University of Twente

# Forecast accuracy improvements at a fast moving consumer goods company

**How to improve the Raws and Packs material requirements forecast to reduce procurement losses**

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## Management Summary

The company produces many grocery items at several production facilities in Europe. These products are made in external factories and internal company factories. To produce the finished goods items, many raw and packaging materials are required. We executed this research to improve the forecast accuracy of the mid- and long term material requirements forecast. This means that we looked at a 3-12 months forecast horizon, on a European product number aggregation level, and with time buckets of one month. The research focusses on all the materials that are supplied to seven company owned factories in Europe. The company needs a high forecast accuracy as materials are bought on contract basis. When contracted volumes are higher than the actual requirements, it can result in forced buys, additional holding cost, and write-off costs. When contracted volumes are smaller than the actual requirements, buyers need to find additional amounts at the spot markets. As prices for specific ingredients fluctuate heavily, this results in additional cost or lost sales if additional volumes cannot be found.

The current mid- and long term accuracy is 59.6% while the targeted accuracy is 70%. The problem statement that this report addresses is how to improve the raws and packs material requirements forecast accuracy of the forecast used at procurement.

Based on different steps in the process from material requirements and lot-sizing rules the Vendor forecast is generated. By combining the Vendor forecast with the actual requirements the forecast accuracy can be calculated. We identified that the current forecast generating process is set up in a way that activities can be started before their predecessors are finished. Further, the analysis showed that the material resource planning system used in SAP is not a primary source of the low accuracy. The low accuracy seems to be driven by incomplete and incorrect information that is provided as input. To find the settings and parameters that are important in the process of generating the raws and packs material requirements forecast, we analyzed literature. In literature we found that there are components of the MRP system that can have a large impact on the forecast accuracy. We studied the demand forecasting process, Bill of Materials usage, freezing method, lot-sizing rules, lead times, safety stocks and planning horizon.

The research has shown that there are different factors that drive the low forecast accuracy. The biggest driver is that the planning horizon of the finished good promotional demand forecast is shorter than the material requirements forecast horizon. This lead to a situation where only around 80% of the requirements were forecasted. Further, high minimal order quantities for the different ingredients and the impact of the current crop planning process are sources of the low forecast accuracy. We identified item specific errors with lead times and incremental order quantities. Further we redesigned the total process that results in the raws and packs material requirements forecast. A tradeoff between the costs and the forecast accuracy improvement percentage, of different solutions proposed, has been made. This resulted in a list of solutions that need to be implemented and solutions that will result in a higher accuracy but do not outweigh the investment, do not bring enough improvements, have negative side effect, or are not feasible to implement. Solutions are proposed to improve different parts of the process like: the SAP material

requirements generation process, the process to create the Vendor forecast for procurement, and solutions to decrease short term system nervousness and improve accuracy. Different solutions are proposed that can improve the forecast accuracy to 75.2% if they are implemented on top of each other.

| | | | |
|---|---|---|---|
| • Current forecast | | | 59.8% |
| • Adding the promotional forecast | + | 10% | 69.8% |
| • Changing the crop process | + | 2% | 71.8% |
| • New Product Development Process | + | 1.4% | 73.2% |
| • Tomato paste delivery performance | + | 0.8% | 74.0% |
| • Beans lead time | + | 0.6% | 74.6% |
| • Forecast generating process | + | 0.6% | 75.2% |

At the end the main conclusions of the research are:

- Settings and parameters that have a large impact on the raws and packs forecast accuracy are Bill of Materials, safety stocks, safety lead time/ planned lead time, Lot-sizing rules, planning horizon and the frozen period.
- The forecast horizons of different processes are not aligned. All processes required to generate the forecast should have a horizon equal or longer than the final Raws and packs material requirements/Vendor forecast.
- Crop production runs have a large impact on the production plan as they are crop driven, instead of demand driven.
- The current process is sensitive for errors as new activities can start before their predecessor has finished
- For several raw and packaging materials, parameters like the Minimal order quantity, incremental order quantity or lead time are not correctly entered in the system or need to be changed as they create Lumpy demand patterns which are harder to forecast.
- The current forecast accuracy measurement has a backward looking focus. Instead of proactively identifying mismatches between contracted and expected requirements.

To solve these problems we recommend the company to make the following improvements:

- The promotional demand forecast planning horizon should be changed in a rolling horizon of at least 1 year.
- The crop production planning process needs to be improved, as crop production batches need to be re-planned and tracked if harvests are delayed.
- New product developments should trigger material requirements before production starts
- The tomato paste transportation companies performance should be measured and tracked to push them to improve their delivery performance.
- The lead time of beans is not correct in SAP and should be changed to reduce the phasing inaccuracy.
- The process around the material requirements forecast generation needs to be changed to make sure activities are finished before the next activity starts

- MOQs that cover more than 3 months of requirements should be reduced by renegotiation, as they are not allowed in the company policy and because they create lumpy demand patterns, which are harder to forecast
- Further, some small parameter changes need to be made to improve the accuracy for a specific group of ingredients as the system is not forecasting based on the correct parameters.

At the end of the research some recommendations are already implemented, the most important ones are the promotional forecast, forecast generating process, and lead time/rounding value changes. The MOQ reduction has been started and the tomato paste supplier is tracked. Based on the current status a forecast accuracy of 71.0% has been reached and the processes started can improve another 2.8%. The last 1.4% is related to the new product development process that needs a longer implementation time as many departments need to be involved and the company needs to decide if they want to reach 75.2%.

# Preface

In order to complete my Master Industrial Engineering and Management, I wrote this master thesis at the company. During this research I learned a lot about the fast moving consumer goods industry, the supply chain challenges, and the importance of accurate forecast on finished goods, raw, and packaging materials.

Next to all the learning experiences I got the chance to develop myself in the field of project management. I thank the company and esspecially my supervisors for guiding me during this project at the company.

Further, I thank Matthieu van der Heijden and Marco Schutten for their feedback and guidance while writing my final thesis. Their feedback and insights helped me to compose my final report.

Nard Weierink

# Contents

## List of Abbreviations

- CPC: Commercial product code
- EPN: European product number
- OTIF: On-time in full
- CFR: Case fill rate
- R&P: Raws and packs
- AOP: Annual operations plan
- ETA: Expected time of arrival
- MPS: Master production schedule
- MRP: Material requirements planning
- PO: Purchase order
- Pur Rqs: Purchase requisitions
- DTP: Duties and taxes paid

## Definitions

- *Demand planners*
  - Representatives in the local markets who are responsible for composing a reliable and realistic demand forecast of finished goods.
- Case Fill rate (CFR)
  - Amount of orders tha.t are fulfilled in comparison to the total amount of orders received
- *Supply planners*
  - Planners at the supply chain hub who compose the tactical production plan for the next five to six weeks based on capacity restrictions, lead times, MOQs and safety stocks. Next to this they are responsible for providing the parameters to the system in order to make a 2 year forecast production plan.
- *Contract period*
  - The duration of the contracts with suppliers made by Procurement. The contracts can have a duration between three and eighteen months due to regulations, prices, etc.
- *Raws and packs material requirements forecast*
  - Material requirements for each period based on the periods production plan and current inventory levels.
- Vendor Forecast
  - Raws and Packs material requirements forecast after ordering lot-sizing rules have been applied
- Dummy code
  - A product code that is used to reserve capacity and to plan demand on while the EPN of a new product is not known yet.
- Status 5 item
  - A new finished good item that is going to be launched on a short term. The item has all the codes and is ready to start production, the only thing that still needs to be done is that the item needs to be activated.

# 1 Introduction

This chapter we explain the necessity of this research. Section 1.1 describes the history of the company. Then Section 1.2 explains the motivation for the research. In Section 1.3 we identified the problems faced at the different departments and the root causes. The conclusions of this chapter are the main problem statement and sub questions in Section 1.4. Section 1.5 gives a short outline of the report.

## 1.1 The company

## 1.2 Research motivation

After a merger the focus of the company was moved to cutting costs. Nowadays the focus is shifting to growth and innovation while maintaining a low cost profile. Zero Based Budgeting (ZBB) has been applied at all the departments in the company. This means that the budget is built from scratch each year and all costs, have to be explained. In this way unexplainable costs are identified and the search for a root cause starts. This way of working lead to the identification of some different problems that are related to the Raws & Packs materials requirements forecast. The following problems were identified by the procurement and finance departments:

- Additional costs are made when contracted ingredient amounts are not in line with the actual inbound requirements. If the actual inbounds are higher the buyers need to buy more of the ingredient at higher prices. If the actual inbounds are smaller than the contracted amount it leads to forced buys, additional inventory costs, obsolete risks and fines. For most products a difference of 5% between the contracted amount and actual requirements is acceptable but for some products this percentage is smaller.
- If the material request is higher than the contracted amount but suppliers are unable to deliver more ingredients than contracted, and there are no alternatives available, the business loses sales. This only happens to some key ingredients, which can cause big problems in the business.
- Finance hedges amounts of money to cover fluctuations in currencies. Hedging decisions are made on the difference between forecasts on inbounds and finished goods sales in a specific currency. When inbound quantities are inaccurately forecasted in combination with differences between forecast and actuals of finished goods demand, it may lead to additional losses or profits. Both cases are unwanted because hedging should cover risks and in these cases additional risks are taken. Because the amount hedged depends on the forecast of R&P, a high accuracy is required.

The common cause of these problems is that all of them are based on an inbound forecast, see Figure 1-1. The inbound forecast does not completely depend on the forecast of finished goods as is also influenced by other internal factors as explained in Section 2.1

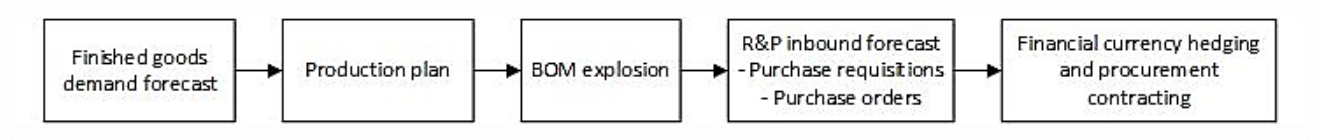


*Figure 1-1 Flow from demand forecast to R&P forecast.*

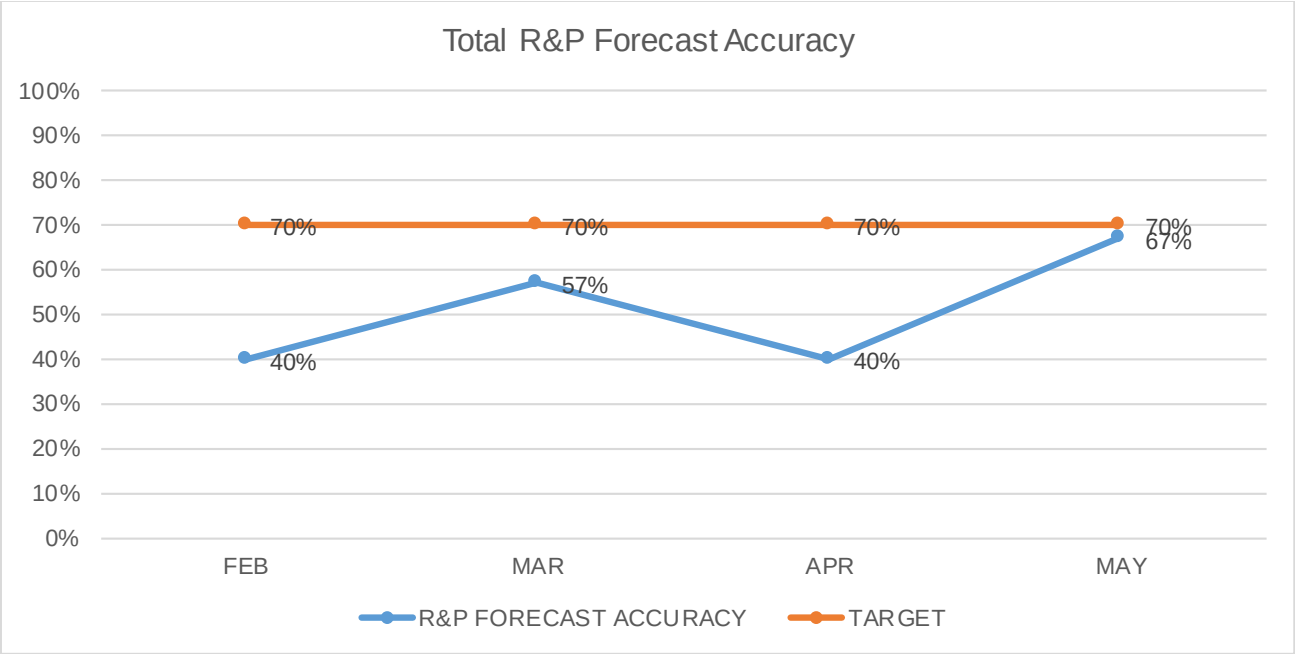


*Figure 1-2 R&P forecast accuracy*

The one month forecast[1] accuracy has been measured for four months by the Sales and operations planning department, it is highly variable and therefore it does not seem to be in control as can be seen in Figure 1-2. The goal for R&P forecast accuracy in Europe on the weighted percentage over all materials and KeyStone[2] production facilities was set on 70%. The goal of 70% is based on the current situation of finished goods forecast accuracy[3] and the improvement potential. It can be seen that the R&P forecast accuracy was between 40% and 67% during the period February- May.

