the time it takes to get from Antwerp to the destination. This is different for each destination and is added to the lead time to determine the promised delivery date. The lead time is the time that is needed to produce, load and send the product. The lead time is different for each group. For a MOQ product, there is a variable lead time. This group has a variable lead time because it is not known when the product is going to be produced. Once the minimum production quantity is reached the customer gets a message when he can expect the product. As explained is the shipping time added to determine the promised delivery date. A MTS product is a product that is already in stock, therefore delivery can be done fast. AB InBev determined that it takes one week to load and send the product. So delivery should be in the time period of the shipping time plus one week. MTO products are not on stock, but production can be planned immediately. Therefore the lead time is known. Promised delivery is here calculated by the shipping time plus twelve weeks. These twelve weeks are determined by AB InBev and are an internal measure.

For communication purposes to customers the promised delivery is fine, on contrary this date is not very efficient to manage internal processes. To manage internal processes, the made availability date (MAD) is used. This date is the date products should be available in the warehouse of AB InBev in Antwerp, it is back propagated from the promised delivery date. The MAD is one week plus the shipping time before the promised delivery date. This means that one week after production the product should be in a container. This MAD is used in the following departments to manage processes.

3.2.2 Supply network planning

Supply network planning (SNP) plans the whole supply chain from grain until customer. The planning is done over a timespan of several months because they have to look ahead what is going to come and correct for deviations of the plan. To make this plan the forecast of the individual markets is used. In order to keep an overview, only the part of the process that influences freshness is discussed. SNP determines weekly production quantities for the bottling lines. The weekly production quantities are determined 3 weeks before MAD or 2 weeks before production. After this SNP cannot change the schedule anymore.

In order to use the bottling machines optimally, a whole week of orders is batched together and produced in the week before MAD. This way batches are bigger and there is less time lost due to the set-up of machines. For freshness it means that if a product has an MAD on Monday or Friday the week of production is the same. It is possible that the product for Monday is produced on Friday which means there are only 2 days between MAD and production. The worst case scenario is that the product for Friday is produced on Monday which is 11 days before the actual need. The production day is determined by the scheduling department and will be treated in the next section.

SNP manages the weekly production quantities as follows. They determine whether production capacity is surpassed. If production capacity is surpassed they make sure they produce some orders more up front, this way the production is guaranteed. This way of working is visualized in the fictive example Figure 12. The green line shows how much capacity would have been used if everything is produced one week before MAD. It is clear that the production limit is surpassed several times. In order to guarantee production SNP pulls orders more upfront, by doing this the blue line is going to be the actual capacity utilisation. In this fictive example the production limit is 80% utilisation, not equal to 100%, because spare capacity is needed to correct for unforeseen events.

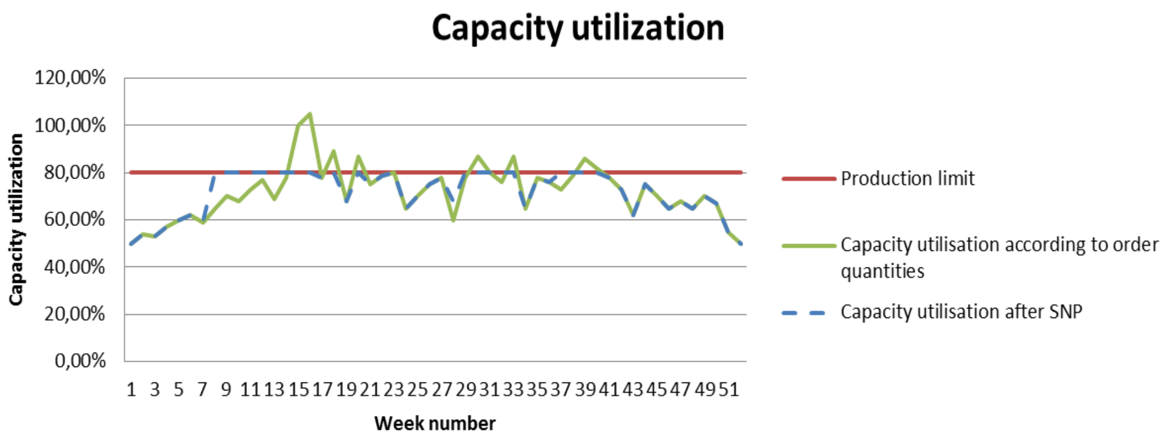

Figure 12: Capacity utilization

3.2.3 Scheduling

Scheduling is the department responsible for what is produced on each line. They receive the production quantities of SNP two weeks before MAD. When they receive the production quantities. They check if and when the packaging material can be delivered. There are several suppliers like for example Katoen Natie because KTN cleans empty kegs that come back from overseas.

A whole week of orders are batched together. In order to produce these products efficiently they have some supplementary rules. First of all they try to produce all products with the same content and with more or less the same packaging at once. For example kegs for the American market and European market are more or less the same and they contain exactly the same product. This is why they are produced together in order to reduce set-up time. They also try to end with a MTS product, this way it is not that important if the exact quantity is produced, because the products are not ordered yet. MTO and MOQ products are ordered before, so if the production quantity deviates from the ordered quantity it will cause delays in delivering the ordered products. Scheduling knows the MAD so they use this date if something was not produced in time and they have to produce it the week after. They keep revising the schedule to keep it up to date, because there are always unforeseen events.

3.2.4 Inventory deployment

Inventory deployment manages the stock level of the Katoen Natie warehouse and makes sure that the transport planning department plans the appropriate amount of transport. The two tools for managing stock levels are stock transfer orders (STO's) and order releases. First the two tools are explained second the whole process of inventory deployment is discussed.

Stock transfer order

The first tool, stock transfer orders (STO's), is used to transport stock from the brewery to the warehouse. A stock transfer order is an order for the domestic transport department to transport stock from the breweries to a customer within the zone. An STO has to be made by the inventory deployment team and the execution has to be planned in the brewery. Next the number of products specified on the STO are transported to the customer. The process of making and executing an STO takes some time. So if a product only goes to the warehouse, there is no need to make an STO. Seen the making and executing of the STO would only take time. Everything coming from the bottling line can go directly to the warehouse. If the SKU is purely for export to America for example, it always has to be shipped from Antwerp so it does not make sense to have an intermediate stock at the brewery where stock should wait for an STO in order to be transported.

Therefore a distinction is made between two types of products: pull and push. Pull products are products needed for customers locally and at the warehouse. If the product is needed locally from the brewery an STO has to be made to get the product form the brewery to the customer. For the warehouse the same logic applies, they also have to make an STO to get stock. Inventory deployment has to pull the product to the warehouse using an STO.

Push products on the other hand are only or mostly needed at the warehouse. Push products are delivered in the warehouse directly from the brewery without making an STO first. By doing this there is only stock at the warehouse and it is easier to manage the stock levels of the product. As mentioned this is only applicable to products needed only or mostly in the warehouse. Mostly because it could be more beneficial to arrange distribution locally from the warehouse instead of from the brewery because the volume distributed from the brewery is low. By making these products push products there is less chance for stock deterioration and more clarity what and where the oldest stock is, this is more advantageous than distributing the products from the brewery. In addition it has to be mentioned that the biggest volume of products are push products, so there is often no need to make STO's.

Release

The second tool, a release of an order, is to make sure stock leaves the warehouse. Releasing an order means determining the date when the order is ready in the warehouse, called the inventory availability date. This date is used by the international transport department to arrange transport from Antwerp to the port of destination. The inventory availability date is mostly determined before the product arrives in the warehouse. It has to be determined up front in order to plan transport which takes some time. If the transport department would wait until the product is actually available in the warehouse it would take too long to arrange transport.

Inventory deployment process

The inventory deployment process is also a part of the BPMN, and can be seen on Figure 13. The first step in the BPMN of the inventory deployment process is to collect all orders with an MAD in the next 3 weeks, this means that all products have to be send within 4 weeks. As explained in section 3.2.1, MAD is promised delivery date minus transport time plus one week to load it. So according to the promised delivery date the product should be shipped 7 days after MAD. Next, all these orders are checked for expected vessel problems. If capacity shortages are pending to certain destinations, international transport planning wants to book transport as soon as possible. This way capacity shortages can be avoided. Capacity shortages easily delay a shipment by one or two weeks. Therefore inventory deployment releases these orders 3 weeks before MAD but because no department knows when the product will be produced the inventory availability date is put 4 days after MAD. Chinese new year is a possible cause for capacity shortages. In this period a lot of goods are exported to China increasing the risk of running out of space on a vessel. In order to avoid the risk of having no capacity on the vessel to ship, bookings are done early.

The second step is to compare the stock available in Katoen Natie(KTN) and the stock needed for the released but not loaded orders. If there are more products than released but not loaded some extra stock can be released. The data for this task comes from Plato, a KTN owned software package that manages the stock. Each pallet that arrives in KTN is scanned and kept in Plato. Inventory deployment looks at the total of orders pending to be executed, this are the orders released but not loaded, and the total number of pallets available. Based on these numbers they release orders. It is very important the stock is kept up to date to avoid mistakes. This step is more a control step in the process seen inventory deployment tries to release orders before they arrive in KTN. In the following steps it will become clear why only few products will be released by the step just discussed.

The third step is to filter out orders with an MAD in the next seven days. The other orders are put aside and keep looping the first two steps till they also have an MAD in the next seven days. Next it is checked if the orders with an MAD in 7 days are on the production schedule. A difference has to be made between pull and push products.

First the process for the push products is discussed. Push products are brought immediately to the warehouse. Next it is checked when and if the products are on the production schedule. This schedule is retrieved from the ERP system of AB InBev were it was uploaded by the scheduling department. Important to note is that the goods are not linked to an order yet. If the products are on the schedule the inventory availability date is put two, three or four days after the production date in the schedule. The exact number of days after production is determined by an employee of the inventory deployment department based on experience and the volume of the order. When the amount of products on the planning are lower than the amount needed it is signaled to the production schedulers. Based on their input, an inventory availability date is determined.

Next the process for pull products is discussed. Pull products are products where stock is kept at the brewery. Inventory deployment has to make stock transfer orders (STO) in order to get stock in the warehouse of Katoen Natie. As determined in the step before the products are needed in the next seven days. First the stock of the brewery is consulted. In case the stock is available an STO is made and the inventory availability date is put one day after the current day. In case the stock is not available, the production schedule is checked. If the products are on the schedule, inventory deployment waits till the products are available in the brewery, then the STO and inventory availability date is determined. If the products are not on the schedule, it is signaled to the schedulers and waited until the products are available.

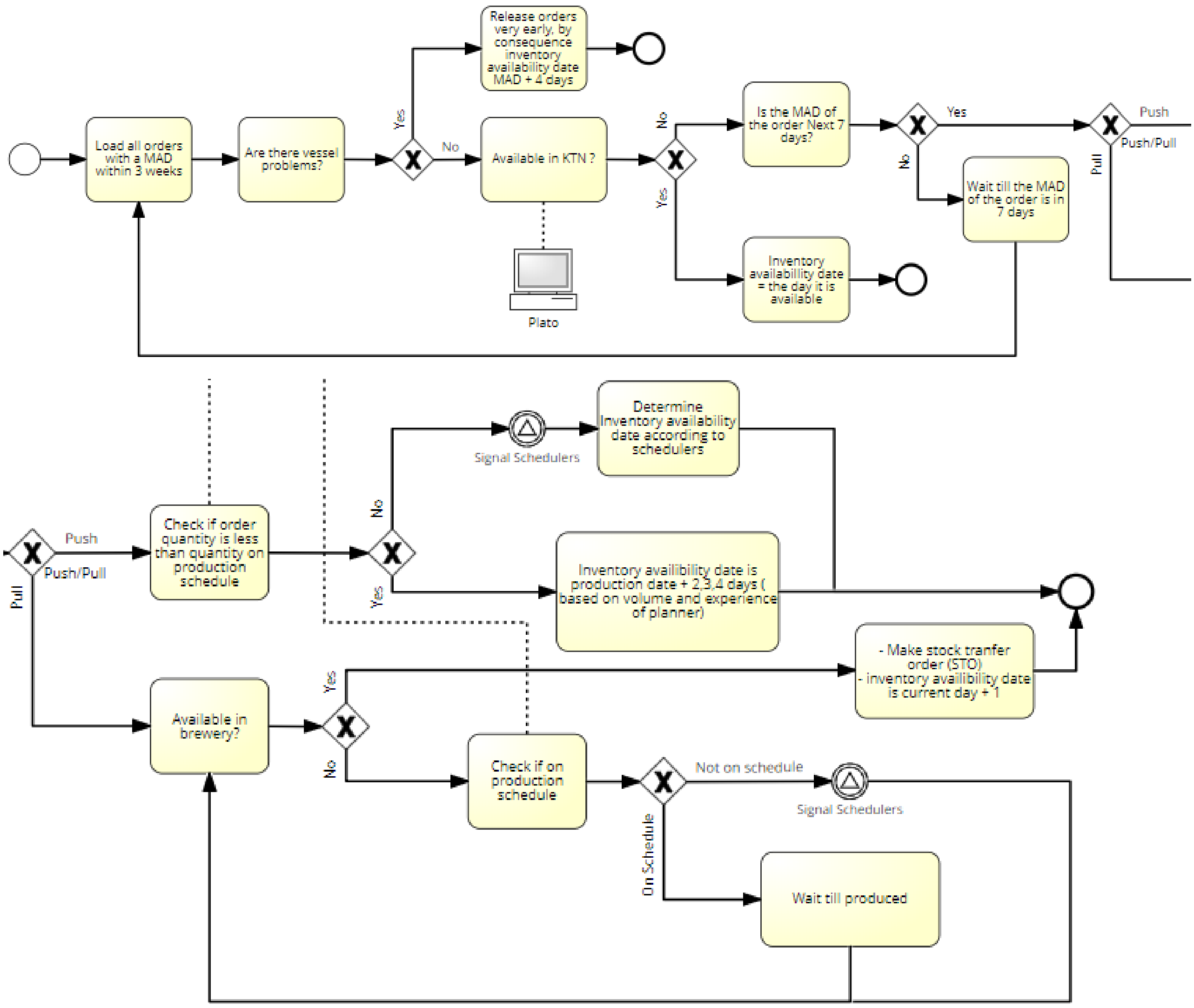

Figure 13: BPMN Inventory deployment

3.2.5 *Domestic transport planning*

Domestic transport planning arranges all the transport from the breweries to the local distribution centres, customers and the warehouse. For the warehouse this is physically done by picking up full trailers with beer at the brewery, dropping them off at the warehouse, taking a full trailer with packaging material back to the brewery and start the cycle over again. Domestic transport planning tries to use as few trailers as possible in an optimal way. They constantly monitor where the trailers are through a sophisticated GPS-system. The day before the actual transport they try to plan drivers, trucks and where the stock should come from as there are different breweries. In order to optimise where stock comes from optimal route to market software (ORTM) is used, this way it is guaranteed that stock comes from the closest location possible and unnecessary transport is avoided.

For transport planning there is also a difference between push and pull products. Push products planning is done by using the production plan of the next day determined by the scheduling department. As mentioned before (3.2.3) push products should not stay too long in the brewery. On the other hand packaging material should be delivered just in time. Because the rides from and to the brewery are combined, it is difficult to manage the just-in-time arrival. Trailer rotation is important to make sure this process is going well. For pull products STO's are made. The transport department tries to execute these orders the day after the placement of the STO. Stock has to wait until an STO is made. There are two ways to select stock: LIFO and FIFO. In the case the exported amount of an SKU is really small it is beneficial for freshness to get products LIFO: the freshest products are taken first for export. This is possible since most stock is needed from the brewery itself which is taken FIFO of course. If too much products would be exported, LIFO would not be beneficial for freshness because it would cause obsoletes. Obsoletes are products that could not be sold anymore because they are too old and have to be destroyed.

3.2.6 International transport planning

The last department discussed within AB InBev is international transport planning. This department is responsible for all transportation of beer overseas. They arrange that there is a container and a spot on a vessel to get the container in the port of destination. The aim of international transport planning is to determine a planned loading date. This date is to determine when a specific order should be loaded into a container at the Katoen Natie warehouse.

The first step of the process is to determine which vessel might be possible to take for an order. In order to select a vessel four dates should be taken into account: inventory availability and booking date plus two, MAD and vehicle good mass (VGM) cut-off. In order to take a vessel, the goods should be on time at the warehouse. An agreement between KTN and AB InBev says that goods should be available 2 days before loading and that the booking of the container should have been passed 2 days before loading of the container, to guarantee a timely loading. Therefore the earliest planned loading date is the inventory availability plus two days or the booking date plus 2 days, depending on which one is the latest. The next date MAD has to be taken into account because of an internal policy. The policy says that orders should be send after MAD. If orders are send before MAD the goods will probably arrive too early. As mentioned in section 3.2.1 there should be one week after MAD to load the order. If it is send before it will arrive one week earlier than the promised delivery date. This is negative for the customer because he cannot receive containers of goods that are not needed yet. Early arrival could cause problems in the customer's warehouse or with the handling of containers. The last date influencing the selection of vessels is the VGM cut-off. The meaning of this date is vehicle good mass, in other words the weight of the container has to be known. This deadline is imposed by carriers, they oblige that the cargo is in the terminal several days before the actual loading of the vessel. This date is there so carriers can safely place cargo in their vessels, because they have to fill the vessel according to SOLAS regulations. Safety of lives at sea (SOLAS) regulations make sure the vessel does not capsize or break. Next the earliest vessel where the cargo can be loaded on is requested from the carrier. The planner waits for a confirmation from the carrier which can take maximum one working day before going to the next step. If the carrier cannot put the extra order on the vessel, the carrier proposes the next available vessel.

The last step after the vessel has been determined is to specify the planned loading date. As said before, planned loading should be after inventory availability date plus two days and before VGM-cut-off. The previous step makes sure the vessel does not leave before MAD. There are also other factors to take into account when determining the planned loading date. The first factor is the internal policy of service level. Service level (SL) is calculated as the percentage of goods loaded before or on the 10th day after MAD. Service level is an important KPI and is an element of the balanced scorecard of most managers within AB InBev. SL-hits are therefore very important to minimize. An SL-hit is when a product is loaded after MAD plus 10 days. The last factor to take into account when planning the loading of containers is detention and demurrage.

Detention and demurrage are fines if a container is too long in the possession of the shipper (AB InBev). The carrier wants to have optimal utilisation of his capital. Therefore containers have to be shipped and they should not stay too long at one place. Detention and demurrage can be divided into three costs. The first is detention, this is the rent you have to pay for having an empty container longer than a certain period. Demurrage are the costs that have to be paid for having a full container longer than a certain period. In practice the difference between detention and demurrage is often not taken into account. For most contracts AB InBev has a joined free time and only one fee. The last cost is port storage, these costs are imposed by the ocean terminal, the company that fills the vessels. Port storage is paid to avoid congestion of a terminal. An ocean terminal only has a limited space to put containers and they want to optimize their operations. This is the easiest if there are only a few containers. They try to oblige their customers to deliver containers not too much upfront by imposing storage costs.

The last step was to determine the planned loading date. By taking into account inventory availability date plus two days, detention and demurrage, service level and VGM-cutoff. There is a limited time span in which the planned loading date can be put. The planned loading date is mostly put on MAD if this is in the time span and if the risk for no stock, late arrival at the terminal, a service level hit or getting detention and demurrage is minimal. If all these risks have been taken into account it is up to the experience of the planners where to put the planned loading date. Figure 14 is an example where several dates are taken into account.

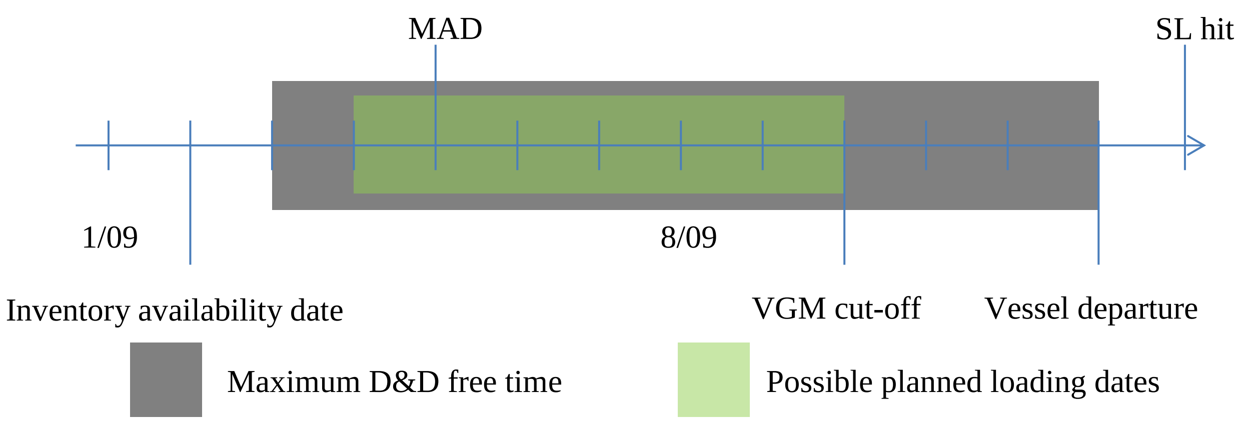

Figure 14: Example Planned loading date

3.2.7 Katoen Natie

The last external part of the process is the execution of unloading, storing and loading, which is arranged by Katoen Natie (KTN). As explained KTN is the warehouse provider of AB InBev, they arrange the loading and unloading of containers and trailers. The aim of KTN is to load everything according to the planned loading date which the international transportation team determined. In order to load on time there has to be a container and stock. The stock arrives after the domestic transportation team arranges the transport which is immediately after production for push stock or after an STO has been made for pull stock. Once the goods arrive in a trailer, the trailer is directed to the right unloading spot where they are unloaded, checked for damages, scanned and stored. The data coming from the scanning is saved in Plato, the warehouse management system of Katoen Natie.

In order to get a container, two systems can be used: an open or a specific reference. An open reference means that the destination of the container is not determined when it arrives at KTN. Because the destination is not determined it is possible to have a pool of containers which can be used for any destination. Most containers are retrieved from this pool. Because of this it is theoretically possible to immediately load a container when stock arrives. In practise this is not possible: since a container should be put in front of a loading gate, people should be arranged to load the container and the container should be linked to a destination. A specific reference means that the destination of the container is determined before it arrives in KTN. This kind of containers is picked up a few days before the planned loading date at the terminal of the carrier. A specific reference can only be used for that specific order. Because of the inflexibility of this way of working it is avoided to use a specific reference. All containers are managed by the container management system KTMS.

Next there is a process to get stock in the container. As explained all received stock is scanned and put into Plato. From Plato a list is retrieved with all products in the warehouse. Out of this list the available products are linked with the orders which are the most urgent. A product is available as long as it is not linked to a specific container or order. The most urgent orders are orders which could cause a SL-hit or orders risking to miss VGM cut-off. If the urgent ones are linked, KTN starts linking the orders that are going to be loaded after or on the planned loading date. They also link orders to be loaded one or two days before planned loading in order to secure that there is work and that the workload is spread out through the week. KTN tries to link orders two days before its planned loading date, as outlined in the agreement mentioned in section 3.2.4. The agreement says that stock should be in KTN and the booking should be passed two days before it can be loaded. In these two days several activities have to be done or planned. First the stock has to be linked, and the loading has to be planned. KTN has around 100 loading places, and because they load 100 container each day each loading spot is only used once a day, which makes it difficult to load faster than two days. In addition they want to reduce the risk of putting a container in front of a gate which is not loaded because the products are not available in the warehouse. Consequently stock is checked before it is linked to a container.

After the order is linked to the stock a container has to be linked to it. Therefore a connection has to be made between the warehouse management system Plato and the container management system KTMS. Here the containers are linked on FIFO basis. Which means that the oldest container is linked first. Next a loading order is released. This order communicates where the container should go and is executed by the stacker. A stacker is a machine capable of transporting and stacking containers. If the container is placed, the loading order can be executed by the forklift driver who fills the container. Next the container is sealed and put aside by the stacker to be loaded on a train.

3.3 Data analysis

In section 3.2 the process is described the next step is to measure performance. In order to evaluate performance one should determine what the process is capable of without changing the system as it is. First the theoretical performance of the current process is discussed. Second the available data and the structure of the data is explained. Last the most important results of the analysis are discussed.

3.3.1 Theoretical performance

Freshness is the time between production and loading of a container. From the business process model one can try to estimate freshness. There are three flows that should be investigated, the planned flow, the physical flow and the system flow. The planning flow is the time needed for the departments to make the planning and arrange transport and loading. The physical flow it the time a product actually needs to get transported to the warehouse and in a container. The system flow is the flow that is planned. In the following paragraphs the planning flow and the system flow will be discussed. The physical flow will not be treated since it is theoretically possible to transport the products from the brewery and to load the products in a container within a day.