As a low forecast accuracy impacts the decisions made at Procurement and Finance. Therefore the sales and operational department(S&OP) wants to know if the process to generate the raws and packs material forecast is correct and reliable. The need of the S&OP department resulted into this research on how the forecast accuracy can be improved and how it should be measured.

## 1.3 The research problem

Based on interviews with procurement, finance and planning, we identified possible causes of inaccurate forecasts and the resulting consequences. The information provided by the different stakeholders was captured in order to identify the main problem. The goal is to identify what is driving the mismatch between forecasted requirements and actual requirement. Further, it needs to be clear how the low forecast accuracy influences decision making at other departments. Section 1.3.1 describes the forecast issues as faced by procurement. In Section 1.3.2 we analyzed the issues

[1] The forecast of April is extracted from the system at the first day of March and at the beginning of May and the forecasted inbounds and the actual inbounds of May are compared.
[2] The sites that use the SAP system
[3] Measured for more than 5 years now with a European goal of 73% and a bias of less than 4%

faced at finance. Section 1.3.3 combines the outcomes of Section 1.3.1 and 1.3.2 into an identification of the root cause.

### 1.3.1 Forecast issues at procurement

Procurement contracts and secures volumes with suppliers to make sure materials are bought at the best financial conditions. The contracting period differs per portfolio or sub-portfolio based on the specific market conditions. After the contracting period it becomes harder and more expensive to buy these ingredients. Some of these products are regulated by European regulations and others are only available during a limited period of the year. Products can have short or long contract periods (3-18 months) and the spot rate prices fluctuate heavily. The earlier an increase/decrease in requirements is visible, the better the buyers are able to anticipate on the new requirements and the more likely they are able to close the best contacts.

The buyers close contracts with suppliers over a set period of time for a specific total amount. The supplier expects that demand is spread evenly over the contract period unless agreed differently. Mainly for commodity goods the volumes are strict, if The company orders less than the contracted amount they are forced to buy the contracted amount or The company can be fined. If the production requirements are higher than the contracted amount, the buyer needs to find additional amounts of ingredients on the spot market. Procurement is mainly involved with contracting the materials. Actual orders are placed by the material schedulers that are located at the production sites. These material schedulers order the ingredients based on the production plan as defined by the supply planner at the hub.

For the buyers the annual operations plan (AOP), which is generated each year in September-October, has a big influence on the costs procurement expects to spend on every product. When this AOP forecast is completely different from the actual material requirements, the prices are incorrect and the buyers need to justify the difference. This differences can be positive or negative, in order to create stability and a clear perspective procurement needs a reliable forecast, preferable on at least a one year horizon.

Next to this, a problem arises due to the different ways of working within the company. As the objectives and information requirements of the departments differ they share information among each other based on their own needs and from their own perspective. Most departments work with different forecast horizons based on their own needs. Demand forecast of finished goods on base demand has a horizon of 2 years, and the promotional demand forecast is one year to go. Supply planning uses a forecast until the end of the year and starts reviewing the next calendar year from October. Procurement uses different contract periods based on regulations and prices in the market. Some products such as oil can only be contracted for a maximum period of three months, sugar on the other hand needs to be contracted on a yearly basis. Due to all these different horizons, the needs for a stable forecast are different for the different buyer portfolios.

### 1.3.2 Forecast issues at Finance

Next to the procurement department the financial department wants to have a reliable material requirements forecast. As The company buys and sells ingredients and products in different currencies, the company has to deal with fluctuating exchange rates. These fluctuations in exchange rates can have a huge effect on the reported earnings of the organization, therefore the financial department hedges based on the difference between sales and payments in a specific currency. By hedging they are able to get more stability in the exchange rates, as a result they generate stability in the business results and get control over the cash flows. Stability in the business results is important because the company is registered at the stock market. By hedging the current amounts upfront the company is better able to predict what the sales/inbound difference in the different currencies will add to the business results. If the exchange currency weakens the company may have hedged to high and faces opportunity losses caused by the more profitable spot rates. Based on the volatile character of the current markets hedging decisions are hard to manage, based on the companies attitude towards risk, the available data and systems the financial department tries to cover the risks in the best ways possible.

The material requirements forecast is used as input to the financial hedging process. Based on forecasted incoming and outgoing cash flows of Polish Zloty, GB Pound, and US dollar, the finance department hedges in order to reduce the risk of currency fluctuations. As opposed to the procurement department, the hedging results of the finance department are not only depending on the R&P material requirement forecast. There are more factors like finished goods forecast, price setting, and hedging assumptions, which influence the outcomes of the hedging decisions as shown in Figure 1-3. When the accuracy on the forecasted volumes will increase the financial department can profit from it but this is not a definite outcome due to the influence of the other factors.

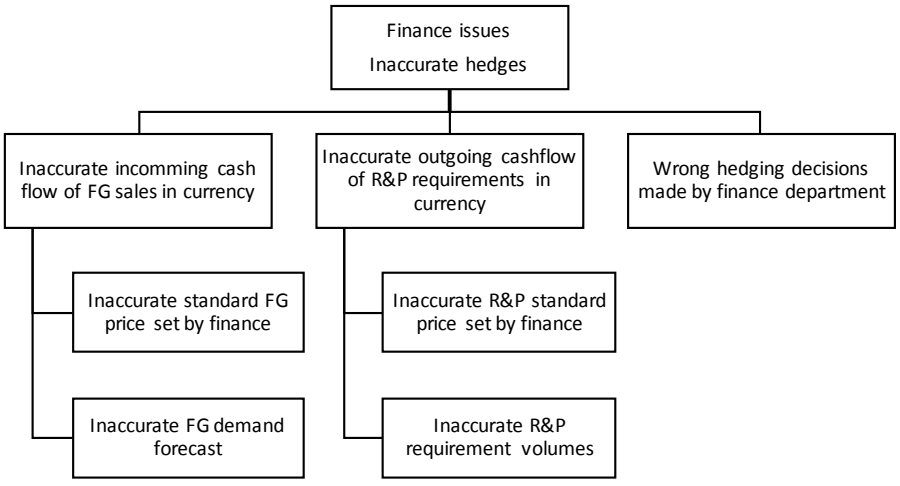


*Figure 1-3 Problem net finance*

### 1.3.3 Root Causes

Based on the short analysis conducted in Sections 1.3.1 and 1.3.2, the issues faced at procurement are more direct related to the R&P forecast volumes than the issues faced at finance. For both departments an accurate R&P material forecast will lead to profitable results. An inaccurate R&P requirement forecast has a direct negative impact on procurement, for finance this is an indirect relation and therefore the focus of this research will be on the forecast accuracy of the R&P volumes.

Although the forecast accuracy is an important performance indicator for procurement there are other interests that should be taken into account. Due to the involvement of several departments in the process around the Raws and Packs material requirements forecast, these findings need to be taken into account.

- The departments work, and want to work, with different forecast and planning horizons. The horizons used fluctuate between 2 and 18 months.
- Procurement wants to be flexible when to contract ingredients and for which period. Constraints on the moment to close contract and the duration of the contracts will only be used as guidelines.
- For planning the OTIF (on time in full) rate is the most important. Therefore the production plan will be changed if necessary to maintain the OTIF rate. Planning cares less about changing delivery dates and/or amounts of material requirements.
- To make sure the OTIF level is maintained, production can be shifted between sites. This might result in buying materials from different suppliers in different currencies.

To wrap up, the company wants to be flexible on how much, when, where, and what to produce in order to fulfill finished goods demand. At the same time there is a need for a reliable planning as the supplier contracts and indirectly the hedging decisions are based on the production planning. A lot of the root causes identified are (in)directly related to the contradicting interests, flexibility, and stability. Due to the different objectives of the departments, in combination with their desire to be flexible in their decision making, there are conflicting interests and a tradeoff needs to be made.

The main goal of this research is to identify how the forecast on raws and packs should be made. As described earlier there are a lot of factors that influence the difference between forecast and actuals while the forecast is mainly based on the production schedule at a specific point in time. Therefore this research focuses on identifying a better way of forecasting the raws and pack material requirements on the mid- and long term horizon.

## 1.4 Problem definition

The problem statement of this research is:

*How can the Forecast on Raw and Packaging materials at the company be improved in order to improve the reliability of the forecast volumes for procurement?*

- We are looking at the forecast on a 3-12 months horizon on a European Product number aggregation level with time buckets of one month.

Research questions

1. **What is the current procurement and planning structure and which items face the biggest inaccuracy issues?** In this first part of the research we will identify the current way of working. The different processes in generating the forecast are described. Further, the complete process from finished products demand forecast until R&P forecast is captured in a flowchart to understand the process. For each process step we identified the forecast horizon, aggregation level, and the time buckets. The processes are modeled in a flowchart and we mapped the dependencies between the processes. Based on the problems identified by procurement the R&P materials that are most sensitive for the problems described by procurement need to be identified. In order to identify the critical materials several aspects are taken into account. Some of the criteria that are important to identify the biggest issues are: financial impact, supplier issues, total volume required, and number of finished goods that use the material. We describe the characteristics of these products and materials with similar behavior are grouped together in order to solve the problems. We analyze the processes of these items to see where the mismatch between forecasted amounts and actual amounts arises.

2. **Which solutions are known in literature to forecast raw material requirements and which factors have a large impact on the forecast generated?** A literature review has been executed in order to see which existing methodologies are used to incorporate the finished product demand and internal influencing factors into raws and packs material forecast. We identified parts of the material resource planning process that can have a negative impact on generating the material requirements forecast. In this way we identified critical points/parameters that should be set correctly in order generate a highly accurate material requirements forecast. At the end a conclusion is formulated on which findings from literature should be used and which parameters have an impact on the forecast accuracy.

3. **How should the current R&P materials forecast be changed in order to improve the accuracy?** Based on the different forecast issue groups identified and the outcomes of the literature review an analysis is executed in order to identify how these groups of raws and packs should be forecasted. Which parts of the process need to be changed and which parameters need to be changed? Possible solutions are described and we identified the tradeoffs between the pros and cons of the options. Which horizon should be used and how will these

solutions lead to a better forecast accuracy. The final solution is explained and the process of generating the forecast is described. The roles of the different stakeholders that need to be involved during different parts of the process are described.

4. **Does the proposed solution solve the errors and meet the needs of procurement?**
   The proposed solution needs to be checked and valued to see whether the solution solves the problem described in earlier chapters and to see whether or not the proposed solution does what is should do. Based on historic data the expected impact of the different solutions will be quantified and a tradeoff needs to be made between the benefits on forecast accuracy and the costs. Costs can be monetary costs or time and process changes that require a lot of time to be invested.

5. **How should the solution be implemented and how can it be sustained?**
   Based on the outcomes of the previous sub question the impact will be clear. The solution need to be implemented in a sustainable way in order to make sure that the solution will result in the desired benefits. Therefore we made a description of how the solution should be implemented and sustained. Responsibility for the process needs to be assigned and clear communication lines about the forecast should be established. Further, the measurement tools will be described and realistic targets will be identified for the KPIs on which the performance will be measured.

### SCOPE

This report has as main purpose to improve the R&P forecast accuracy for the European production locations. Below an overview of the scope of the research:

In the scope of this project are:

- Raw and Packaging material requirements forecast.
- 7 Internal factories
- The contracting process of raw materials.
- The one year rolling material requirement forecast.
  - The mid- and long term initial forecast on which contracts are closed, and the short term forecast to act on if the long term forecast is not as accurate as expected.
- The raw and packaging materials, which face issues at procurement.

As a result of the earlier described scope the following points are not in the scope of the research.