Planning flow

The planning flow starts with the inventory deployment department. The planning flow of the departments before do not influence freshness seen this is always before production. Freshness is also influenced by inventory deployment. This department determines when stock is in the warehouse. In most cases they forecast the arrival of stock before the product is produced and transported. Normally inventory deployment has one day to determine the inventory availability date. After the inventory ability date is determined, the transport department needs one working day to choose a vessel and book it. Next the carrier has one working day to confirm the booking. If the booking is confirmed it is communicated to Katoen Natie where the order and booking are linked to the available stock. For linking again one day is needed. After linking at least one day is needed to put the container in a loading spot and load it. The releasing, booking and planning takes three days between release of the order by inventory deployment and the receipt of the order at KTN. If the container and stock is available it takes at least two days to plan loading. So in total it takes at least 5 days.

There are three notes for this flow. First the departments in AB InBev and KTN who do the releasing, booking and linking do not work in the weekend. However loading can be done on Saturday. Between the release of stock and loading of stock are at least five days. The chance of adding two days because of the weekend is quite big. So in total it mostly takes around 7 days to book a vessel and load the container. Secondly is it possible to reduce the number of days between releasing of inventory deployment and loading at KTN but this is only done when it is really necessary. Thirdly the release of the orders is mostly one week before MAD. By consequence this planning process is started before the production of the products. Therefore freshness is not directly influenced by the planning flow.

System flow

The system flow also starts with the order taking department, which determines the MAD date. Since the link between the placement of the MAD date and freshness is unclear, the effect of the order taking department on freshness will not be researched further. The next departments are supply network planning and scheduling. Beer is produced in buckets of one week. Supply network planning takes together all the orders with an MAD in the same week and scheduling produces them the week before. It is possible that orders needed on Friday are produced the week before on Monday. This means that the order is maximum 11 days old before MAD. The average time between production and MAD is 6,5 days. This calculation is done as follows. Assume production was on Monday, the MAD date could be from Monday till Friday the week after, respectively 7,8,9,10 or 11 days till MAD. For products produced on Tuesday the time between production and MAD is respectively 6,7,8,9, or 10 days. This is done for every day of the week except Sunday since there is mostly no production on Sunday. This results in the following average.

$$\bar{X} = \frac{(7+8+9+10+11)+(6+\cdots+10)+(5+\cdots+9)+(4+\cdots+8)+(3+\cdots+7)+(2+\cdots+6)}{30} = 6{,}5$$

Equation 1 Calculation average difference Production MAD

The inventory availability date influences freshness because loading can only be planned after or on the inventory availability date. In the case there are capacity issues they plan MAD + 4. This brings the average freshness for products having capacity problems on 10,5 days. To determine the other inventory availability dates the experience of the planner and the production schedule is used.

For the international transport department. It is important to notice that each destination can only be shipped once a week. Since the shipping date cannot be taken into account when determining the MAD it is possible that some goods have to wait 6 days in order to be shipped. The theoretical average is 2,8 days. The VGM cut-off and MAD is never in the weekend. It is assumed that a vessel can always be taken and that the VGM cut-off is randomly during the week.

The calculation is as follows: a product with MAD on Monday can be shipped Monday to Friday. This is a difference of respectively 0,1,2,3 or 4 days. For an MAD on Tuesday the VGM cut-off date can be Tuesday till Friday or Monday the week after with a difference of respectively 0,1,2,3 or 6 days. This is done analogically for every day of the week and the average is taken which is 2,8 days. It should be noted that planned loading is somewhere in between VGM cut-off and MAD. Therefore these 2,8 days cannot be added as time needed but it gives a better insight.

$$\bar{X} = \frac{(0+1+2+3+4)+(0+\cdots+3+6)+(0+1+2+5+6)+(0+1+4+5+6)+(0+3+4+5+6)}{25} = 2{,}8$$

conclusion

The conclusion is that freshness is difficult to determine since it is the difference between loading and production. It is influenced by the planning flow which can influence freshness but could also be arranged before production. It is also influenced by the system flow were the loading date is possibly put before MAD, making it impossible to determine how long this flow takes. The lower boundary of the system flow is two days since KTN needs the stock and booking for two days.

3.3.2 Data structure

To start the measuring phase data should be gathered. This section explains how the data is gathered. The gathered data contained data of each pallet received in KTN. Each week an Excel file was made containing all the pallets loaded that week. The data analyzed was from beginning of 2016 until the ninth week of 2018. So in total 113 files were used to analyze and measure the problem. Each file contains around 15.000 pallets and each pallet is a line. So around 1,7 million lines have to be analyzed. PowerBI is used for the analyses. PowerBI is free software from Microsoft designed to do business analyses.

Each line contains specific information about a pallet. The original data contains the following columns: Source.Name; Article; Pallet no; lot-batch; Production date; Arrived at terminal; Transport no.; Shelf life (days); End loading date; Transport no._1; Delta delivery; Customer reference 2; Customer reference; HL; Age at loading; Product; MTO/MTS; Market; Plant Number; Plant; Age and destination. Most of these columns are easy to understand, only the unclear and important columns are explained. The first column Source.Name is the name of the excel file the row comes from. Arrived at terminal is the date the pallet arrived in KTN. Shelf life is the number of days between production and expiry of the product. End loading date is the date of loading at KTN. HL is the amount of hectoliters on one pallet. The age at loading is the difference between the production and the loading of the container. Age of loading is the same as freshness. Product is the brand name of the product for example this is Stella Artois or Hoegaarden. Market is the market of destination, for example Europe or North American zone (NAZ). Plant is the production location of the product for example Leuven or Jupille. Age ok if the product left before it has passed 30% of its shelf life and not ok if it did not. If a product is older than this the customer can refuse the product which could cause costs. The last column is destination, this is the country of destination. A two letter abbreviation of each country is used according to the international naming convention (ISO 3166).

The possibility to do analysis with the data just described is limited. Analyses that can be done is the evolution of freshness for different groups of products. Other than freshness the time in the cross-dock or the age at arrival can be evaluated. In order to measure the process better, extra information is added. The first information that can be added is the list of push and pull products which can be linked to the existing data using the article number. Other added information is the packaging type, which is mostly keg, can or bottle. LIFO is also added to the data. Most products are FIFO but LIFO is used for products that are not exported that much. The last information added is the filling frequency, SKU's with a high production volume are produced every week but other products, that are not needed that much, are produced only once every two, three or four weeks. Although this already gives a lot of information it is still difficult to use this information to evaluate the departments, since most of the departments do not interact directly with the physical flow but with the system flow.

In order to get a better insight in the system flow inventory availability date, MAD, and planned loading should be added to the data. AB InBev was not able to add inventory availability date but MAD and planned loading is added as of week 16 in 2017. With this data the system flow can be evaluated. For most analysis only this part of the data is used.

3.3.3 Data analysis results

In the data analysis several factors will be analyzed. First the global evolution of freshness is analyzed. For the global evolution only the physical flow is analyzed because this was only available over the whole period. In the following sections there is a deeper analyses on the system flow. First the system flow is analyzed without making a difference for the different groups included in the sample. Next the performance of different groups of products is reviewed. First the difference between Push/Pull and MTS/MTO is analyzed. Next the difference between breweries and destinations is discussed. Lastly the performance of several SKU's are compared.

Global view

Figure 15 shows the evolution of freshness for every month from the beginning of 2016 until week 9 in 2018. In Figure 15 three elements for each month are plotted. The black line indicates the average freshness for each month. The red line indicates the average age at arrival at KTN. The grey columns in the background visualizes the number of pallets exported each month. A difference can be seen between 2016 and 2017. In the first half year of 2017 freshness is clearly higher than in 2016 and the second half of 2017. The elevated freshness has mainly two reasons, the freshness of January is higher because there was no production the last week of 2016. Therefore the stock send in the first week of January was at least one week old. The second reason is a stock build for the US which is explained in the next paragraph.

Usually stock levels are higher before the summer. This is done to assure that the beer is available. In the summer the variability of beer consumption is higher, because it is highly influenced by the weather and sport events. The biggest US products are MTO products. This means the lead time is 12 weeks + shipping time (3.2.1). In order to cope with the lead time of 12 weeks in the summer a lot of stock is stored in the US. However in the US storage capacity is expensive. Therefore it is interesting for them to store products elsewhere in the supply chain. The stock build is stock for the US that is stored in the cross dock of KTN in Antwerp Belgium. By consequence the lead time if more stock is needed is reduced to the shipping time plus one week. Stock is made by delaying the delivery of a product two weeks. AB InBev chose to delay the MAD two weeks while keeping production in the same week. So instead of producing the week before MAD, products are produced three weeks before MAD.

The red line also shows a significant improvement in 2017, it is clear that the time between production and arrival at KTN diminishes. This also has two reasons. The first reason is a better managing of push flows towards KTN. A better trailer rotation made it possible to reduce the time between production and receipt of the goods in KTN. The second reason is the implementation of ATLS, automated trailer loading system. This is a system which loads trailers fully automatically. The GPS tracking of trailers can even improve the age at arrival but this is only implemented in 2018 so to see the results more recent data should be analyzed.

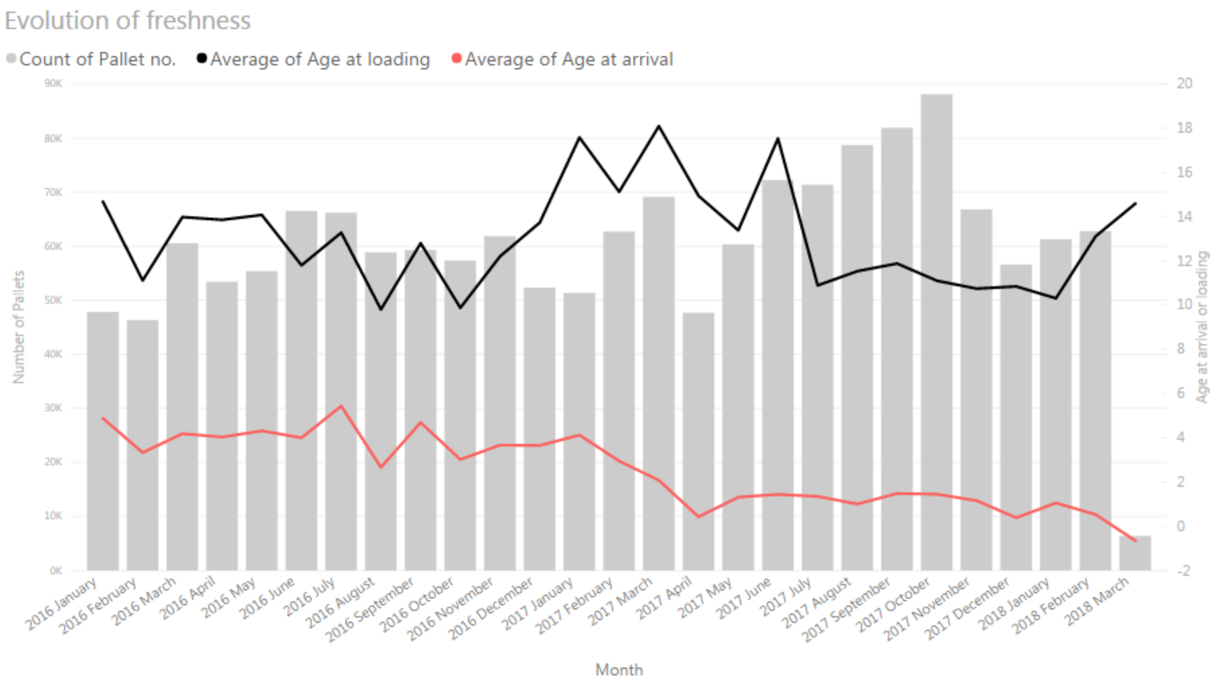

Figure 15: Evolution of Freshness

The stock build is only done for the American market and is not used for every product. So in order to compare articles or breweries only the data for the period between July 2017 and the first week of March 2018 will be used. It is impossible to exclude the US seen it has 59% of the exported volume as can be seen in Figure 16. By consequence the biggest effort to improve should be done for the US market since the US is responsible for the biggest volume.