- External factories.
- The factories in Seclin and Latina because they use a different ERP system (BPCS).
- Financial hedging decision making.
- Materials that are not highlighted by procurement.
- Production planning methods used

## 1.5 Research outline

This chapter described the purpose of the research, the main question and the required deliverables. Chapter 2 contains an overview of the current way of working, the most critical items for procurement and the current way of measuring. In Chapter 3 literature is analyzed to see which solution are available so solve the issues as faced by the company. At the end of this Chapter literature is selected that will be used to improve the forecast accuracy. In Chapter 4, different solutions are proposed based on the current situation and literature study. Chapter 5 contains the cost and benefits analysis and the decision on which solutions should be implemented. Further, the implementation plan and measurements are presented in Chapter 6. Chapter 7 contains the conclusion, recommendations and areas for further research.

# 2 Current situation

Because the company is active in the fast moving consumer goods industry, the company is mainly forecast driven. Several departments are involved in different forecasting processes or depend on the forecast of raws and packs. The complete process from generating the finished goods forecast until the usage of the raws and packs forecast is described in this chapter.

The process to generate a material requirements forecast to be used at the procurement department of the company has three important process steps. First the material requirements are generated based on the demand forecast and production batches that are planned. Then based on the current stock levels of the raw and packaging materials a Vendor forecast is generated. The Vendor forecast is a material requirements forecast that is adapted by the application of lot-sizing rules to generate an inbound/procurement forecast. This forecast tells the procurement department how much of an ingredient or packaging material is expected to be ordered for each month. Based on this Vendor forecast the buyer contracts amounts of ingredients to cover the needs for every month. If the forecasted amounts are different from the actual requirements the buyers need to react on a short horizon to buy additional volumes or to make sure fines are minimized when contract quotas are not reached.

In Section 2.1 the process is described in more detail and a process flow is given. In Section 2.2 the main procurement materials that face issues are identified. In Section 2.3 the current measurement tool is introduced and analyzed. Section 2.4 summarizes the outcomes of the current situation analysis.

## 2.1 R&P requirements process

The R&P material requirement forecast is a dependent forecast. The forecasting process starts with the finished goods demand forecast, which is generated by the sales and marketing department (see Figure 2-1) together with the demand planners at the different business units (see Figure 2-1). The business units are responsible for specific parts of the European market. The demand planners are located in these markets and work together with the sales and marketing departments in order to understand their business units' market.

The demand forecast of finished goods starts with a base forecast that is generated based on historic data, as described by Kalchschmidt, Zotteri, and Verganti (2003). This finished goods demand data is reviewed by the demand planners. Based on their market insights and the information they receive about promotional activities, they correct the finished goods demand forecast. After the demand planners have adapted the forecast it reflects the expected finished goods demand as good as possible.

The demand planners work with a fixed end time of the horizon for the forecast period. The forecast period starts from the next month and lasts until the end of the first quarter of the next calendar year. So as the year progresses the forecast horizon becomes shorter. When the demand planners finish their forecast they upload it in the JDA system. JDA is the system used for planning and demand. The demand is planned for monthly buckets on a commercial product code (CPC) aggregation level. A commercial

product code includes one or more European Product Numbers (EPN), these EPNs use exactly the same raw and packaging materials, only the label or the trays can be different.

After the demand planners have uploaded the forecast in the JDA system, the supply planners (see Figure 2-1) are able to start planning the production on a weekly basis for each Stock Keeping Unit (SKU), which has a unique EPN. Based on the inventory level at the beginning of a week, the actual orders, remaining demand forecast, safety stock levels, stock cover, line performance, material availability, and capacity restrictions, the supply planners try to find a suitable production schedule for the different production jobs and batches. If we look at the planning horizon of the supply planners, everything on a horizon of more than 6 weeks is called liquid and subject to many changes. These changes are caused by differences between the planned and actual production planning in earlier weeks. The production plan of 3 to 5 weeks is confirmed and called slushy. The 2 weeks closest to the start date of the production batch, the planning is called frozen and it is really hard to make changes in the schedule. Next to this the supply planner sets the planning parameters (order quantities, planning calendars, sourcing and transportation settings, etc.) and checks the production batches that have been planned automatically by the JDA system. The planner checks the production plan for the year to go on capacity violations and corrects these if necessary.

The supply planners build the production plan in JDA in weekly time buckets (see Figure 2-1). For some production lines this is a tough

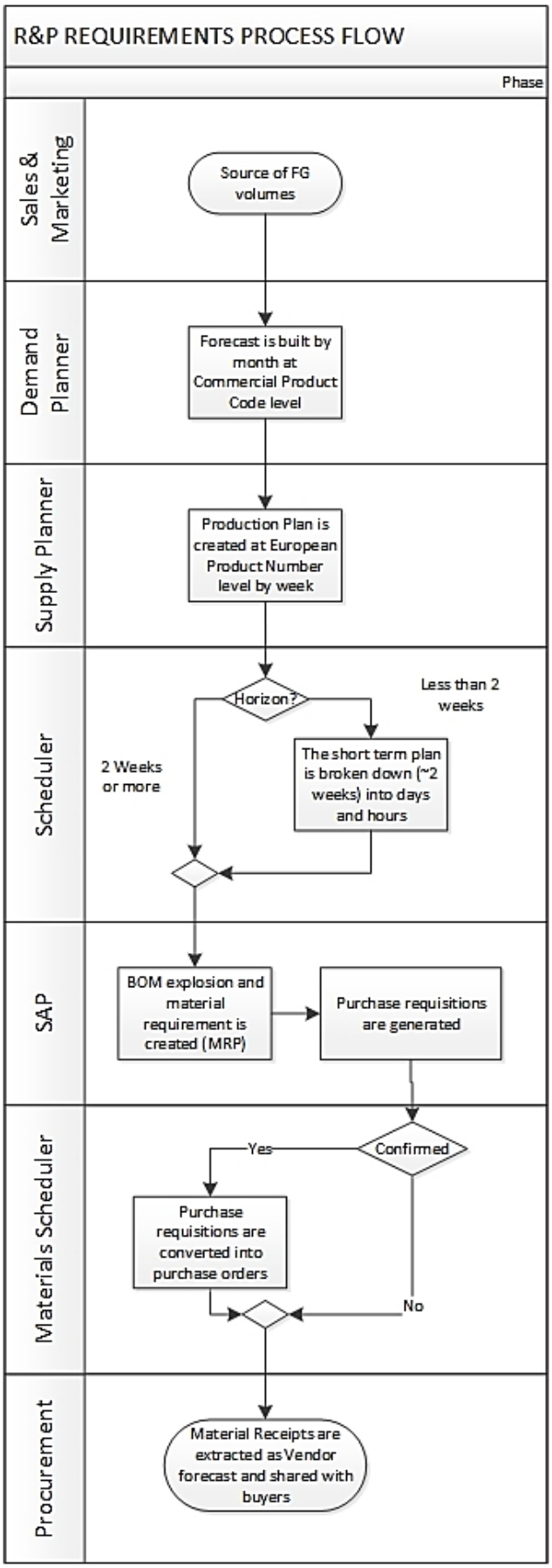


*Figure 2-1 Process flow*

assignment due to the fact that different products use different machines that are not committed to one line only. Shifting the production of one product can influence the production plan of many other products as well. After the spply planners have confirmed the production plan the plan is interfaced from the JDA planning system into SAP overnight.

After the supply planner has confirmed the plan in JDA, the plan is sent to the production facilities. At the production site a scheduler (see Figure 2-1) is responsible for scheduling the orders on a day/hour basis. The scheduler makes the final production schedule at the operational level in JDA. The scheduling horizon is 2 weeks, the schedulers at the factories compose a plan per week and per specific SKU/ EPN.

For every finished good SKU (at each site) there is a Bill of Materials (BOM) generated in SAP. Based on the factors and ingredients the BOM can be exploded, which leads to the material requirements that are needed for the planned production jobs. The BOM is exploded for the demand production planned by the planner and by the system. Then, based on minimal order quantities, lead times, time for quality controls, available inventory, and processing times the materials the system generates the material requirements in time. The requirements for all the planned production batches are combined and in this way a purchase requisition is generated for each raw or packaging material. The material schedulers at the site need to confirm this purchase requisition and a purchase order is placed for a requested delivery date.

Based on the requested inbound dates of materials the R&P material requirements forecast is generated and extracted from SAP by Business Intelligence. This forecast document is called the vendor forecast, which is the same as the material requirements forecast. The vendor forecast shows all the requested inbounds, so both purchase orders and purchase requisitions in their required month. In the end the total requirements of a raw or packaging material SKU are shown per site. The vendor forecast has a forecast horizon of a year with buckets of 1 month. The aggregation level is EPN per site. This vendor forecast is then shared with the procurement department.

To summarize, the horizon, aggregation level and time buckets of the most important process steps in generating the R&P material requirement forecast are shown in Table 2-1. As can be seen there is a difference between horizon, aggregation level and time buckets for all the process steps.

| Process stage | Horizon | Aggregation level | Time buckets |
|---|---|---|---|
| Base demand forecast | 24 Months | FC Commercial Product Code | Months |
| Promotional demand forecast | Year to go | FC Commercial Product Code | Months |
| Production plan (supply planner) | 6 Weeks | FG European Product Number | Weeks |
| Production plan (system) | 24 Months | FG European Product Number | Weeks |
| Vendor forecast | 12 Months | R&P Product Number per site | Months |

*Table 2-1 Horizon, aggregation and time buckets per process stage*

Based on the overview in Table 2-1, it is clear that most processes use a rolling forecast horizon of 12 or 24 months. Because the vendor forecast is a dependent forecast, information that is not captured in the beginning of the process will affect the accuracy

of the vendor forecast. Because the promotional forecast has a fixed end of the horizon the total horizon shrinks when the year proceeds. As the new promotional demand forecast is added during the period August-September, the horizon fluctuates between 16 months at the end of September to 4 months at the beginning of August. As the vendor forecast is extracted for at least 1 year (sometimes 1.5 years), the demand drops at the end of the forecast horizon due to the missing promotional demand. The situation is shown in Figure 2-2. In this figure the situation is given for June. In June there is a base demand forecast that has a rolling horizon of two years. The promotional forecast has a horizon until the end of the year, so 6 months. In July this horizon would be 5 months an in August 4 months. Based on these forecast the supply planner plans the production jobs for the first 6 weeks and the JDA planning system plans the production jobs for the next two years. Based on this planning the material requirements are calculated. And the Vendor forecast is extracted as a requirements plan for procurement. We identified that the shorter promotional forecast horizon might be a root cause of a low forecast accuracy. As the promotional demand contributes to approximately 30% of the monthly demand the horizon of the promotional forecast might be changed in order to provide the business with a rolling 12 months finished goods promotional demand forecast.

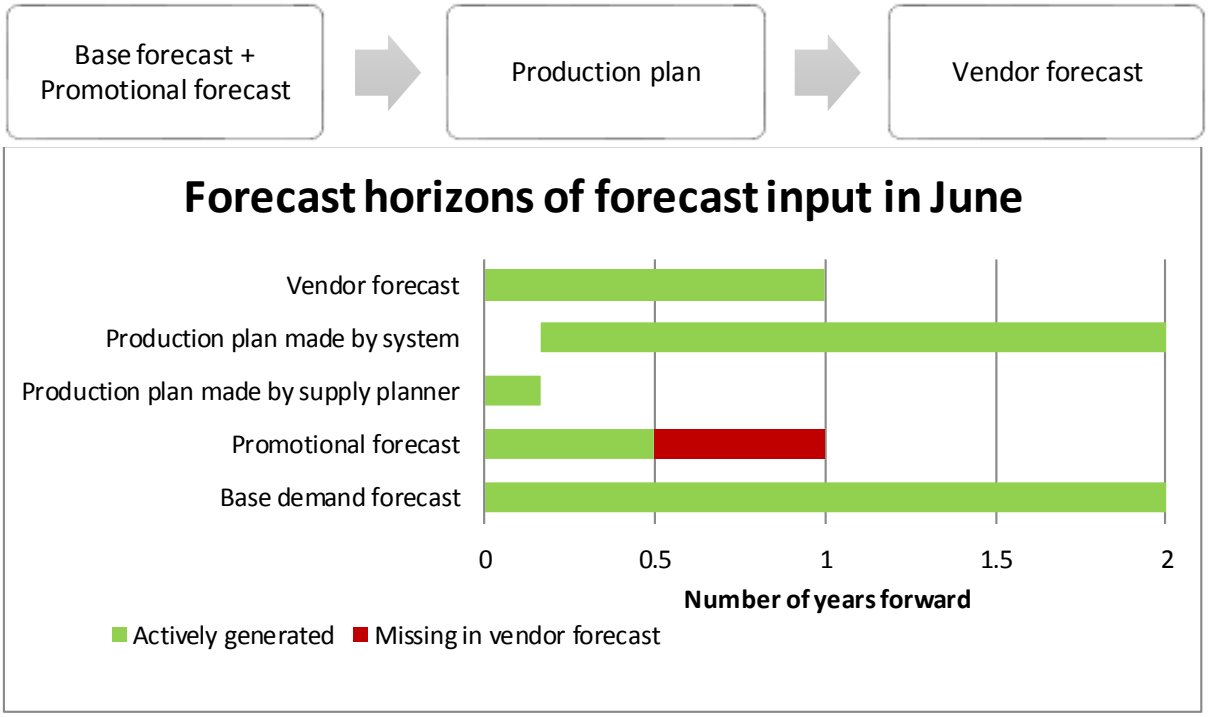


*Figure 2-2 Forecast horizons*

Next to the missing promotional demand it becomes visible that the forecasted volumes before the annual operational plan is generated (August 2016) differ a lot from the forecasted volumes over the same period (2017) after the annual operational plan has been made (October 2016). Some examples of forecast changes are shown in Table 2-2. Further, there are new product developments (NPD) on finished goods items (new items, which are not yet produced), these items can have a non-active status. The status used for items that are not activated is status 5. These status 5 items result in a situation where there is a demand forecast on the finished goods items but the BOM

is not exploded by SAP because the item is not activated. In this way the finished goods demand of these items is not translated into the material requirements forecast.