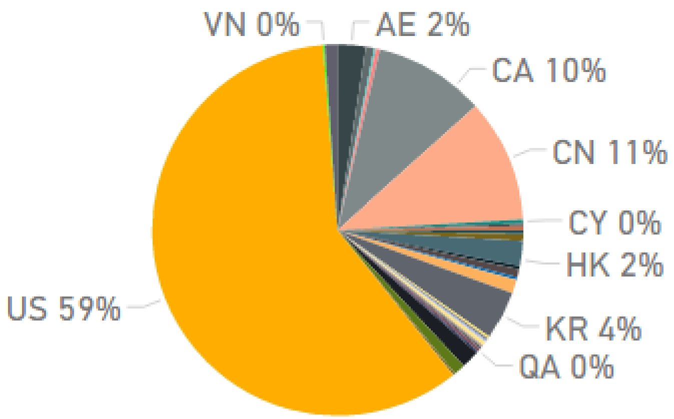

Figure 16: Volume by destination

System level analyses

There is a system flow and a physical flow to be analyzed. Next the system flow is discussed. The system flow exists out of three parts: the time between production and MAD, the time between MAD and planned loading (PL) and the time between planned loading and actual loading. Figure 17 visualizes the evolution of the system flow. The light blue part in each column (Figure 17) indicates the time between MOD and Production. MOD is the same as MAD but with modifications, MAD is sometimes modified by customers or AB InBev because of small problems or mistakes but mostly MOD and MAD are the same. For example if a customer sees that the stock levels are decreasing to quickly and wants to receive his products earlier. The order taking department will ask SNP if it is possible to produce the products earlier. If the answer is positive the MAD changes to another date (MOD). If the answer is negative the MAD stays the same. The dark blue part in a column visualizes the time between MAD and PL. Lastly the red part gives the time between PL and actual loading.

In order to make a reliable figure, Hoegaarden has been excluded from the data. Hoegaarden is a special beer because the fermentation continues in the bottle. Therefore each bottle should stay around three weeks in a warm room. If fermentation is finished, which is determined by tests, the stock is transported. For freshness 31 days are deducted of product age but because tests determine if the product is finished it is common to have a negative freshness. It is also possible to send products to KTN without having the results of the test. They should just wait with loading the goods until the results are in. Because of this complexity, Hoegaarden is left out of the system level analysis.

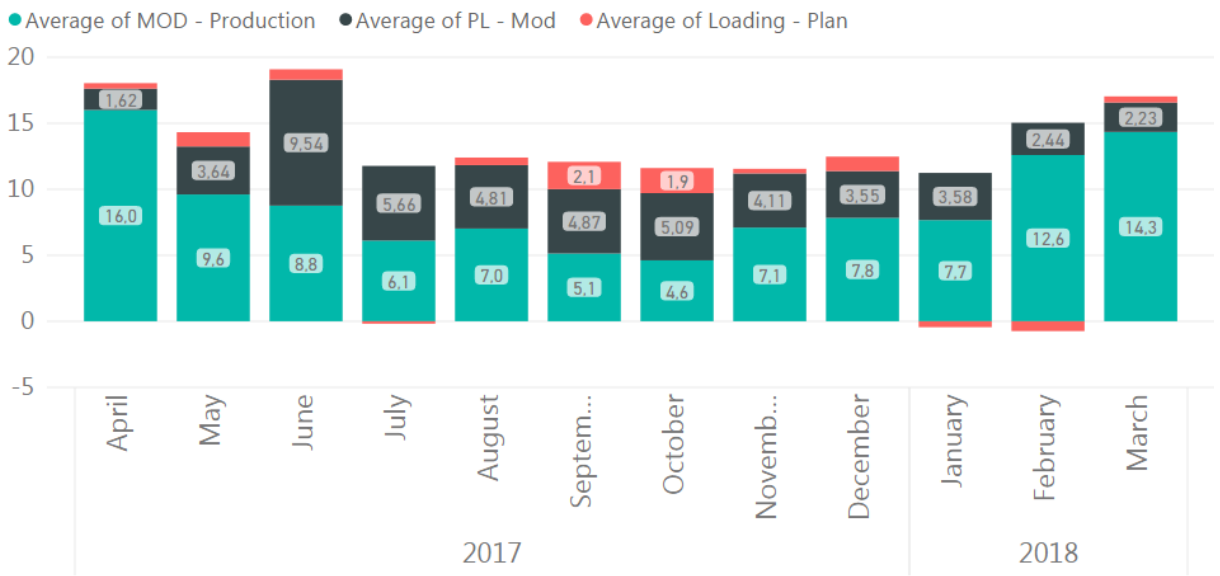

Figure 17: monthly performance MOD vs Production, PL vs MOD, Loading vs PL

As discussed the stock build is done by enlarging the time between MAD and production. In the time period visualized in Figure 17 this is only done in April 2017. The effect of the stock build in April is amplified by limited production capacity. As explained in section 3.2.2. Higher demand higher than production capacity makes that SNP produces orders more up front in order to guarantee production. These two effects, stock build and limited production capacity, are visible in April. In March the same could be concluded but since there are only three days of March included in the data no conclusion can be drawn. The data gathered was till week 9 of 2018 and this week only contained 3 days of March. It should be noted that the time between production and MOD even diminishes to 4,6 which is considerably lower than the average calculated in section **Error! Reference source not found.** which was 6,5. The reason for this are problems with the JIT provision of empty kegs. In and after peak periods the provision of empty kegs is difficult. AB InBev tries to use the minimum amount of kegs since kegs are expensive, by consequence not enough kegs are available in and after peak periods. If there is a low stock level of kegs it is difficult to manage the JIT arrival of kegs in the brewery. If the provision of empty kegs encounters problems, production is often delayed to the week after. The scheduling department then just tries to produce the product before MAD. By consequence the time between production and MAD diminishes. This is clearly visible if looked at Figure 18. In Figure 18, a split is made for the different packaging materials used in October. The different packaging materials are cans, kegs and non-returnable bottles (NRB), other packaging materials are excluded because the volume is too low.

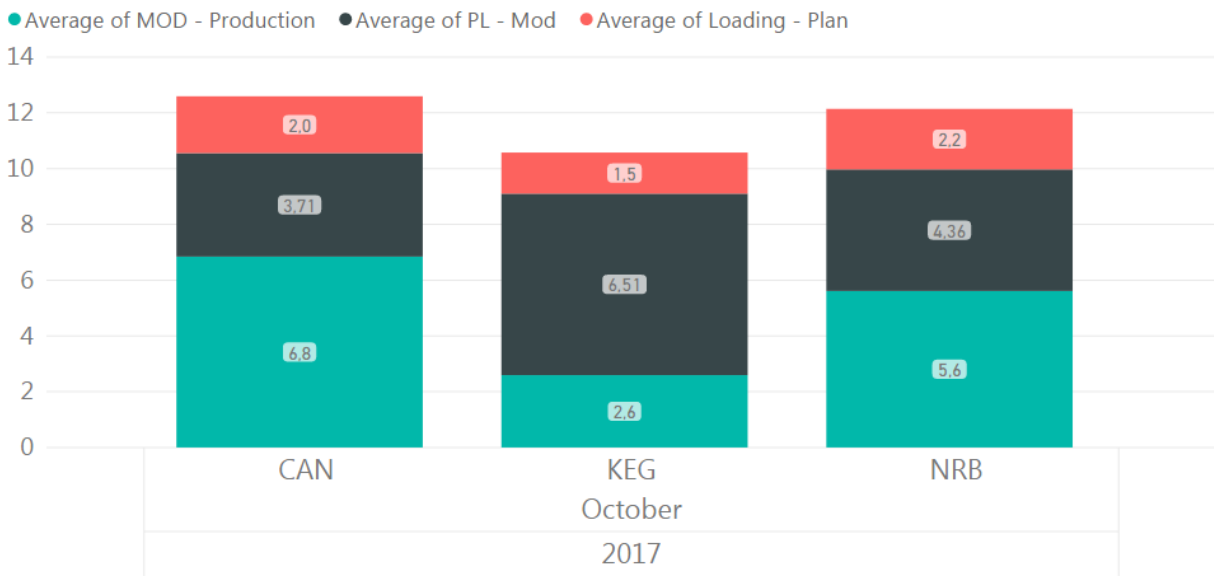

Figure 18: October packaging material split

Next, the difference between MAD and PL will be discussed (Figure 17). There is always some time between MAD and PL, the average is never lower than 0 what theoretically could be possible. Since loading is not directly related to MAD. Based on the interviews it is concluded that the production schedules are too unreliable. Therefore the inventory deployment department is not able to guarantee that stock arrives before MAD. The scheduling department changes schedules constantly and focuses on producing stock before MAD. The department does not focus on giving a reliable schedule. As a consequence the inventory availability date is seldom put before MAD but on MAD. After the inventory availability date is determined, two days are added because stock should be two days in KTN and 2,8 days are added because there is only one vessel each week (**Error! Reference source not found.**) but loading can be during these 2,8 days.

In April the difference between PL and MOD was low because the inventory availability date could be determined exactly seen stock was already in the warehouse but had to wait for two weeks because of the stock build. The outlier of 9,95 days in June can be explained by a capacity shortage to China. This was because less wood could be exported from Borneo and therefore more wood had to come from Europe, by consequence there was a capacity shortage to China. AB InBev did not foresee this capacity issue and therefore had to wait with shipping goods because vessels were fully booked, resulting in 2 to 3 weeks delay for products going to China. From November the number of days between PL and MOD diminishes. This because the inventory deployment department tries to put the inventory availability date as early as possible instead of playing save.

The last difference to discuss is the difference between PL and actual loading. As seen this is high in September and October. This is because of a backlog in KTN. KTN could not follow with loading containers. Therefore they focused on getting containers loaded before VGM cut-off and SL. In January and February there was no backlog anymore and the difference between loading and planned loading became even negative. KTN was perfectly on schedule during January and February and they even loaded earlier than the planned loading date. In Figure 19 the difference between loading and planned loading was visualized for January and February. The horizontal axis gives the difference between loading and planned loading. The blue columns visualize the number of pallets loaded for each difference. For example around 8000 pallets are loaded one day after loading. The black line indicates the percentage of the total orders sent. It can be seen that a little bit more than 20 percent of all the goods loaded is loaded on planned loading. Figure 19 shows that the planned loading date is not followed perfectly. Pallets are most often not loaded on PL but a few days before or after PL.

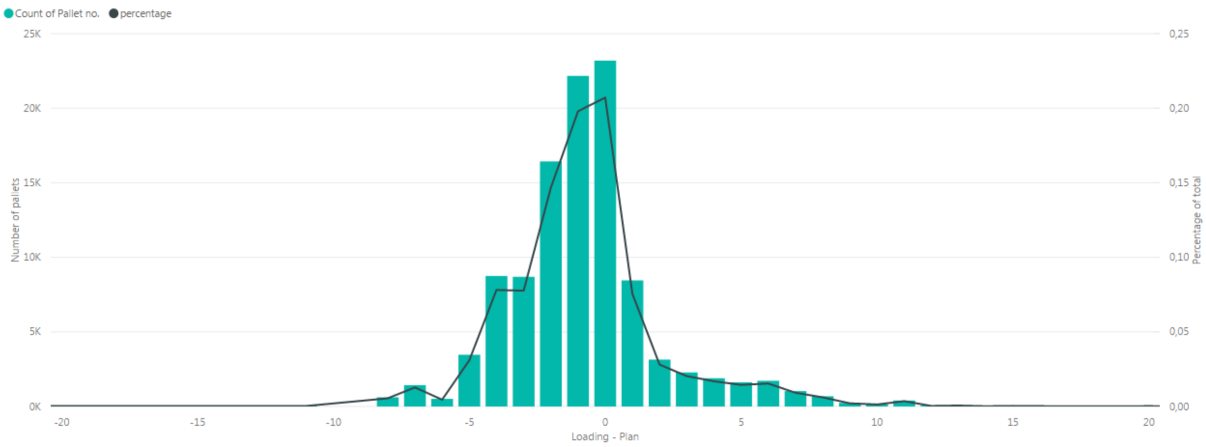

Figure 19: Histogram Actual Loading vs Planned loading (January/February)

Push/Pull and MTS/MTO effect on Freshness

In this paragraph the effect of Push, Pull, MTS and MTO is explained. In Figure 20 the columns mean the same as in the Figure 17 and 18. The only thing added are the two lines. The black line gives the average freshness of each group of products which corresponds to the sum of the system flow elements. The yellow line gives the average age at arrival. Only the period after June 2017 is used for this graph because this is the most stable period. Hoegaarden is excluded from the analysis for reasons explained earlier.

It is clear that the freshness of pull products is higher than the freshness of push products. This is logic since an STO is only made if the stock is needed. This translates in stock arriving only a short period before MAD, which explains the small difference between the yellow line and the light blue column. For push products the arrival is very early, only 1,42 days after production. By consequence this stock stays longer in the warehouse of KTN. Another effect noticeable in Figure 20 is the effect of MTO and MTS. Clearly MTS products are often older than MTO products, which is also logic since MTS products need to be shipped within a week after ordering. Therefore a security stock is needed and stock gets older. The conclusion of this paragraph is that AB InBev should try to have as much MTO and push products as possible since the system clearly works better for those products. AB InBev already knows the advantage of these products and that is why already

70 percent of products are push and MTO. Furthermore should be noted that it is not possible to change all products to Push and MTO because this would cause inefficiencies for customers in Europe or in KTN because of low volumes or shared SKU's between Europe and other zones.