In Table 2-2 it can be seen that the forecast of the raw material usage for 2017 fluctuates a lot this is partly caused by newly added demand, but also by internal noise of the planning process. The table shows the August and October forecast amount on the different items for several production locations. The difference between these two forecasts is shown as a percentage in the total volume column. There does not seem to be a stable forecast over the months as total volumes increase or decrease more than 10%. The next two columns under “month volumes” show the bandwidth for the changes in the monthly requirements. For sugar in a factory for example the total material requirements forecast goes 14% up. The required monthly volumes change between a decrease of 27% and an increase of 113%. The yearly percentage difference is also converted into a financial impact. Based on the approximate price per 1000 units the financial difference between the two forecasts becomes clear. For the Tomato paste this means that the difference of 30% on the total volume has a financial impact of around €1.2 million. If contracts were based on the August forecast the value of the amount contracted would be €1.2 million to high if the October forecast would be more reliable.

| Type of item | Site | August FC | October FC | Total Volume | Month volumes Min | Month volumes Max | App price | Approximate impact |
|---|---|---|---|---|---|---|---|---|
| Sugar | [redacted] | 6.247.292 | 7.102.406 | 14% | -27% | 113% | [redacted] | |
| | | 3.640.000 | 4.622.823 | 27% | -5% | 39% | | |
| | | 6.000.000 | 7.505.707 | 25% | -28% | 65% | | |
| Tomato Paste | | 41.543.680 | 21.600.000 | -48% | -76% | -23% | | |
| | | 4.395.922 | 3.078.000 | -30% | -67% | 34% | | |
| | | 4.939.225 | 3.910.000 | -21% | -60% | 0% | | |
| Carrots fresh | | 2.751.874 | 896.546 | -67% | -88% | 5% | | |
| Carrots frozen | | 0 | 613.800 | = % | = % | = % | | |

*Table 2-2 volume evolution*

## 2.2 Procurement risk list

As a result of the wide portfolio of finished goods items produced by the company there are over 6000 materials required at the different sites. Some are fast-moving, and large volume items (tomato paste), others are slow moving, and low volume items that are only used for several finished goods items. Because the variety of these items is wide, not all of the items face the same issues. As many ingredients are bought on contract and their prices/volumes vary more in comparison to packaging materials, most issues are faced on the raw materials forecast. Based on information from the buyers a list of 107 items was made. From these 107 items there are 85 unique items, the other 22 are similar items but required at a different location.

As the procurement department consist of several buyers with different portfolios, the issues described do not need to be urgent in all portfolios. To identify the portfolio specific issues interviews were conducted with all ingredient buyers. Out of these interviews a list of the most critical procurement items was made. In each portfolio there are some problems but the situations are not all the same. Some portfolios contain commodity goods while other items are company specific, custom made,

ingredients. The issues can be divided in two subgroups. One group are the short term contracted items/ limited sourcing items that are described in Section 2.2.1 and the second group of issues consist of the one year contracting items with possible issues at the end of the contracting period as described in Section 2.2.2.

### 2.2.1 Short term issues

The short term issues are mainly faced by buyers that have portfolios that contain items for which the contract periods are 3 months or when items are single sourced at suppliers with capacity restrictions.

*Mustard*

As mustard and mayonnaise cannot be produced in the same factory due to hygiene regulations it is produced at a different site then were the bottles are filled. The mustard supplier has a total capacity of 0.4 tons of mustard production per hour. As the company has built a new filling line, this line is able to process 7 tons per hour. For this difference in production speed the supplier needs time to build stock before production peaks in demand arise. Due to current fluctuations in requirement forecast it generates problems when requirements increase on a short notice.

*Oil*

As oil is an ingredient with a volatile price, the contract period is normally around 3 months. During this contract period there is a total volume commitment and a monthly commitment that is not variable. It is not possible to agree a range with the supplier because the supplier needs to buy and reserve the quantities as well. Therefore supplier and buyer agree on specific contract amounts over the total contract period and for each month. As the contracted volumes are strict and spot prices are usually high[4] it is important that the correct amount is contracted. As oil is a bulk product that is stored in tanks, it is not possible to store more if the tanks are full. Another constraint is that oil deliveries cannot be mixed because the traceability of the ingredients will get lost then.

*Processed grains.*

Pasta is bought in different sizes and shapes and due to specific stock agreements with the supplier the forecast needs to be accurate. The supplier keeps the ownership over The company specific stock at their production location until The company calls off the ingredients. Therefore the agreement has been made that the supplier can run production batches of 8 tons and that the forecast is shared with the supplier on a monthly basis. When actual purchase order volumes are too different from the forecasted volumes the supplier starts complaining due to write-off risks.

*Cocoa*

As cocoa is expensive and bought via one supplier the volumes need to be correct. The contract periods of 3 months are based on the London Cocoa Market, which shows that prices between contract periods can be quite different. If volumes are not correct,

[4] Spot rates can be €30, - higher per ton, with differences of 500 tons the impact is €15k for one month.

carry over cost are charged (to transfer volumes to the next contract period) or additional cost are made to buy cocoa beans at spot rates. The items involved are cocoa butter, powder and liquor.

*Food additives, color*

As Riboflavin, vitamin B2, is a single source item and due to limited availability it results in a high dependency on the delivery performance/capacity of this supplier. As tthe company uses Riboflavin directly in their own products but also buys it for semi-finished item suppliers the volumes provided to the Riboflavin supplier should be as correct as possible to make sure volumes are secured for production. As Riboflavin is an expensive item additional stocks of this item are not desirable.

*Molasses*

For molasses the situation is similar to the mustard. As molasses is single sourced with specific requirements and due to the maximum capacity restriction of the supplier the short term volumes should be correct. For this item there are no strict volumes but due to the single source and maximum capacity of the supplier an inaccurate forecast can lead to production stops.

### 2.2.2 Long term issues

Next to the short term requirement issues faced at procurement, some issues have a more long term character. For these items the contracted versus actual amount required amount over the total period is important for different reasons.

*Tomato paste*

Tomato paste is an item that faces both short term and long term issues. The short term issues arise when requirements fluctuate heavily on a short term. Because the lead time of tomato paste is between 70 and 85 days for the different sites, volumes cannot be changed after the shipment departed from the US. The only possibility to source additional volumes is by faster, more expensive emergency shipments. Further, the contract period of tomato paste is 15 months and it is contracted around August-October. Current contract volumes are based on the R&P material requirements forecast in combination with manual corrections based on historic requirements. For fresh tomatoes the same problem arises as for other fresh fruits and vegetables. When contracted amounts are too small additional sources might not be available or are much more expensive.

*Sugar*

The sugar market is a regulated market were volumes are strict and suppliers are not allowed to sell more than their maximum allowed volume. Therefore they contract their available volumes for around 95%, the last 5% stays available to be sold at spot rates to the companies that have contracted too less. Due to the limited availability of sugar the spot rates are much higher than the contract prices. As different companies might face similar issues on higher sugar requirements, the buyers need to be notified early to buy additional volumes when required. Because the costs of sugar are relatively low the transport costs are a bigger part of the total costs of these items. Therefore the forecast needs to distinguish the needs per site as sourcing might be different.

*Meat products*

As many meat products are customized for the company the agreements in the contract are strict. Due to specialized production lines at the supplier the volumes that are contracted need to be correct. The contract period is 12 months. Because many meat ingredients are frozen products the supplier charges high carry over costs if volumes need to be carried over to new contracts. Due to the low forecast accuracy the buyer decided to extract MRP report himself. He does this because he wants to have a better overview of the current situation than currently provided by the monthly vendor forecast report.

*Carrots*

Carrots are mainly used for soups, based on the availability of carrots fresh or frozen carrots can be used. During the season fresh carrots are used, when fresh carrots are no longer available the switch is made to frozen carrots. The volumes required in the period December to March are extremely important due to limited availability of fresh and frozen carrots. When the available amount is less than the requested amount the company asks their farmers to harvest earlier. This means less volume of the harvest and higher costs due to contracting additional volumes later. Therefore the volumes for December-March need to be correct as it reduces the available amount during the remaining of the contract year and leads to additional costs.

*Other fruits and vegetables*

For a large group of fruits and vegetables the volumes contracted need to be correct due to the limited availability of these ingredients after the season. Most of these contracts are closed in September, so before the new annual operational plan is made. The required volumes need to be correct to cope with poor harvests in an early stage. Further, the traceability of baby food ingredients is extremely important what makes it impossible to source additional volumes. These products are mainly produced at the factory of Latina and therefore out of the scope of this research.

### 2.2.3 Quantification of issues

| Group | # items | # locations | Future requirements | Price | Storage | Contracted | Impact | Horizon |
|---|---|---|---|---|---|---|---|---|
| Cocoa | 3 | 1 | Medium | High | Yes | Yes | Fin. | 3 Months |
| Fruits | 9 | 3 | Low | Medium | No | Yes | Fin. + CFR | 3-12 Months |
| Meat | 7 | 2 | Medium | High | No | Yes | Fin. | 3 Months |
| Mustard | 3 | 1 | Medium | Medium | No | No | Fin. + CFR | 3 Months |
| Oil | 6 | 2 | High | Medium | No | Yes | Fin. | 3-12 Months |
| Processed grains | 21 | 1 | Low | Medium | Yes | No | Fin. | 3 Months |
| Riboflavine | 6 | 3 | Low | Very High | Yes | No | Fin. + CFR | 3 Months |
| Sweeteners | 22 | 7 | High | Low | Some | Yes | Fin. | 12 Months |
| Tomato Paste | 8 | 5 | Very High | Medium | No | Yes | Fin. | 12 Months |
| Vegetables | 17 | 5 | High | Medium | No | Yes | Fin. + CFR | 12 Months |

*Table 2-3 Quantification of the issues*

| Future requirements | |
|---|---|
| Low | <500.000 |
| Medium | 500.000-1.000.000 |
| High | 1.000.000-5.000.000 |
| Very High | >5.000.000 |
| **Price** | |
| Low | <500 |
| Medium | 500-2.000 |
| High | 2.000-10.000 |
| Very High | >10.000 |

*Table 2-4 Quantification groups*

In Table 2-3 an overview is given to quantify the issues as faced by procurement, the different items were grouped together in the earlier mentioned groups. The table shows how many items from several sites are captured in a group. Further, the future requirements in SAP are shown and a qualification is given to the groups based on the price is shown. The scores are based on the information in Table 2-4. The storage column in Table 2-3 shows whether or not it is possible to store additional amounts of the ingredient. Mainly the items that are bough as bulk and stored in silos, and items that are bough fresh or frozen cannot be stored in big amounts due to the special requirements on the storage location. As not all items are bought on a contract basis this is shown in the contracted column. In the last two columns the impact of an incorrect forecast is mentioned, this could be only financial (Fin.) due to spot rate buying or financial and service level related (CFR) due to the limited availability of the material. In the last column the most important horizon is shown. For some this is 3 months as the short term volumes communicated to suppliers need to be right or because of short contract periods. For other items the horizon is a year and complete yearly volumes are contracted.

For sugar the regulations of the market will be changed from September 2017 as the regulations on the maximum sales volumes for suppliers will disappear. Therefore the contracted amounts become less important.