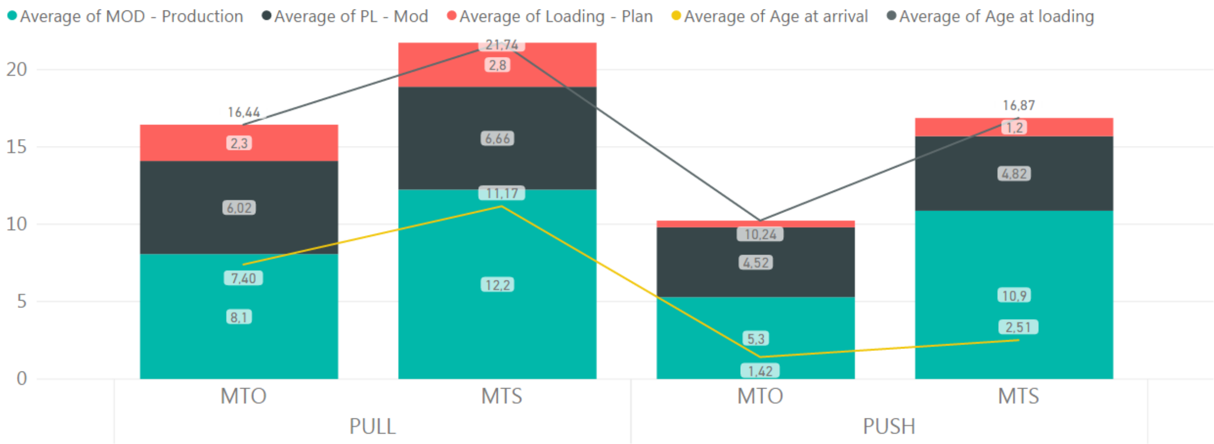

Figure 20: Comparison of Push/Pull and MTO/MTS products period after June

Breweries

The effect of the brewery that produces the beer on the freshness is also investigated. In Figure 21 Hoegaarden is not excluded from the data and only the stable period after June is taken. The columns are the same as in Figure 18, 19 or 20 but a purple line has been added to the figure. This purple line is the number of pallets made by that brewery in this time period.

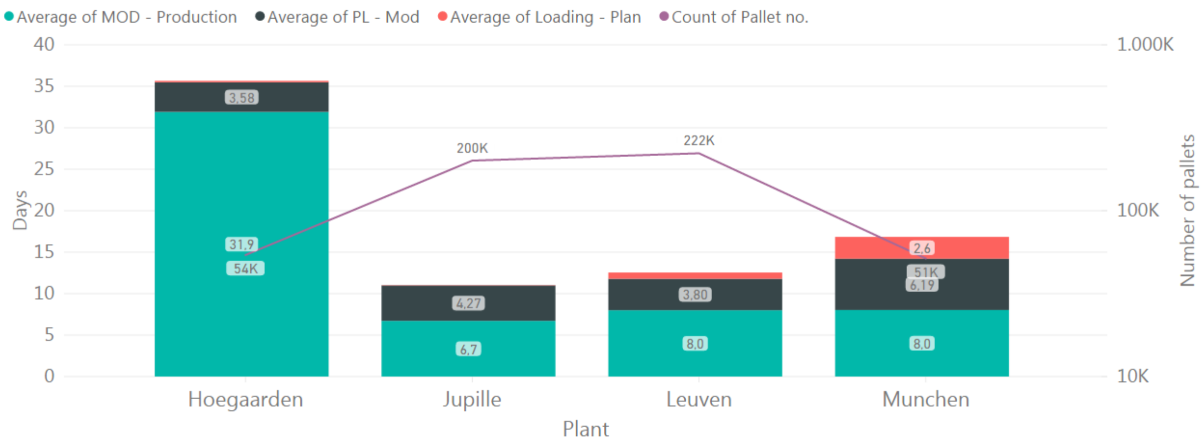

Figure 21: Brewery comparison

As can be seen in Figure 21 there are no big differences between Leuven and Jupille. Only the planned loading differs from the actual loading and a higher difference between MOD and production. This can be explained because Leuven mainly produces non-returnable bottles (NRB) and Jupille mainly kegs. This is visible in the difference between MOD and production because of the shortage of empty kegs explained earlier. This difference in product mix is also visible in the warehouse because forklift drivers need to be more careful with bottles than with kegs. By consequence it is easier to attain the planned loading date for kegs.

The biggest difference can be observed between Hoegaarden and the other breweries. As explained above the reason why the Hoegaarden brewery was excluded from other analyses was because there is fermentation in the bottle. This is can be seen in Figure 20 where the difference between production and MOD is very large.

Lastly the difference between the brewery in Munich and the breweries in Leuven and Jupille is examined. First Munich is further away and therefore has to cope with a longer transportation time to Antwerp. Secondly and most importantly Munich is a recent brewery of AB InBev and therefore the way of working which is used in other breweries like Leuven or Jupille is not yet integrated in Munich. For example the biggest part of their products are still pull products. Push products have only been recently introduced. They are in the transition to convert pull products to push products. This will increase freshness but it takes time till the processes are implemented.

Destinations

In order to describe the effect of the destination on freshness Figure 22 is made. In this figure Hoegaarden is excluded from the data and only the stable period after June is taken. The four destinations with the highest exported volume are selected to compare: Arabic Emirates (AE), Canada (CA), China (CN) and the Unites States (US). The same lay-out as in Figure 21 is used but here the purple line gives the number of pallets exported to each country.

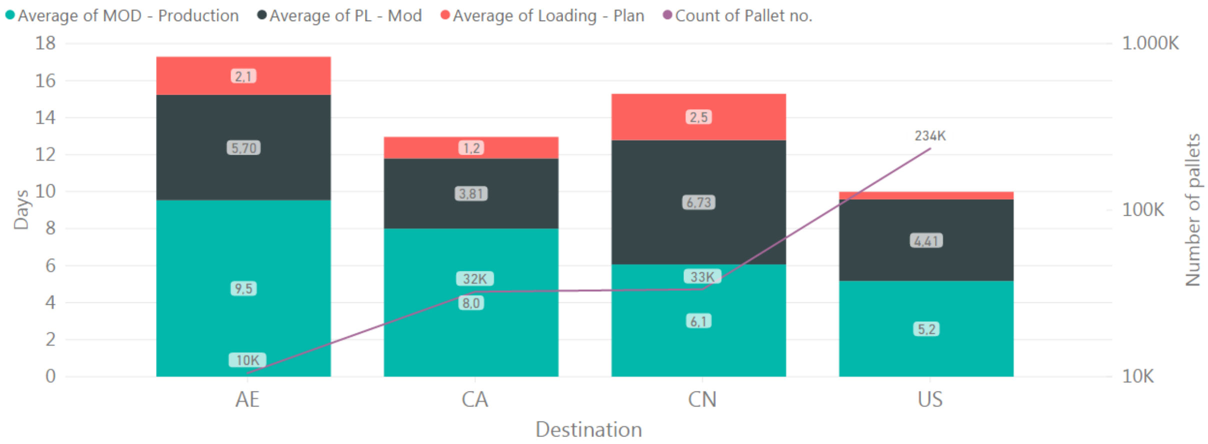

Figure 22: System split by destination

Figure 22 shows the importance of the US with 234 thousand pallets exported from the 370 thousand exported in total (without Hoegaarden). Further can be seen that the US gets really fresh products in comparison to China (CN) and de Arabic Emirates (AE). This can partly be explained because China and the Arabic Emirates need a specific document from the FAVV (Federaal agentschap voor voedselveiligheid), the federal agency for food security of Belgium. In order to get this certificate an inspector of FAVV has to inspect the goods loaded in the container. Because this inspector is not constantly available in KTN this causes delays. Furthermore it is impossible to split bookings. When the international transport department books a vessel they take several containers and book them altogether. Because of this the containers should be transported together. However if one product is too late the booking is split so a part of the booking can still be send. For China and Arabic Emirates it is not possible to split bookings which causes that if one product is late nothing can leave the warehouse. A solution could be to make bookings per container, but this would cause a big workload increase and according costs.

There is also a second reason why products for China are older. The product mix between the US and China differs considerably. The most important product sold in China is Franziskaner which has to come from the Munich brewery and has a high freshness as explained in the section above. This is visualized in Figure 23 below. The most important product sold in the US on the other hand s Stella Artois which has to come from Leuven or Jupille.

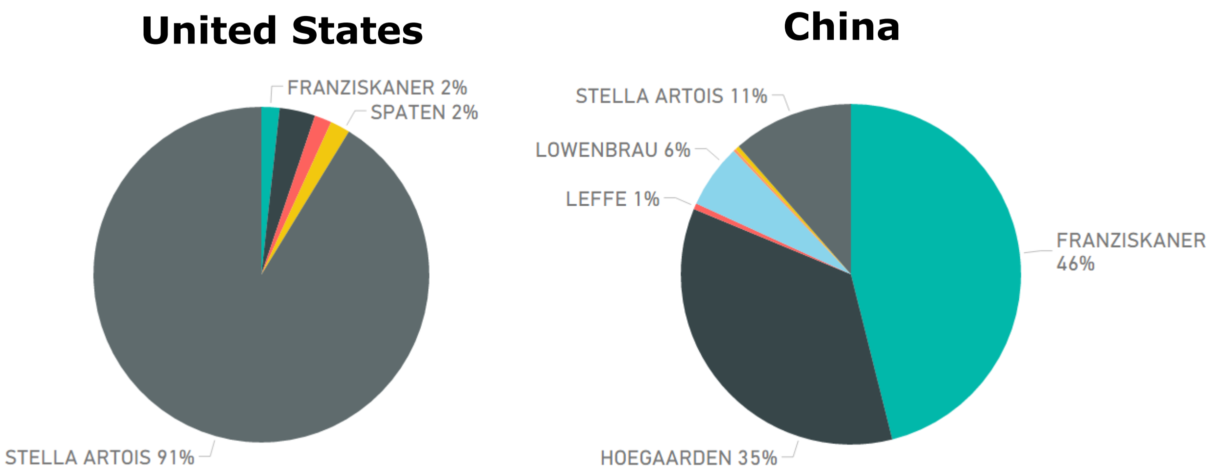

Figure 23: Product mix United States and China

Article analysis

The last analysis focusses on the difference between several important articles. The five biggest articles in number of pallets are selected. Figure 24 contains the same elements as Figure 22. Article numbers are very hard to interpret. Therefore Table 1 is added giving the most important information for each article. It gives the description of the product, the type of product, the pack type, the production location, how much is produced on each location and if it is MTO or MTS.

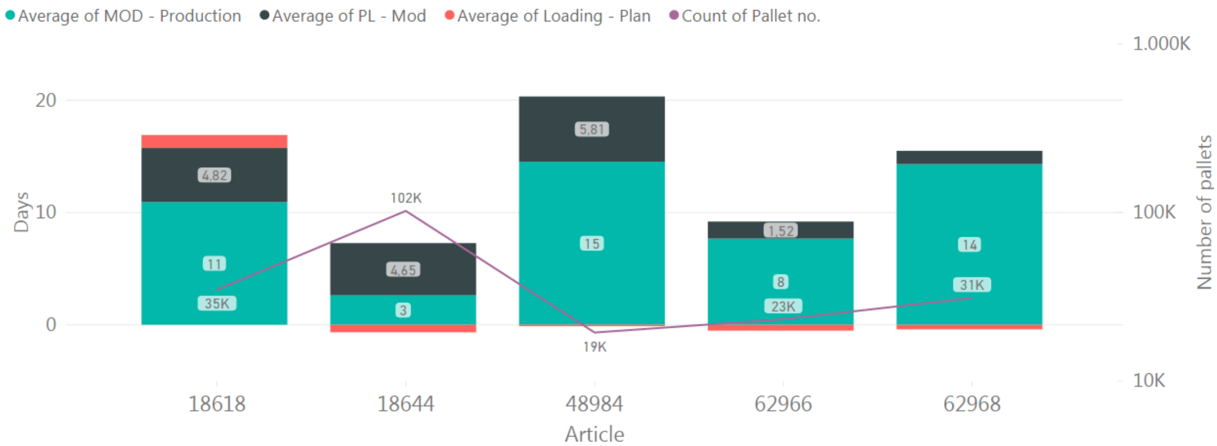

Figure 24: Article comparison

Based on Figure 24 it can be concluded that there are big differences between these SKU's. Even though all SKU's are push products except 18618. 18618 is a special product because it is produced in Leuven and Jupille and has a different policy how products get to the port. In Jupille products are pushed to the port but in Leuven products are pulled. By consequence the amount of pallets coming from Leuven is low.