Improving the forecast accuracy should mainly focus on forecasting the total required volumes on tomato paste, vegetables and oils. All of these item groups are bought on a contract basis, cannot be stored easily and require a long term reliable forecast. Further, there are some item specific reasons why the focus should be on these item groups. Tomato paste due to the high requirements, impact on the business, and long lead times, therefore it is much harder to make last-minute changes in quantities and timing. Oils because spot rates are much higher, which results in higher financial consequences. The last focus group should be vegetables as this group of items has an impact on both service levels and cost. Furthermore there are circular relationships

between the items (as described by carrots), which can aggravate the problem as resources are limited during periods of the year.

## 2.3 Forecast Accuracy measurement

Currently the forecast accuracy is measured on a monthly basis. At the first day of a new financial month the actuals of the last month and the forecast for the next month are extracted from the SAP system. The forecast and the actuals are then mapped together to be able to calculate the delta between the forecast and actuals. The absolute value from the delta is taken and the forecast accuracy on this item can be calculated. Finance provides the business with a forecast accuracy report that shows the overall forecast accuracy of the Keystone sites and the forecast accuracy of all the individual sites. The formulas used are:

*Equation 2-1 SKU forecast accuracy*

$$R\&P\ Forecast\ accuracy_{ijt} = 1 - \frac{\left|FCST_{ijt} - ACT_{ijt}\right|}{ACT_{ijt}}$$

- i = SKU index i= 1,.., I
- j = factory index j= 1,..,J
- t = period index t=1,…,T
- $FCST_{ijt}$ is the inbound forecast lag-1 for item i at factory j for period t, so the forecast for June is extracted at the first day of May.
- $ACT_{ijt}$ is the actual amount of inbounds of item i at factory j in period t.
- The periods are months based on the fiscal calendar.

*Equation 2-2 Factory forecast accuracy*

$$R\&P\ Forecast\ accuracy_{jt} = 1 - \frac{\sum_i((\left|FCST_{ijt} - ACT_{ijt}\right|) * \mathrm{SP}_{ij})}{\sum_i(ACT_{ijt} * \mathrm{SP}_{ij})}$$

- i = SKU index i= 1,.., I
- j = factory index j= 1,..,J
- t = period index t=1,…,T
- $FCST_{ijt}$ is the inbound forecast lag-1 for item i at factory j for period t
- $ACT_{ijt}$ is the actual amount of inbounds of item i at factory j in period t.
- $SP_{ij}$ is the standard price of item i at factory j.
- The periods are months based on the fiscal calendar.

*Equation 2-3 Total forecast accuracy*

$$R\&P\ Forecast\ accuracy = 1 - \frac{\sum_j\sum_i((\left|FCST_{ijt} - ACT_{ijt}\right|) * \mathrm{SP}_{ij})}{\sum_j\sum_i(ACT_{ijt} * \mathrm{SP}_{ij})}$$

- The formula is similar to the other formulas but now the total of the forecast and actuals of all SKU's at all sites is calculated over a period.

As forecasts on a longer horizon are harder to make, the formulas explained in the last section (section 2.3) focus on the short term horizon. This horizon has been chosen to identify mismatches that happen on the short-term horizon. As the production jobs and demand are much easier to predict this report should be able to show the largest errors. A short term forecast error can be caused by incorrect parameters, some of these parameters are lead times, lot sizing rules, and stock levels. These incorrect parameters are much easier to identify on the short term, due to shorter forecast-actuals cycles. Changes made in the parameters should result in improvements after 2 months. To measure the impact on improvements on the long term it takes much more time to see if the improvement resulted in the expected improvements. Based on earlier mentioned formulas a report is generated on a monthly basis. While analyzing these reports, several mismatches between forecast and actuals were identified that were driving the low forecast accuracy on the short-term measurement. The provided data has shown that the material requirements did not match the actual inbounds in a specific time bucket. The current measurement shows that the biggest issues involve the production facilities 1, 2, and 3, as these factories contribute to around 75% of the error. When looking one layer deeper into the forecast error of these sites there are a few buyers portfolios that stand out due to their big contribution to the total forecast error of these sites.

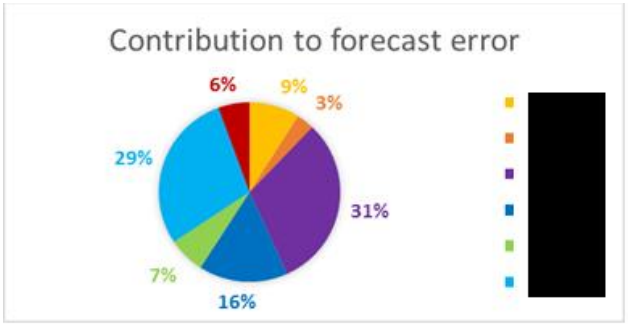


*Figure 2-3 Contribution of sites to total forecast error*

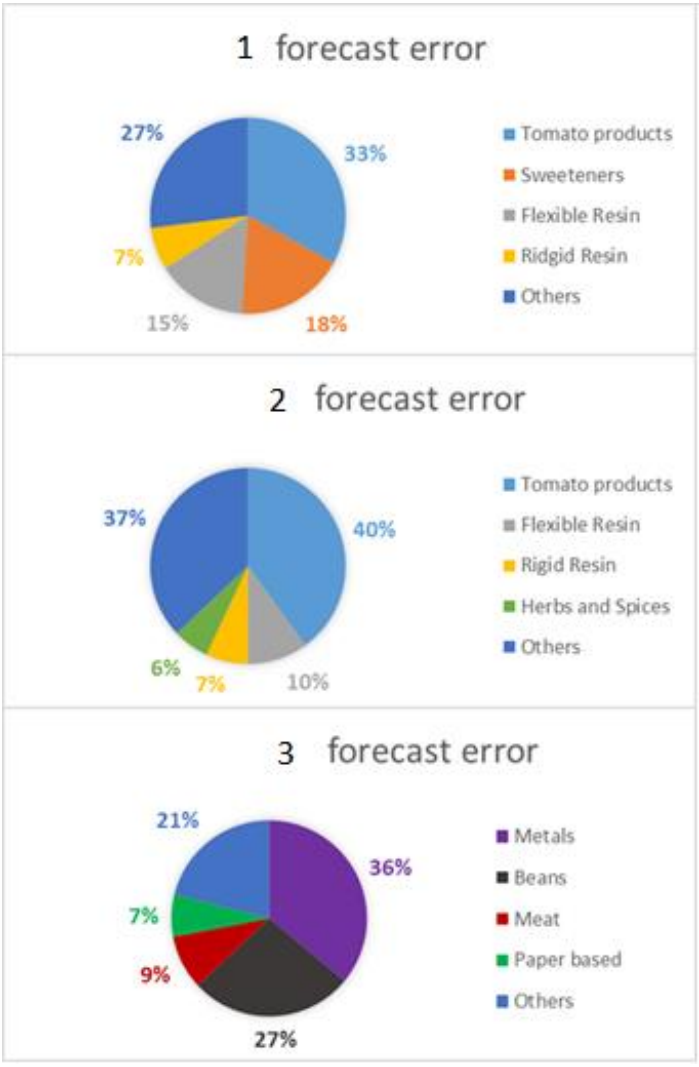


*Figure 2-4 Forecast error per site*

For location 1 the biggest driver of the forecast error is Tomato paste, followed by Sweeteners and the different types of Resin. In factory 2 the drivers are approximately equal to the drivers in location 1, only Herbs and spices is in the top 4 of site 2 and

Sweeteners is not. For factory 3 the biggest driver of the low forecast accuracy is Metals, followed by Beans. As these two portfolios cause more than 50% of the error of this factory, which contributes to 31% of the overall forecast this should be an area to focus on. The top 4 of this site is completed by the Meat and Paper based portfolios. In order to identify the root causes of the low forecast accuracy on these items, the different processes were studied.

Based on the issues described by the buyers their problem will not be solved by this measurement. The current report can help to analyze supplier's delivery performance, production plan stability in the last month, and inventory projections. The impact on procurement activities will not directly be improved by this measurement due to the short horizon and all the influencing factors on the actual inbound date that are not important for procurement. Therefore not only this short term measurement should be used to measure the forecast accuracy.

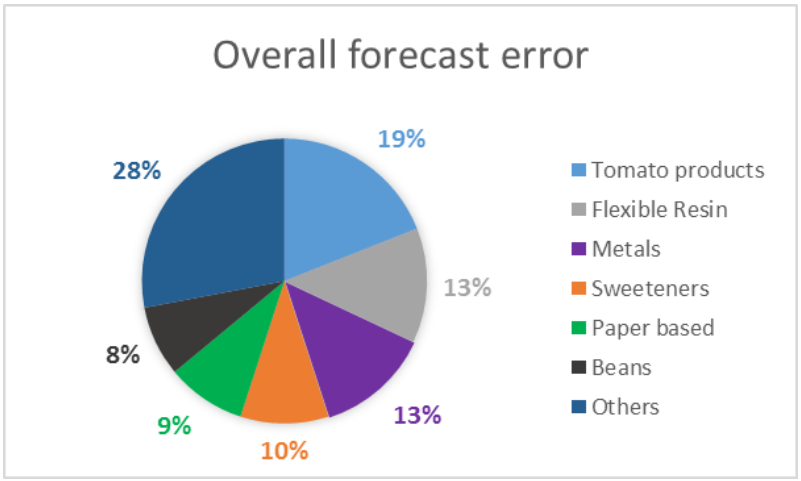


*Figure 2-3 Portfolio contribution to total forecast error*

### LONG TERM MEASUREMENT

Although the procurement issues are mainly related to the mid- and long term horizon, the current measurement focusses on the short term accuracy on a one month horizon. Even when the accuracy on the short term is close to 100%, the procurements issues can still be there as these decisions are made on a longer horizon. Therefore we analyzed the forecast accuracy on the mid- and long term horizon. Each month a forecast is generated, which made it possible to use historic forecasts from April 2015 until September 2015. The accuracy of these months on the different portfolios is shown in Table 2-5. From each of these forecasts the total requirements forecasted for the first 6 months of 2016 were compared to the actual inbounds over the same period. The outcomes are shown in Table 2-5. As can be seen in Table 2-5, the forecast accuracy on the mid- and long term horizon does not reach the target value of 70%.

| | April Fcst | May Fcst | June Fcst | July Fcst | August Fcst | September Fcst |
|---|---|---|---|---|---|---|
| Aseptic Cardboards | 25% | 20% | 17% | 19% | 14% | 12% |
| Beans / Pulses | 75% | 76% | 76% | 90% | 80% | 92% |
| Cartons | 34% | 35% | 61% | 38% | 62% | 58% |
| Corrugates | 39% | 43% | 45% | 46% | 49% | 52% |
| Dairy | 71% | 76% | 75% | 78% | 75% | 79% |
| Flexible Resin | 47% | 56% | 58% | 66% | 59% | 67% |
| Food Additives | 57% | 59% | 61% | 66% | 63% | 69% |
| Fruits / Nuts | 66% | 66% | 66% | 78% | 64% | 76% |
| Glass | 56% | 63% | 67% | 56% | 75% | 65% |
| Herbs,Spices&Misc. | 24% | 37% | 38% | 42% | 43% | 48% |
| Labels | 33% | 34% | 34% | 47% | 36% | 37% |
| Metals | 68% | 71% | 70% | 77% | 71% | 74% |
| Misc. Packaging | 12% | 18% | 22% | 32% | 18% | 16% |
| Oils & Fats | 61% | 63% | 64% | 70% | 66% | 74% |
| Potatoes | 41% | 42% | 73% | 39% | 73% | 74% |
| Processed Grains | 68% | 74% | 74% | 81% | 73% | 67% |
| Proteins | 56% | 63% | 41% | 54% | 64% | 75% |
| Rigid Resin | 51% | 52% | 54% | 65% | 55% | 61% |
| Starches | 61% | 66% | 62% | 75% | 68% | 76% |
| Sweeteners | 26% | 27% | 33% | 32% | 27% | 30% |
| Tomatoes | 42% | 51% | 51% | 72% | 56% | 71% |
| Vegetables | 53% | 56% | 52% | 72% | 56% | 25% |
| **Total** | **52%** | **57%** | **57%** | **67%** | **60%** | **66%** |

*Table 2-5 Mid- and Long term accuracy 2015*

Over the period April-September, all the forecasts show a total accuracy below 70% with an average of 59.8%, which is 10% below the targeted total accuracy on the complete range of items. The data shows that many packaging materials have a low accuracy. For the packaging issues this is less an issue as these materials are not bought on a strict contract basis and materials are easier sourced. When we identified the low accuracy on aseptic Cardboards, it was directly solved. In the Aseptic cardboard portfolio there are only Tetra Brik items from Alfaro, these items are bought on a VMI basis. Based on the production plan at Alfaro, the supplier makes sure that the stock levels are high enough to cover the production requirements. The supplier shares their delivery plans with the factory but this information is not updated in the SAP system. After identification of this issue the material scheduler in Alfaro started updating the forecast numbers.

## 2.4 Conclusion current situation

When the findings of this chapter are shortly summarized the issues as faced by procurement can be subdivided in two groups of problems, some are short term availability problems while others are more related to the mid-and long term range.

Based on the analysis made of the current way of working some conclusions are drawn.

***The demand forecasting process is performing above the target***

- The finished goods demand forecast does not seem to be the primary source of the low material requirements forecast accuracy. As opposed to the raws and packs forecast, there is much attention paid to the forecast of finished goods demand and the process of composing the production plan on the short term. It needs to be validated whether or not the current way the company generates a finished goods demand forecast is aligned with the solutions provided in the literature. Therefore literature on demand forecasting will be used in next chapter.

***There is no clear process around the generation of the raws and packs material requirements forecast***

- The current way the process is set up generates a mismatch between responsibility and ownership. There are no checks in the process whether or not the system is ready to provide the R&P forecast. In this way the forecast provided can give an incorrect indication of the future perspective as the forecast can be extracted before the production plan is correct in the system. An extraction of the R&P forecast before the production plan is ready can lead to incorrect decision making in other parts of the business. This finding needs to be taken into account when developing a solution.

***The current vendor forecast performs well for some items and poor for other items. This might be caused by incorrect inputs in the MRP process.***

- The data in SAP shows errors in the reporting and system parameters, which are not filtered out of the forecast. The main problem does not seem to be the MRP model, it is more probable that incorrect inputs drive the poor system performance. The literature study provides insights on which parameters play an important role and should be set correctly to provide the best material requirements forecast.

***The performance measurement currently used at the company to measure the short-term forecast accuracy, does not provide direct information if there will be procurement issues or not.***

- The current way of measuring forecast accuracy helps a lot in identifying incorrect input parameters and special processes that cause a mismatch between the actual and the forecasted inbound amounts and timings of raw and packaging materials. These settings are important to provide the business with a detailed vendor forecast but due to the short term focus of the measurement the KPI does not provide an answer on the accuracy of the mid-long term forecast. Further, the contract status is not taken into account and the contract status is not an input for the supply planners while generating the production plan.

***In the current Situation the Raws and Packs forecast accuracy is approximately 60% on the total range of items, 10% below the targeted accuracy of 70%.***

- The target of 70% was set for the R&P material requirements forecast. The current accuracy is around 60% so improvements need to be implemented to bridge the gap of 10% between the targeted level of accuracy and the current level.

***The improved situation at the end of the research should be able to:***

- Provide a stable long term total material requirements forecast on the mid-long horizon (3-12 months). The accuracy of this forecast should be target of 70%.
- The short term forecast (next month) should have an accuracy of at least 70%. This because of phasing issues and due to strict monthly volumes on specific ingredients.
- A measurement needs to designed that is able to identify situation were the current contracted material requirements do not cover the expected requirements over the period.

In the next chapter the literature is analyzed to see if the current demand forecasting process is set up in line with the literature. Because the material requirements forecast is a dependent forecast that depends heavily on the finished goods demand forecast the demand forecasting process is verified. The application and execution of an MRP system needs to be described and the input parameters that can influence the process will be identified in the next chapter.

# 3 Literature review

As the company is active in the food and beverage industry, quality and safety are key issues. As mentioned by Bourlakis and Weightman (as cited by (Eksoz, Mansouri, & Bourlakis, 2014)) the fact that the Food Supply Chain has a purpose to guarantee healthy and safe products where the process is completely traceable from farm to fork, it is different from other supply chains. A key concern in the forecast is the short shelf life of perishable and seasonal products where substantial effort is required to keep product freshness and shelf availability (Eksoz, Mansouri, & Bourlakis, 2014).

The MRP Production planning system as composed by Enns (2001) and shown in Figure 3-1, is the basis for this chapter. This chapter takes a closer look at the process of generating a raws and packs material requirements forecast (Order Release Plan in Figure 3-1). Section 3.1 addresses the demand forecasting process. The next section, Section 3.2, explains how the Master Production Schedule is converted into Material Requirements Plan and Section 3.3 zooms in on the input that the system requires next to the demand forecast and production plan. The conclusions of this chapter are formulated in Section 3.4.

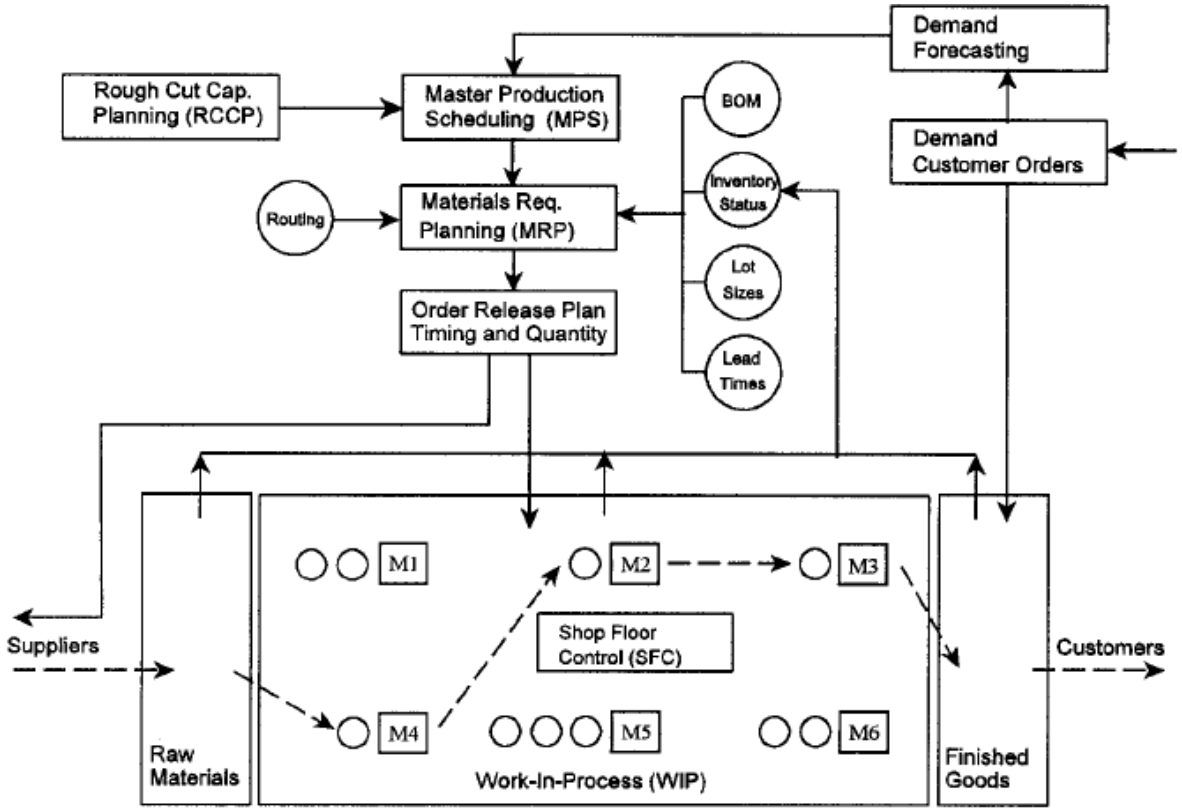


*Figure 3-1 MRP production planning system (Enns, 2001)*

## 3.1 Customer orders and demand forecast

The raws and packs material requirements forecast tries to forecast dependent demand. The material requirements depend on the number of finished goods produced, which depends on the finished goods demand in the different markets. There are different demand forecasting models described in literature, the most basic model is the moving-average forecasting method. This method takes the average of

the last N periods of demand and takes that number as the forecast for the next period. This forecasting method works best if the demand fluctuates around a base demand level, when demand patterns become lumpier the performance of the model decreases. Next to the moving average model an exponential smoothing model can be applied to forecast finished goods demand. By making use of a smoothing parameter this model gives a weight to the most recent demand. The formula used to generate a demand forecast for period t can be based on the demand over the periods before t (Winters, 1960).

Holt developed exponential smoothing with a trend, this forecasting model works best for linear patterns where a base level and a periodic trend are visible. After every period the base forecast and the trend can be updated based on the new realized values. Also seasonal trends can be taken into account in an exponential smoothing model. Then the length of the seasonal pattern and the impact of the season need to be known (Winters, 1960).

As proposed by Lamouri and Thomas (2000), the finished product at the top of the BOM should be replaced by a product family on which commercial forecast is determined. At the company the forecast is generated on a Commercial Product Code, afterwards it is converted into requirements on an EPN level. At the company a base demand forecast is generated based on historic demand patterns and the trend, and afterwards an historic based over layer is added to add the promotional demand forecast. As the finished goods demand forecast is above the targeted accuracy level of 70%, the focus of the company is not on improving the finished goods demand forecast. Further, the companies way of forecasting the finished goods base demand is aligned with Kekre's (1990) analyses on how a finished goods forecast should be generated. First a statistic base demand forecast is generated based on historic demand patterns and the trend, a promotional demand over layer is added and the forecast for the next periods is generated. Finally errors in the finished goods demand forecast do not have to propagate into errors at the components level (Ho & Ireland, 1998). This is because safety stocks at the finished goods level, lot-sizing rules and safety stocks on the material levels can absorb errors. The focus should not be on redesigning the finished goods demand forecasting process as this is in line with the findings in literature.

If the company decides to target a higher finished goods forecast accuracy, improvements in the quality and accuracy of the demand forecast can be reached by investing in the collection of information regarding the purchase plans of large customers. This information can lead to substantial improvements of the performance of the supply chain (Kalchschmidt, Zotteri, & Verganti, 2003). As most peaks in demand at the company are generated by a small number of large customers, the costs related to collecting the information should be low (Kalchschmidt, Zotteri, & Verganti, 2003).

## 3.2 MRP planning

In order to convert finished goods demand into the material requirements, planning activities are used (Kekre, Morton, & Smunt, 1990). A frequently used planning activity is Material Requirement Planning (MRP). For a given time horizon the goal of the MRP system is to generate a material replenishment schedule for the given horizon. This schedule is generated based on the finished goods requirements, the lead time and the Bill of Materials (BOM). The BOM can have a one-level or multi-level structure. A one-level structure means the products is directly assembled from (several) components (multi-item), see Figure 3-2. A multi-level structure consists out of several assembly levels and subassemblies, see Figure 3-3. At the company most BOMs have a multi-level structure with several semi-finished products.


*Figure 3-2 One level BOM structure*

Based on Dolgui and Prodhon (2007) the MRP approach works based on inputs from the master production schedule. In this way the material requirements for the raw and packaging material are calculated and time-phased orders are released based on the lead times in each stage of the BOM (Enns, 2001). So based on the finished goods demand, stock levels and lead times, the material requirements for each period are calculated.

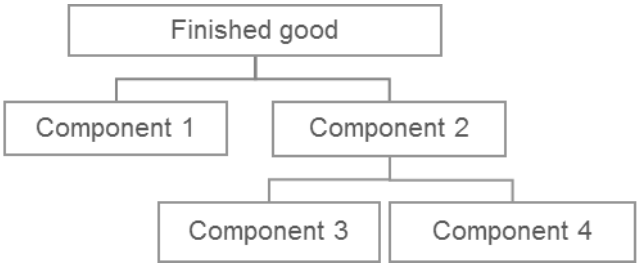


*Figure 3-3 Multi level BOM structure*

As the master production schedule is used for material requirements planning, frequent changes in the production plan lead to schedule adjustments in the system (Tang & Grübbström, 2002), called system nervousness (Kadipasaoglu & Sridharan, 1995) (Sridharan & La Forge, 1989). The magnitude of the nervousness might even increase due to lot-sizing effect (Sridharan & La Forge, 1989). Nervousness in the MRP system can have different causes, freezing is used to reduce the nervousness of the system (Zhao & Lee, 1993) (Shridharan, Berry, & Udayabhanu, 1987). For multi-level MRP systems, Zhao and Lee (1993) investigated the impact of freezing the master production schedule on total costs and schedule instability (Zhao & Lee, 1993). The frozen period equals the number of periods of the production schedule for which no changes are made anymore and the schedules are implemented according to the original plan (Zhao & Lee, 1993). The higher the frozen period proportion of the planning horizon, the lower the nervousness (Zhao & Lee, 1993). On the other hand it might increase the amount of stock-outs due to a lower responsiveness.