This table and Figure have been showed to several employees within AB InBev. Most employees could not explain why some SKU's perform better than others. A connection between the product 18618 and 18644 can be found. As seen in table 1 both products are kegs that contain Stella Artois and are mainly produced in Jupille. The difference between both is that one is MTS and the other is MTO. Because both kegs contain the same product they are mostly produced after each other. The MTS product 18618 after the MTO product 18644. As explained above there can be problems with the provision of kegs to the production line. These problems occur often with the 50l kegs from the United States, because they have to come back from overseas to be filled again. As explained the scheduling department always choses to produce MTS products after MTO products because that way you can perfectly produce what you need. What happens on the production line is that the provision of 50l kegs stops for some reason and therefore production is switched to 18618. By consequence 18618 is produced too much and 18644 too less. Therefore 18618 performs badly on freshness and 18644 really well.

Article	DESCR	Product	PACKTYPE	Plant	Count of Pallet no.	MTO / MTS
18618	STEL ART KEG 30L IPPC N	STELLA ARTOIS	KEG	Jupille	31862	MTS
18618	STEL ART KEG 30L IPPC N	STELLA ARTOIS	KEG	Leuven	2866	MTS
18644	STEL ART KEG 50L USA N	STELLA ARTOIS	KEG	Jupille	91606	MTO
18644	STEL ART KEG 50L USA N	STELLA ARTOIS	KEG	Leuven	10579	MTO
48984	STEL ART OW 2X12 0,33L TRA USA DEP VBI	STELLA ARTOIS	NRB	Jupille	15796	MTO
48984	STEL ART OW 2X12 0,33L TRA USA DEP VBI	STELLA ARTOIS	NRB	Leuven	3577	MTO
62966	STEL ART OW 4X6 0,33L BOX WRA DEP US NPA	STELLA ARTOIS	NRB	Jupille	3363	MTO
62966	STEL ART OW 4X6 0,33L BOX WRA DEP US NPA	STELLA ARTOIS	NRB	Leuven	19869	MTO
62968	STEL ART OW 2X12 0,33L TRA USA DEP NPA	STELLA ARTOIS	NRB	Jupille	28140	MTO
62968	STEL ART OW 2X12 0,33L TRA USA DEP NPA	STELLA ARTOIS	NRB	Leuven	2941	MTO
Total					**210599**	

Table 1: Article information 18618, 18644, 48984, 62966, 62968

Conclusion

The main conclusion of the data analysis is that the empty keg problem should be solved so production gets more reliable. Furthermore there should be special attention for destinations as China and breweries as Munich. It should also be forecasted better when capacity shortages are pending, because it should not be used too often but also not too few.

To conclude the system cannot perform better if the production schedule stays unreliable. If the production schedule is more reliable it would be possible for inventory deployment to perfectly determine the inventory availability date, which in return would benefit the planned loading date. It would also improve the operations of KTN since stock would be there at the moment it is promised. Furthermore it could be tried to reduce the two days needed for KTN, if stock arrives reliable. Of course one should take in mind that nothing goes perfectly as planned and therefore still some buffers would be needed.

4. Case study AB InBev: Solution

In the data analysis different groups of products have been evaluated. Some groups perform better than others although no group performs better than 10 days of freshness. Only 18644 performs better due to the empty keg problem which also has negative consequences for 18618. The most important problem keeping freshness from performing better is production. Which produces in weekly buckets and is unreliable. If AB InBev wants to improve freshness further significant changes in the current way of working should be done.

As discussed in the literature review there are several ways of improving the way of working. According to the MRP strategy one should try to plan everything in advance like AB InBev is doing already. The main improvement point is to improve the determination of the inventory availability date and to reduce the need to have stock available for two days in KTN. This means there should be a better knowledge of which stock is going to be produced. It should also be more reliable to know how long transportation takes. With the available data it should be possible to better determine how long transportation takes. However it is really difficult to determine when a specific product is produced. Since the production schedule changes every day and there is no information why certain products are delayed.

The JIT theory focusses on getting everything just in time. In the case of AB InBev the main problem is that everything is produced one week before MAD. JIT would focus on making smaller batches more frequent. This way one day would be produced what is needed the next day. This way of working is not possible since there are long set-up times and only a limited production capacity. However it could be recommended to focus on reducing set-up times, increase capacity and make smaller buckets. For example instead of taking one week of orders all together and produce them the week before one could make buckets of half a week. This means products are only produced 7,6,5,4,3, 2 or 1 day before MAD, reducing theoretical average of 6,5 to 3,5 (**Error! Reference source not found.**). The theoretical gain of producing this often would decrease freshness by 3,5 days. This could be a considerable improvement but in order to attain this the needed investments should be done to reduce set-up time and to increase capacity.

The last theory that could make improvements to freshness is flexibility. Since the push process of AB InBev is very flexible this way of working could be continued. If the shipping companies would be more flexible when determining what and when an order is shipped it would increase freshness, because it would be possible to ship goods last minute. For example one could wait until the stock is actually in KTN and then take the next available vessel which is the same week or the week after. A way to get this much flexibility is by negotiating an option contract. First in section 4.1 the financial option contract is explained. Second this financial option contract is translated into a logistical option contract in section 4.2. Lastly the challenges to implement such a contract are discussed in section 4.3.

4.1 Financial option contract

An option contract comes from the financial world where it is common to use option contracts. An option contract in a financial context is a contract that buys the right to buy or sell a certain amount of stock in the future for a price determined before. For example a person wants to buy a certain stock for 100 €/share in one year. The 100 Euro is the execution price and in one year is the execution date. At the same moment someone else has the same stock which is worth 110 €/share. The second person wants to agree to sell the stock for 100 €/share in a year if the first person agrees to buy that right. The price of that right depends on the expectations for that specific stock. If the expectations are that the stock price rises the right will be more expensive than if the expectation is that stock prices will go down. If for example the expectation is that prices stay the same and the interest is 11,1%, the option will cost 9€. The 9€ will be worth 10€ in one year and because of the interest rate the first person would have paid 110€ in total if he buys the option (Cox, Ross, & Rubinstein, 1979).

In this case the first person will have a higher return on investment if he decides to buy the stock the year after. He only paid the right to buy the stock for 9€, and he will only buy the stock if the value of the stock exceeds the predetermined buying price, so more than 100€. This 100€ is called the execution price. After the execution price is paid the market price of the stock will determine if the person earned money yes or no. If the stock is worth 112€ he will have a return on investment of 33% because only 9euros were invested. If the price of the stock goes under 100€ he will not buy the option and will have lost 9€ (Cox, Ross, & Rubinstein, 1979).

The second person had the advantage to receive the price of the option one year earlier and if the option is executed he will get the price determined beforehand. If the stock did not go up enough he will still have his share and he will at least have earned the selling price of the option (Cox, Ross, & Rubinstein, 1979).

4.2 Logistical option contract

In this paragraph it is explained how a financial option contract can be translated into a logistical option contract. Here the buyer of the option would be AB InBev and the focus would not be on getting a better return on investment but on making sure there is always the possibility for products to be send to a specific destination. The aim for freshness would be to specify last minute what and how much is send. Instead of trying to forecast when stock arrives, stock arrives as fast as possible and is loaded on the earliest possible vessel. If something arrives unexpected two days before VGM cut-off it should still be loaded in time to catch the vessel. This would be the most beneficial contract, where everything is sold using the option contract (Prof. Dr. I. Van Nieuwenhuyse).

Analogue to the financial option contract, an execution price and date should be determined. The contract should be over a long period and in the contract weekly quantities should be determined. Because of the certain demand over a long period the carrier also has an advantage of working with an option contract. An option contract could be for example 10 containers each week to New

York for the execution price C_e of 800 Euro. In order to reserve these spots a reservation price C_r should be paid, for example 200 Euro for each container. An important assumption of the model is that if the container had to be bought extra outside of the contract a higher price is paid, for example 1200 Euro. This can also be called the penalty price or spot price C_t (Prof. Dr. I. Van Nieuwenhuyse).

In a logistical option contract there are two forces. The first force does not want to reserve to many places on a vessel because for each reservation the reservation price C_r of 200 Euro should be paid. The other force wants to make optimal use of the lower price because the spot price of 1200 Euro is higher than the total option contract price of 1000 Euro. The two forces make that the number of containers reserved each week are an optimisation problem (Prof. Dr. I. Van Nieuwenhuyse).

This optimisation problem is solved by using the probability of how many containers are shipped in one week. There is a high probability that each week will need one container but this probability diminishes as the number of containers goes up. The containers reserved by the option contract can be send last minute, therefore the best for freshness would be that a high amount of containers is reserved each week. Over a year the cumulative distribution function can be determined. This function gives the probability that the number of containers shipped in one week is lower or equal to X. Figure 25 is the cumulative distribution function for products going from Antwerp to New York. Based on this graph there is a probability of 80% that less than or equal to 187 containers are shipped in a random week. The other 20% are weeks that ship more than 187 containers. The optimisation problem can be solved by determining the probability that the reserved spots are used like in the cumulative distribution function. In order to determine the probability the marginal cost of shortage of capacity C_u should be determined (Prof. Dr. I. Van Nieuwenhuyse).

$$C_u = C_t - C_r - C_e$$

In our example: C_u = 1200 – 200 – 800 = 200

The marginal cost of excess capacity C_o should also be determined which is equal to the reservation price.

$$C_o = C_r$$

The optimal percentage can be calculated using the following formula:

$$K^* = \frac{C_u}{C_u + C_o}$$

In our example this would lead to: $K^* = \frac{200}{200+200} = 50\%$

Based on this calculation it can be concluded that 50% of all weeks should be covered. This is visualized in Figure 25. As can be deducted out of the figure a coverage of 50 percent would mean that each week 113 containers should be bought via the option contract. The striped light green area represents the overcapacity, this area are the weeks that less than 113 containers are send. In these weeks the reservation cost of 200 is lost. The striped light blue area visualizes the weeks with undercapacity.

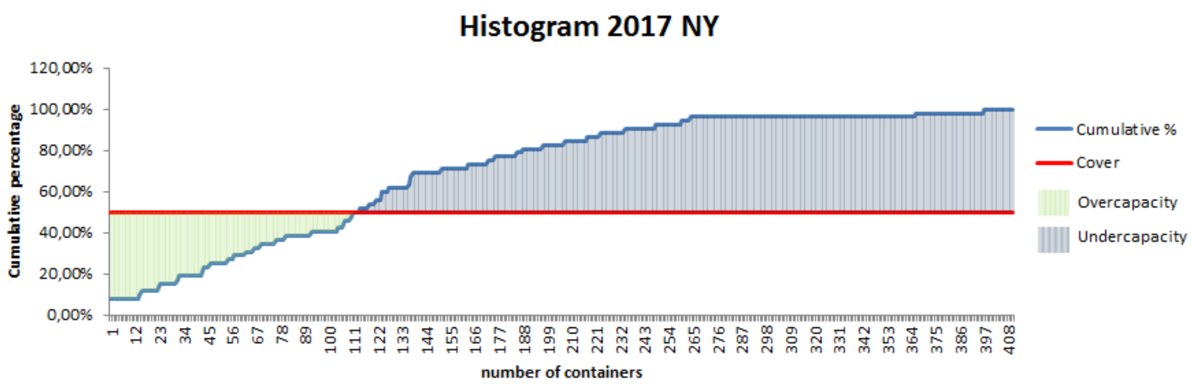

Figure 25:Option contract coverage

4.3 Challenges

As with every change there are challenges in implementing a different way of working. In order to implement an option contract in AB InBev processes have to be changed. First internal processes should be changed. Currently, a booking is immediately linked to an order making it very difficult to change the content of a booking. The link between booking and order should be made at the moment the container is filled, this way the option contract can be used optimally. By delaying the decision when an order is shipped one can wait until the last moment to specify which vessel is going to be taken for a specific order.

A first draft of the processes would look as follows. The inventory deployment department would still have the task to determine the inventory availability date. However this date will always be the date of the current day since it is possible to wait until the stock is in KTN. An extra task for inventory deployment would be to try to forecast the undercapacity. If undercapacity is expected the international transport department should buy extra capacity for the spot price. The international transport department would keep the task to determine the planned loading date. However instead of asking a confirmation from the carrier the transport planning department could immediately book the vessel for the stock and communicate this to KTN because a reservation is already made. By implementing an option contract, AB InBev could benefit a better freshness other advantages could be that SL-hits could be avoided and the receiving customer receives more constant volumes. Because of the constant volumes handling costs incurred by the customer could be avoided.