Based on Dolgui and Prodhon (2007) the MRP logic provides an optimal just-in-time schedule in a deterministic environment. For a stochastic environment, as it is at the company, correct parameters need to be set. Therefore the next section addresses the input parameters that have the biggest impact on the performance of an MRP system.

## 3.3 Input parameters

In the MRP process several input parameters are used. The uncertainty in the finished goods demand impacts all the layers as due dates of the finished goods requirements might change. Further, lead time uncertainty can lead to problems when the planned lead time is different from the actual lead time and materials do not arrive at the right time. (Dolgui & Prodhon, 2007)

To deal with uncertainties several parameters should be set correctly as these parameters can influence the uncertainty. Correct settings of these parameters are important as these parameters, when set incorrectly, can aggravate the impact of the uncertainty. Parameters that are often mentioned in literature, and will be described in the remaining of this section are:

- Safety stocks
- Safety lead time/ planned lead time
- Lot-sizing rules
- Planning horizon

### Safety Stocks and Safety lead time

Safety stocks are used to minimize the costs of shortages but increase the holding costs. A tradeoff needs to be made to find the optimal amount of safety stock to guarantee a certain service level and at the same time keep holding costs low. Next to safety stocks, safety lead-time can be used, in this case the lead time is corrected based on k times the standard deviation of the lead time. Based on Ho and Ireland (1998) safety stocks should be used to cope with uncertainties in quantity and safety lead time should be used to cope with lead time uncertainty.

### Lot Sizing rules

Another parameter that has a big impact on the performance of the MRP system is the lot-sizing rule that is used. Several lot-sizing rules are described in literature and can be applied. The period based balancing rule, economic order quantity, Wagner-Within algorithm and Silver-Meal heuristic are mentioned several times. At the company there are different lot sizing rules applied, most items use a period lot sizing rule, which combines the uncovered requirements in a period in combination with a lot-for-lot rule. As an addition to these rules a minimal order quantity is used as a threshold, this MOQ value is the minimal amount of an order. Based on the planning calendar the required amount for the period is determined, if it is below the MOQ threshold an MOQ amount is ordered and otherwise the actual requirements are ordered. So if for example an MOQ equals 2 pallets it is not possible to order less than 2 pallets.

Because the material requirements are driven by planned end-item orders, the requirements are often lumpy (Kadipasaoglu & Sridharan, 1995). At the company lumpy patterns are also created as a result of the MOQ threshold. If demand stays constant, bigger order quantities result in less orders and a lumpier pattern. If the difference in demand between periods is large, these items have a lumpier demand than when the demand pattern is flat (Ho & Ireland, 1998). MRP system performance is impacted by the selection and use of a lot-sizing rule (Ho & Ireland, 1998) (Zhao & Lee, 1993). An inappropriate rule can aggravate the impact on the schedule when

small changes are made. This happens when a small change triggers a bigger change as the rule works with larger batch sizes.

PLANNING HORIZON

As the system is set up to minimize the costs over a period of time in the future there needs to be a planning horizon for which the requirements are generated. The end of the horizon should be rolling based on a certain frequency. Due to the dynamic nature of the demand and production planning, data should be updated periodically, this period is the replanning frequency. The company works with a rolling horizon as is proposed in literature, at the same time this rolling horizon is a source of nervousness. When a new period with demand is added, this demand triggers new production batches, which were not there before (Kadipasaoglu & Sridharan, 1995). These new batches can impact earlier planned production batches. Even when demand is known this is a source of instability (Sridharan & La Forge, 1989).

## 3.4 Conclusions

The literature that has been used in this chapter leads to the following conclusions.

***The finished goods demand forecast at the company is generated in line with what literature proposes.***

- The company works with a base forecast that takes trends and seasonality into account in order to forecast the demand in a period. If the company wants to improve the forecast accuracy on the finished goods demand they should start intensive information sharing with their customers.

***The production plan is an important input to determine the MRP material requirements and needs to be correct.***

- Based on Figure 3-1 the MRP forecast relies mainly on three types of information: The demand forecast, the production schedule and the input parameters. Due to the dependency of the material requirements on the production schedule it is important that the production schedule represents the most recent plan and information.
- The production plan is an important source of information to generate the material requirements forecast. For that reason the process around generating the material requirements forecast needs to be set up correctly to make sure that the MRP system uses the most up to date information.

***Incorrect input can have a big influence on the performance of the MRP system***.

- Due to all the uncertainties in the quantities and timing of demand, input parameters and information need to be correct in order not to aggravate the uncertainty.
- Important settings that need to be set correctly are:
  - Safety stocks
  - Safety lead time/ planned lead time
  - Lot-sizing rules
  - Planning horizon
  - Freezing the MPS
- In the next chapter these input settings are addressed and solutions are proposed on how to improve the forecast accuracy by improving the input.

# 4 Solution design

In this chapter, insights from the literature are applied to solve the issues as faced by the procurement department of the company. We address the issues and propose solutions for the different processes and inputs required to generate the R&P material requirements forecast. Based on the different process stages, different solutions are proposed. We start with the MRP forecast in Section 4.1, where improvements in the demand forecast, production planning process, bill of materials, and the stock levels and safety stocks are discussed. Then Section 4.2 present improvements that can be implemented in the process where the material requirements are transformed in the Vendor forecast for procurement. Section 4.3 focusses on the short term stability as this is the moment that procurement takes actions to solve mismatches between forecasted and actual requirements. The freezing method and lead times are discussed in this section. Section 4.4 zooms out to the total process of generating the Vendor forecast and how this process can be improved. The conclusions of this chapter, on how the MRP process at the company can be improved in order to increase the Raws and Packs forecast accuracy, are formulated in Section 4.5.

## 4.1 MRP forecast

The process of generating the MRP forecast, which is used as a basis to compose the Vendor forecast, depends for a large part on the finished goods demand forecast. Therefore this section starts with the demand forecast. Based on the demand forecast the production plan is generated and then the Bill of Materials is exploded to generate the material requirements. Based on the current stock levels, the additional requirements are determined. In this section, we will go through several improvements in these stages of the process.

### 4.1.1 Demand forecast

The Raws and Packs material requirements forecast is a dependent forecast, which takes the finished goods demand forecast as the initial source. Every error in the demand forecast can be transferred though the different processes and may generate issues at the R&P material requirements forecast. By using lot sizing rules and safety stocks, it is possible that forecast errors on the finished goods demand forecast will not be transferred to the raws and packs requirements. This is because safety

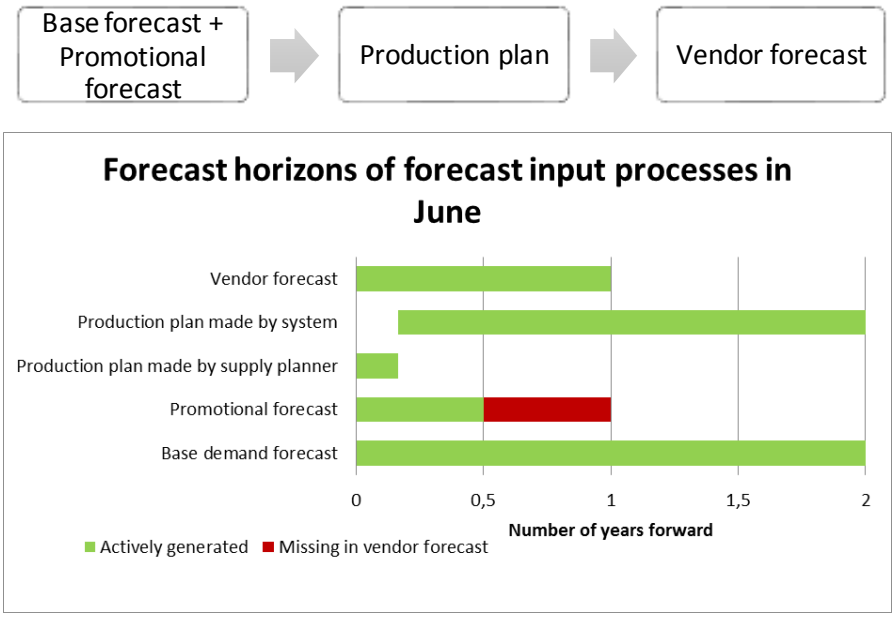


*Figure 4-1 Forecast horizons*

stocks or lot sizing rules can absorb the error and reduce the impact on the raws and packs material requirements.

### PROMOTIONAL DEMAND FORECAST AND CONTRACTING PERIOD

As shown in Section 2.1, and repeated in Figure 4-1, the planning horizon is not the same for all the processes. This difference in horizons does not have to be a problem if the horizon at the beginning of the process is the longest and from there it decreases at every step. But at the company a problem arises because the promotional forecast has the shortest horizon and is in the core of the process. Most processes use rolling forecast horizons but the finished goods promotional forecast uses a forecast until the end of the calendar year. From September onwards the new full year is added. This results in differences in the mid- and long term material requirements forecast as approximately 20% to 30% of the total finished goods demand consists of promotional demand. Figure 4-2 shows the total forecasted volume for the calendar year 2017. During each month in 2016 the requirements forecast, of each SKU, (calculated in €) was provided for the next year (2017). The total requirements over the full year 2017 are shown in the graph. The graph shows that the forecast increased a lot in the period September-October. This increase is related to the fact that the new annual operational plan (AOP) is made and the promotional forecast for 2017 is added. Further, this is the period that the company prepares the next year and therefore more attention is paid to parameters settings and input accuracy.

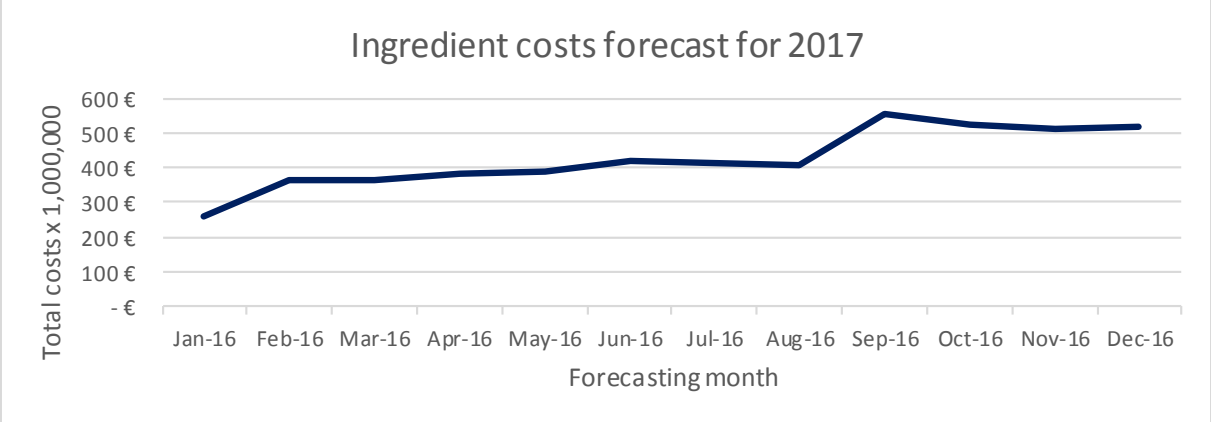


*Figure 4-2 Costs forecast for 2017 generated in 2016*

Procurement closes contracts at all times during the year as contract negotiations are not related to any period or moment. If it would be possible to contract all the ingredients shortly after the Annual Operations Plan has been made, the volumes are much more reliable than when contracts are made based on information available before the AOP plan. The other option is that the accuracy of the forecasts during the complete year needs to be improved, as current contract decisions are made based on the information available at the time of contracting. Due to the decreasing promotional forecast horizon as the year is progressing, contract decisions are made based on incomplete information. The volumes forecasted during January-September do not represent the total requirements for 2017, as there is no promotional demand in the forecast. Procurement is not aware of the reason why the requirements suddenly increase a lot and built their plans before the final AOP numbers are published. The

increasing forecast can have a big impact on the contracts, because if contracts are based on the smaller volume forecast until August, agreed quantities are too small. Instead of adding the complete next year's promotional demand forecast in October, the promotional demand forecast should have a rolling horizon of at least one year. The promotional forecast is built based on available information from the markets in combination with historic promotional patterns. The demand planners are able to add a full year promotional forecast in October, on a horizon of 15 months. Therefore it is would be good to add one more month of promotional forecast each month. This means that instead of adding 12 months of forecast in October the demand planners need to add one month, each month, on at least a horizon of 15 months. The rolling promotional demand forecast horizon will improve the long term material requirements forecast a lot as a large part of the finished goods demand is missing in the input of the MRP process.