Next several external parties should be consulted. First the carriers but also customs and KTN should be asked if it is possible to implement such a contract. Carriers do not like variation in the number of containers shipped, because they have to comply to SOLAS legislation. In order to comply to this legislation difficult calculations are made to guarantee the stability of a vessel. Based on these calculation a stowage plan, a plan where every container should be placed is made.

Further research is needed to determine what carriers want. In an ideal scenario a carrier would want to have the exact weight of each container long before VGM cut-off. This way they can make a good stowage plan. The current way of working lets carriers know how many containers will be shipped around 2 weeks before shipping. However there is a small chance on containers not arriving even though they are booked. With the option contract way of working carriers know the fixed quantities of containers but not the content. On the other hand the shipper (AB InBev) is punished if there is deviation from the fixed quantities. In the option contract way of working there is an incentive for AB InBev to reduce variability since there is a reservation price or a spot price. For the current way there is no incentive to reduce variability. However with the current way of working the carrier can deny a booking for a vessel and the booking is made more in advance.

At the moment custom documents are made after loading for most destinations, so normally it would not be a problem if the content of a container is specified last minute. However there could be a problem for customers asking certain certificates, for example China where an FAVV certificate is needed.

The last external party is KTN. It will be important to include KTN in the changing processes since they execute the unloading of trailers and loading of containers. There should be paid special attention to the communication between KTN and the inventory deployment department as well as the international transport department. Since a lot of last minute changes can be done to the loading.

5. Conclusion

This master thesis researched how freshness can be improved within AB InBev, the largest global beer company in the world. Freshness is the age of products at the moment it is loaded. It is important for customers to receive fresh products to have the maximum shelf-life available to sell the product. AB InBev also has to pay a fine or reimburse the customer if the product is too old at arrival at the customer. The central research question of this master thesis is: "How can the cycle time of finished products between brewery and container shipment be lowered for AB InBev?". In order to answer this question a literature review has been done to identify important theories and principles in supply chain management. The discussed principles were: velocity, variability, vocalize, visualize and value.

After the literature review the case study at AB InBev is started. First a good view on the current processes has to be established, this is done by reviewing all the processes related to freshness using a BPMN approach. The processes of the following departments are researched: order taking, supply network planning, scheduling, inventory deployment and international and domestic transport planning. In addition the external process of Katoen Natie is added. Based on the data available the effect of the different departments on freshness is analysed and the performance of the different groups of products is reviewed. The analysis concluded that there are no ways of reducing the freshness even further, without making significant changes to the current process. The most important differences between groups are explained and no group performs better than the target of 10,5 days. Although if AB InBev insists on reaching the target of 10,5 days the system should be changed. This lead to the introduction of the option contract.

An option contract exists out of three elements a reservation price, an execution price and a spot price. All these prices cause that the places to reserve are an optimization problem. Of course before such a contract can be implemented several challenges should be researched. The two most important players in the option contract , AB InBev and the carriers, have to determine what the best practice is to work with such a contract. There should be internal changes on AB InBev side but on carrier side. Further should be researched what a carrier prefers an option contract or the current way of working.

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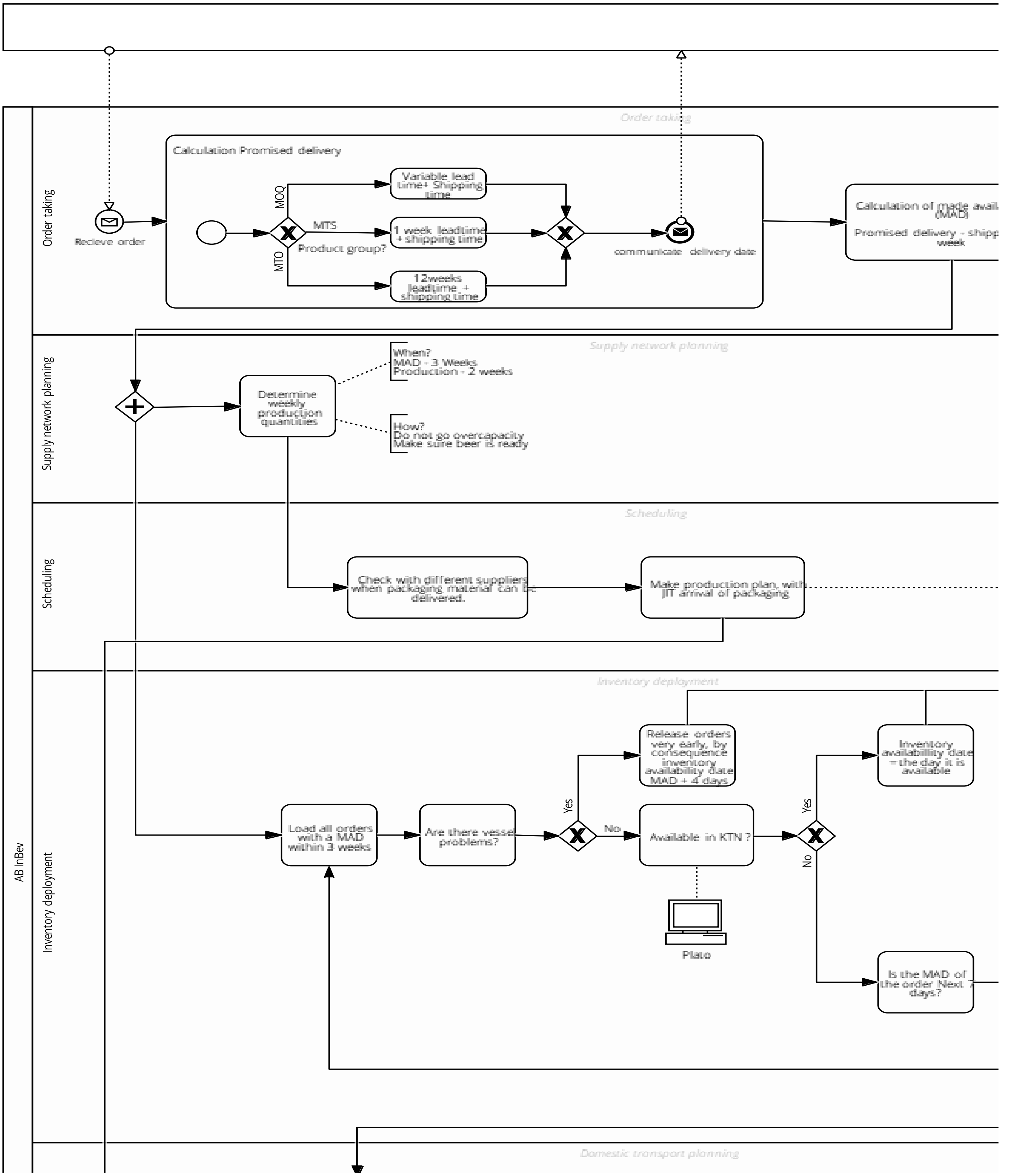
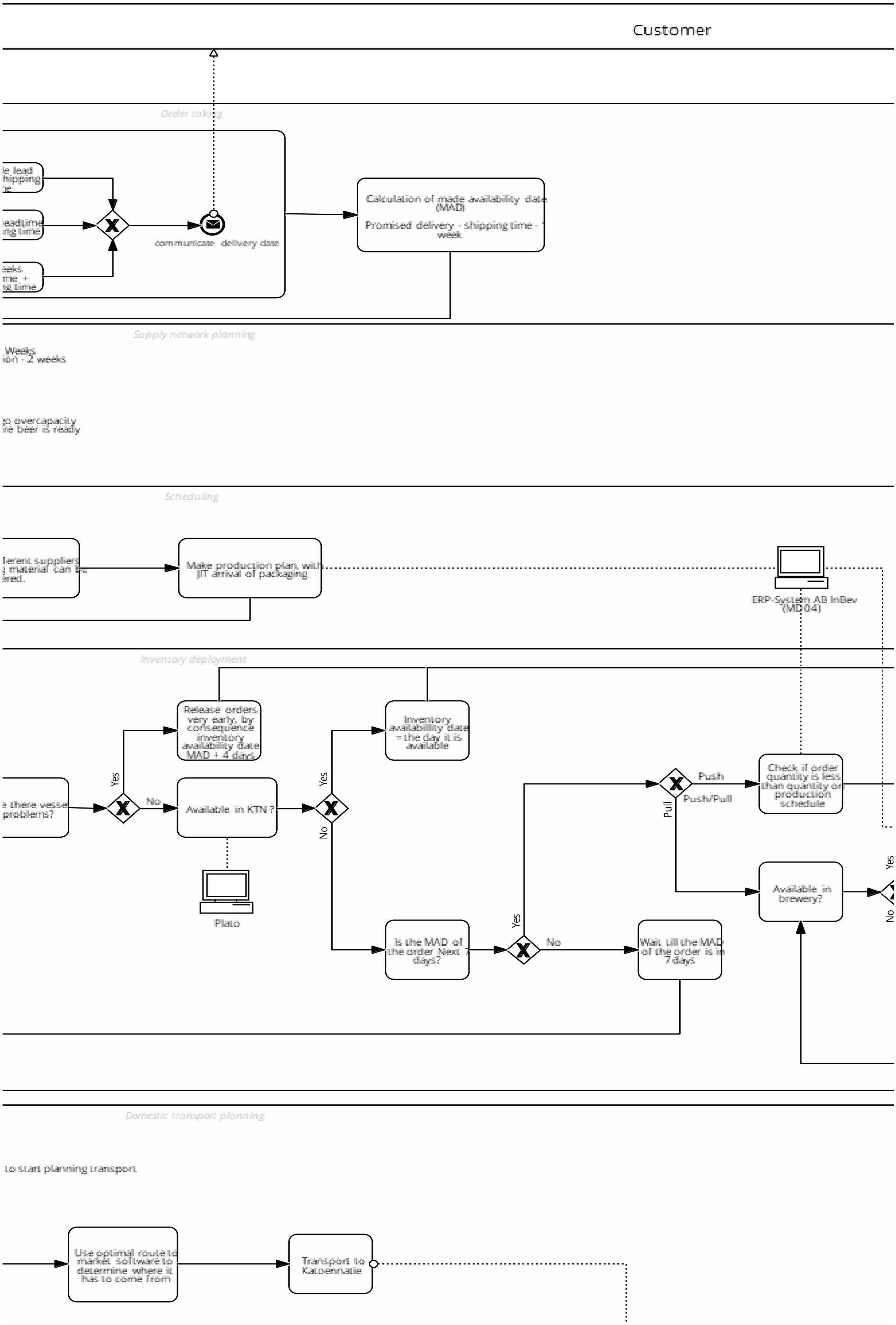
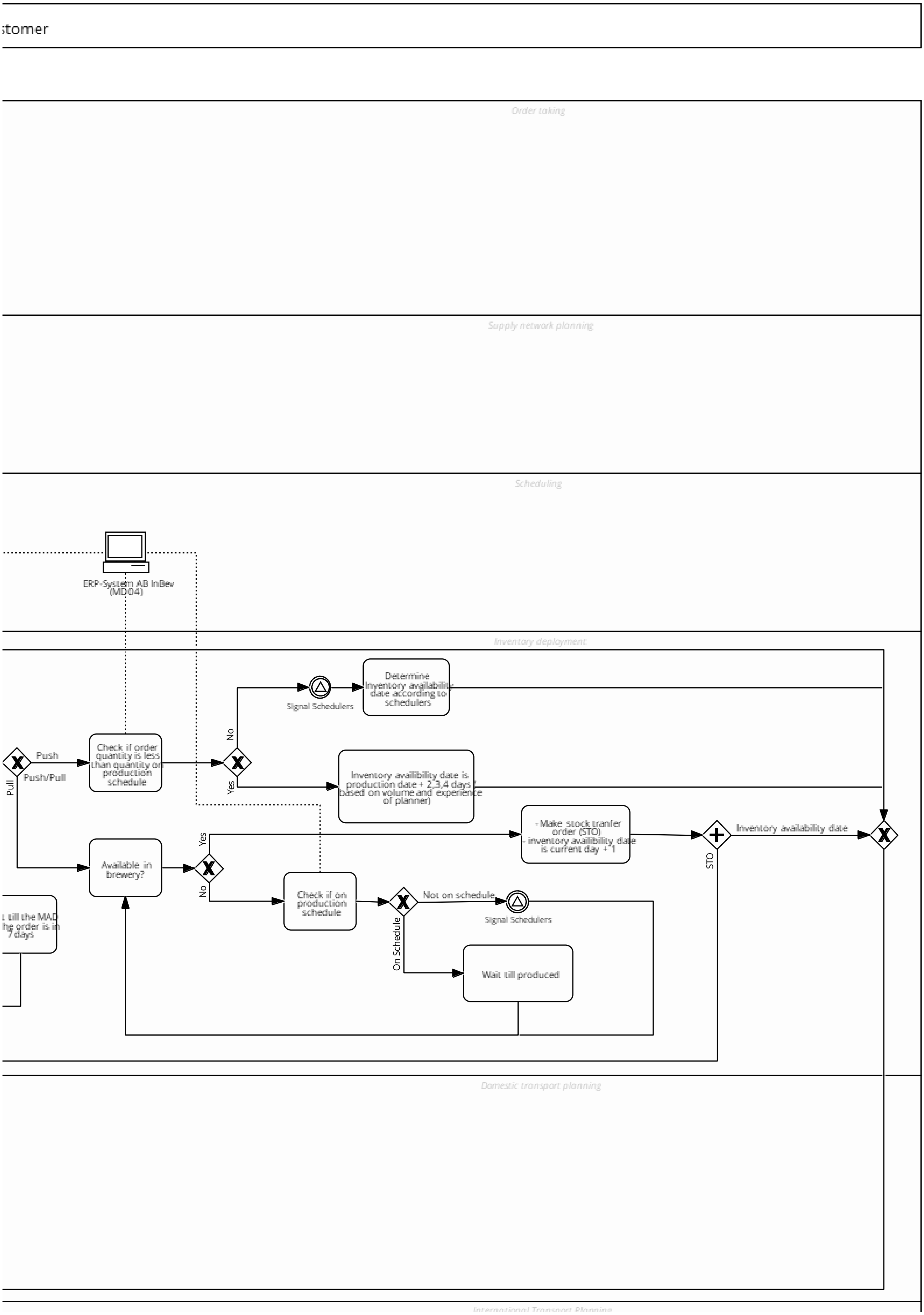
7. Appendix

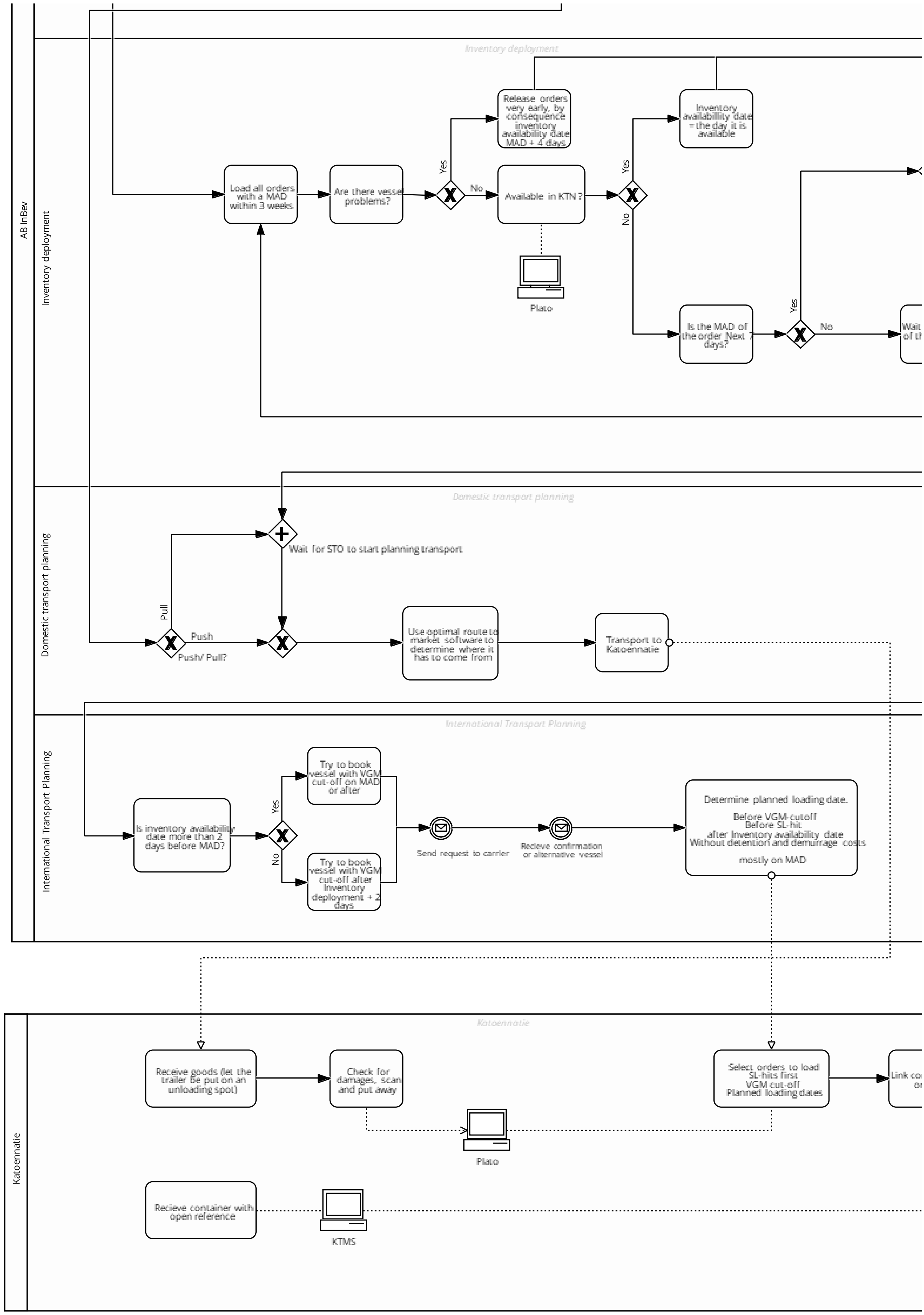
7.1 Appendix: Business process model

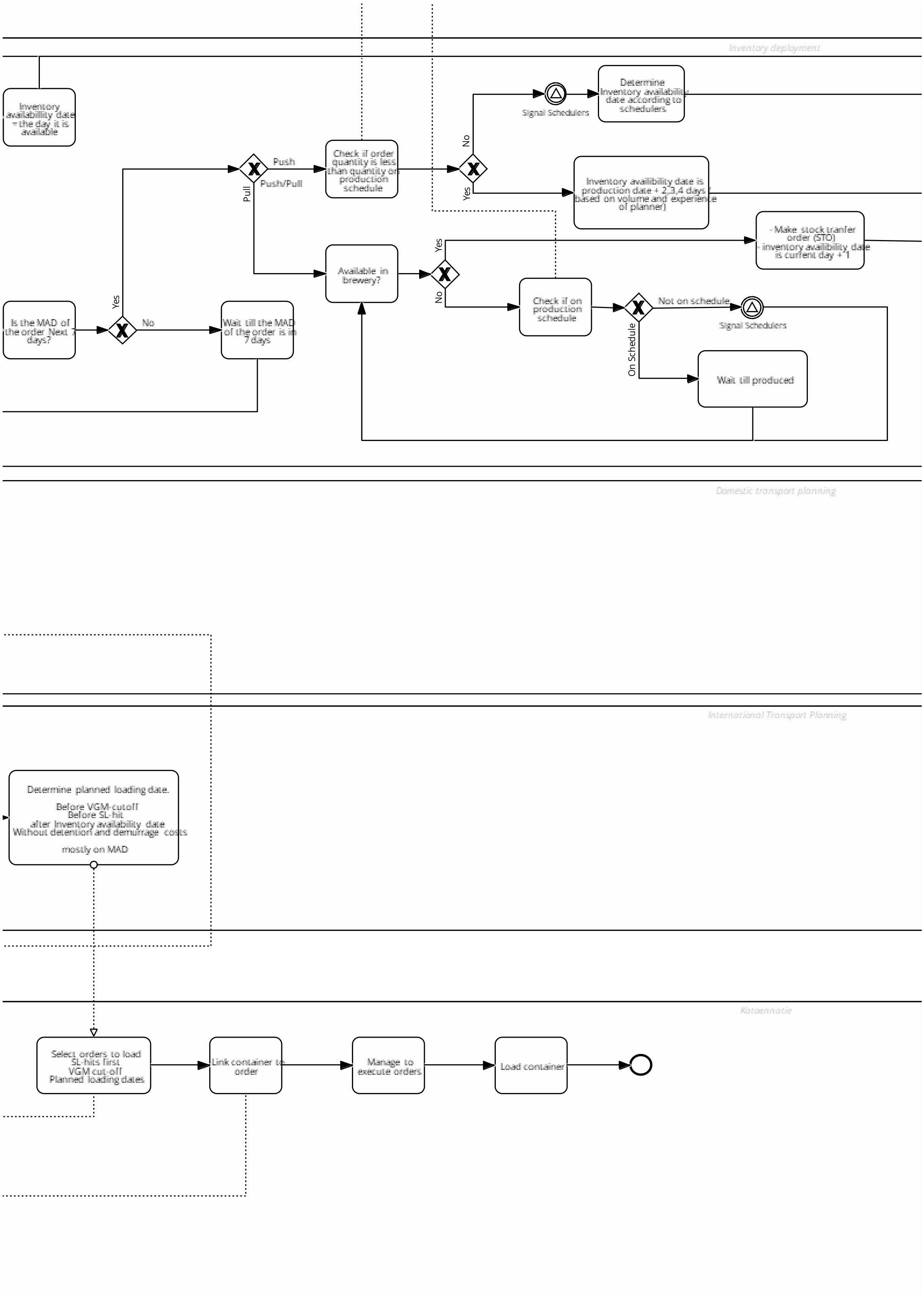



Customer
Order taking
communicate delivery date
Calculation of made availability date (MAD)
Promised delivery - shipping time - 1 week
Supply network planning
Scheduling
Make production plan, with JIT arrival of packaging
ERP-System AB InBev (MD04)
Inventory deployment
Release orders very early, by consequence inventory availability date MAD + 4 days
Inventory availability date = the day it is available
Yes
No
Available in KTN ?
Plato
Is the MAD of the order Next 7 days?
Wait till the MAD of the order is in 7 days
Push
Push/Pull
Pull
Check if order quantity is less than quantity on production schedule
Available in brewery?
Domestic transport planning
to start planning transport
Use optimal route to market software to determine where it has to come from
Transport to Katoennatie



stomer
Order taking
Supply network planning
Scheduling
ERP-System AB InBev (MD04)
Inventory deployment
Determine inventory availability date according to schedulers
Signal Schedulers
No
Push
Check if order quantity is less than quantity on production schedule
Push/Pull
Pull
Yes
Inventory availibility date is production date + 2,3,4 days (based on volume and experience of planner)
- Make stock tranfer order (STO)
- inventory availibility date is current day + 1
Inventory availability date
STO
Available in brewery?
Yes
No
Check if on production schedule
Not on schedule
Signal Schedulers
On Schedule
Wait till produced
till the MAD
he order is in
7 days
Domestic transport planning
International Transport Planning


AB InBev
Inventory deployment
Load all orders with a MAD within 3 weeks
Are there vessel problems?
Yes
No
Release orders very early, by consequence inventory availability date MAD + 4 days
Available in KTN ?
Plato
Inventory availability date = the day it is available
Is the MAD of the order Next 7 days?
Domestic transport planning
Wait for STO to start planning transport
Pull
Push
Push/ Pull?
Use optimal route to market software to determine where it has to come from
Transport to Katoennatie
International Transport Planning
Is inventory availability date more than 2 days before MAD?
Try to book vessel with VGM cut-off on MAD or after
Try to book vessel with VGM cut-off after Inventory deployment + 2 days
Send request to carrier
Recieve confirmation or alternative vessel
Determine planned loading date.
Before VGM-cutoff
Before SL-hit
after Inventory availability date
Without detention and demurrage costs
mostly on MAD
Katoennatie
Receive goods (let the trailer be put on an unloading spot)
Check for damages, scan and put away
Select orders to load
SL-hits first
VGM cut-off
Planned loading dates
Recieve container with open reference
KTMS


Inventory deployment
Inventory availabillity date = the day it is available
Push
Push/Pull
Pull
Check if order quantity is less than quantity on production schedule
No
Yes
Signal Schedulers
Determine Inventory availability date according to schedulers
Inventory availibility date is production date + 2,3,4 days (based on volume and experience of planner)
- Make stock tranfer order (STO)
- inventory availibility date is current day + 1
Available in brewery?
Check if on production schedule
Not on schedule
On Schedule
Wait till produced
Is the MAD of the order Next 7 days?
Wait till the MAD of the order is in 7 days
Domestic transport planning
International Transport Planning
Determine planned loading date.
Before VGM-cutoff
Before SL-hit
after Inventory availability date
Without detention and demurrage costs
mostly on MAD
Katoennatie
Select orders to load
SL-hits first
VGM cut-off
Planned loading dates
Link container to order
Manage to execute orders
Load container

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Analysis of freshness of products: case study AB Inbev

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