### 4.1.2 Production planning and forecast generation

As became clear in Chapter 3, the master production schedule has a direct link to the material requirements planning. As shown in Section 2.1 the production schedule is generated in the first week of every financial month. As the material requirements forecast is generated by the BOM explosion on a set moment in time, Thursday week 1. It is possible that the production plan is not finished or there might be different other errors in the production plan that need to be solved before the MRP material requirements forecast is generated. Sometimes the night batch update did not work correctly, which caused incomplete information in the material requirements forecast as the data from Tuesday week 1 is used while many changes were made on Wednesday. Therefore a process should be established that captures the status of the system and go/no go decision points need to be introduced in the process. The process can be organized with checkpoints as shown in Figure 4-3, where the decision point is newly implemented in the current process. As long as the production plan is not finished for all the factories the R&P material requirements forecast should not be extracted because the information spread in the business can contain incorrect or incomplete information. If procurement buys additional volumes at spot rates while the forecast was incorrect costs are made to buy ingredients that are not required.

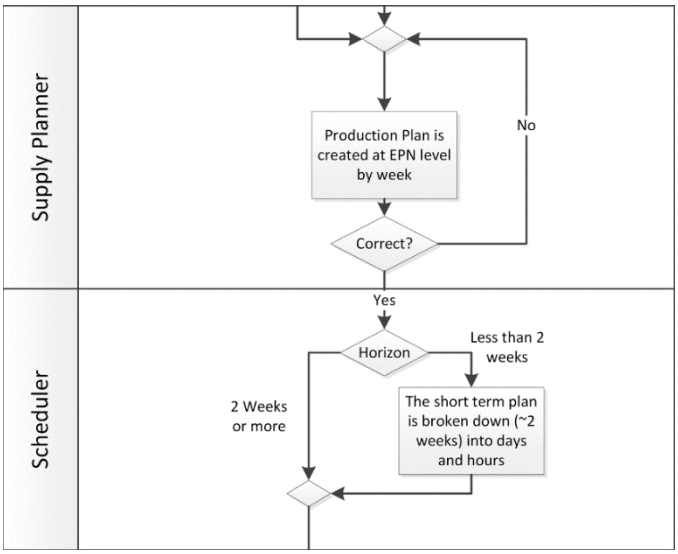


*Figure 4-3 Plan check in process flow*

#### CROP PROCESS

Next to this general change that needs to be made there is a specific group of materials where more process changes need to be made. This group of ingredients are the crop vegetables. These items are only available during the season and need to be

processed as soon as possible due to the short shelf-life of these ingredients. For most of the ingredients the requirements are based on the requirements of the production batches that are planned. For crop ingredients the process is a bit different as production is driven by the crop and not by demand, as the crop season is only once a year these production runs have cycles of 12 months. Because crop ingredients need to be processed as soon as the ingredients are delivered to the factory, other production batches have to be delayed. Due to the high dependency on the weather, the inbound dates of these ingredients are hard to forecast. Therefore the material scheduler places all the inbounds at the beginning of the season. The production planner does the same and schedules one big production run at the beginning of the season. If this capacity is not used for the crop batches, alternative production batches are run on the line and the crop batches are not re-planned. This way of working causes forecast errors on all the items that are related to the crop ingredients or alternative production jobs. All the requirements for the crop batches are placed in the month where the first production job is planned. For the alternative production jobs it works the other way around. If there are no production batches planned in the period there are no material requirements generated and it is not shown in the Vendor forecast.

### FORECAST GENERATING PROCESS

In order to solve a large part of the forecast errors, and to provide procurement with a more realistic plan the way of working needs to be changed and therefore the process as shown in Figure 4-4 can be implemented. This process needs to be executed every month starting from 3 months before the first crop ingredients are harvested. At this point in time the material scheduler needs to review the expected crop inbound dates and the requirements for the alternative jobs. As crop inbounds are currently not replanned, these inbounds are planned in the past and dissapear from the forecast. At the same time, alternative jobs are brought forward but the requirements are still forecasted at the original time planned althought the total requirements can be the same the phasing does matter as well. For these crop ingredients there will always be a larger extent of uncertainty than for the normal ingredients, but without replanning these requirements can dissapear completely from the forecast, which causes large errors due to the large amounts of the crop ingredients. A percentual division over the months based on the expected harvest time would not solve the issue as the requirements should be corrected on a short term horizon to the most recent expectations. In the current situation the requirements forecast is not updated and therefore it is possible that orders are planned to arrive in July, but due to the weather conditions the crop ingredients did not arrive when the end of July is reached. In the current situation these POs are not replanned and the stock is expected to arrive tomorrow. These POs need to be replanned because the monthly requirements for all the ingredients related to the crop batches or the alternative production jobs are not correctly shown in the raws and packs material requirements forecast. The material schedulers are in close contact with the suppliers and are able to make a realistic estimation on when the crop ingredients will be delivered to the factory, based on the input from material schedulers they are able to review the inbound dates around 3 months before the expected inbound. Therefore the process is designed to start reviewing the inbound dates 3 months before.

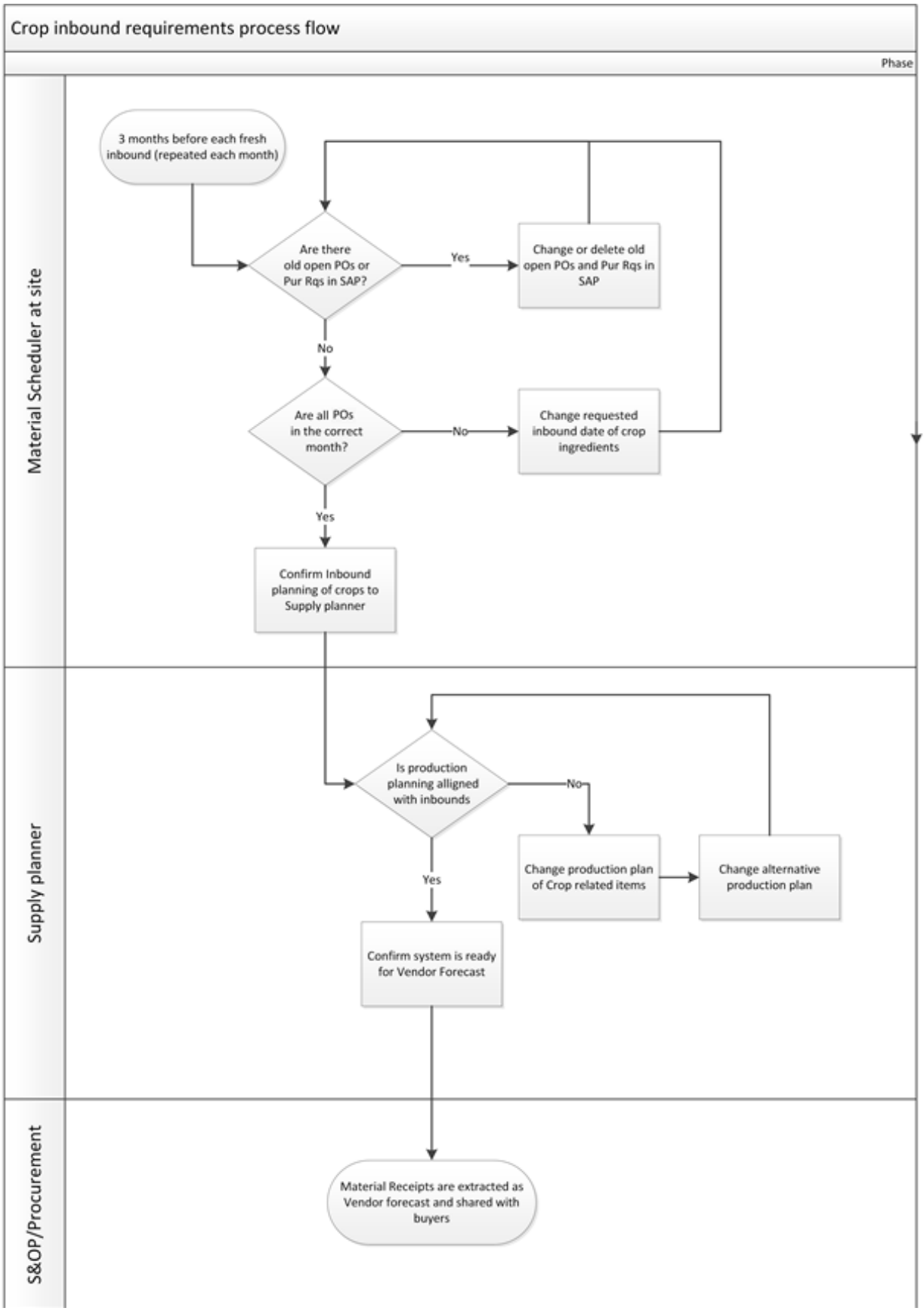


*Figure 4-4 Crop process flow*

### 4.1.3 Bill of Materials and NPD process

The BOM is the link between finished goods production and raw and packaging material requirements. New product development (NPD) is an ongoing activity where new products are added to the company portfolio. When the decision has been made that an item will be launched, the item needs an product code, until this EPN code is in place the item gets a dummy code. In this way production jobs can be planned and capacity can be reserved. At the last stage before the launch, a product gets in status 5, which means that product is ready but not activated. Until the BOM is activated the BOM is not exploded and there will not be any material requirements.

#### NPD PROCESS

When a new product is going to be launched, there is no known EPN. As there is a demand forecast for these items the finished goods demand forecast is placed on a dummy item code. This dummy item code is also used for production planning as capacity needs to be reserved to produce the items on a longer horizon. As the BOM will only be set up for the real product code, and not for the dummy codes, there will not be a BOM explosion as there is nothing to explode. As a result the material requirements for these new items are not generated, which leads to zero material requirements for these items. As the business recognizes this loss of information a new way of working was tested to generate material requirement for the dummy items to incorporate these material requirements in the annual operational plan. As most new items are similar to existing items (new packaging formats etc.) the dummy codes were mapped to the existing items. As a result of mapping the dummy items to existing items, the existing BOM could be exploded. The material requirement for the dummy items and the items in status 5 were generated by an offline BOM explosion, in this offline explosion, lead times were not taken into account. In the end the material requirements were manually added to the material requirements forecast.

The total volume increased with 3% as a result of the dummy and status 5 related demand, as can be seen in Table 4-1. The 3% increase of the material requirements represents a total increase on the material costs of around €20 million. The value of the dummy and status 5 requirements were calculated based on the required amount and the standard price of each item.

| October 2016 | Volume | Percentage |
|---|---|---|
| Current | 5,664,177,102 | 100% |
| Incl. dummy & status 5 | 5,849,092,479 | 103% |

*Table 4-1 Annual volumes with and without Dummy and status 5 requirements*

Although the total impact is relatively small, the impact on individual items is much bigger, especially the ingredients that are not used for a wide range of products show big increases. Some examples of items where the requirements over 2016 where really influenced by the dummy and status 5 requirements are:

- Garlic powder + 11%
- Potatoes + 7%
- Organic sugar + 47%
- Organic vinegar + 50%

- Rapeseed oil + 57%
- Molasses + 8%

Most of the items that show the biggest increases are the special items like the organic ingredients. This is also the biggest problem as these items are specific and cannot easily be replaced by other ingredients while the contracts are as specific as all the others.

As this action, to explode the BOM for the dummy and status 5 items, was executed as a one-time action for AOP, the requirement that are related to the dummy status 5 items are missing in all the other R&P material requirements forecasts. Therefore the BOM should be set up and activated earlier or the new products should be mapped to existing BOMs to be able to generate material requirements for the new products. As it is possible to add validity periods to the BOM these can be set initially and changed afterwards when the final BOM is available.

### 4.1.4 Stock levels and safety stocks

As explained in Section 3.2 the net requirements are determined based on the demand in combination with the available stock. The expected stock levels at a specific moment in time are calculated by adding the current stock level and the expected inbounds until that moment, reducing this number with the demand will give the expected stock level. A problem arises if overdue purchase orders (POs) are not deleted from the system when they will not be supplied. This can happen when there are problems at the supplier or when the company decides to cancel the order. This means that purchase orders with an historic delivery date are not deleted from the system. SAP assumes that all the overdue POs arrive tomorrow and takes these deliveries into account when calculating the material requirements for upcoming periods. Without replanning the delayed deliveries there can be short term shortages and if POs need to be canceled the complete forecast generated is biased. If there are many old open POs in the system this generates noise in the R&P material requirements forecast. These orders are taken into account in the stock levels but will not be delivered. In October there were open POs in the system that represented a value of more than €475.000. The spread over the different sites can be seen in Figure 4-5.

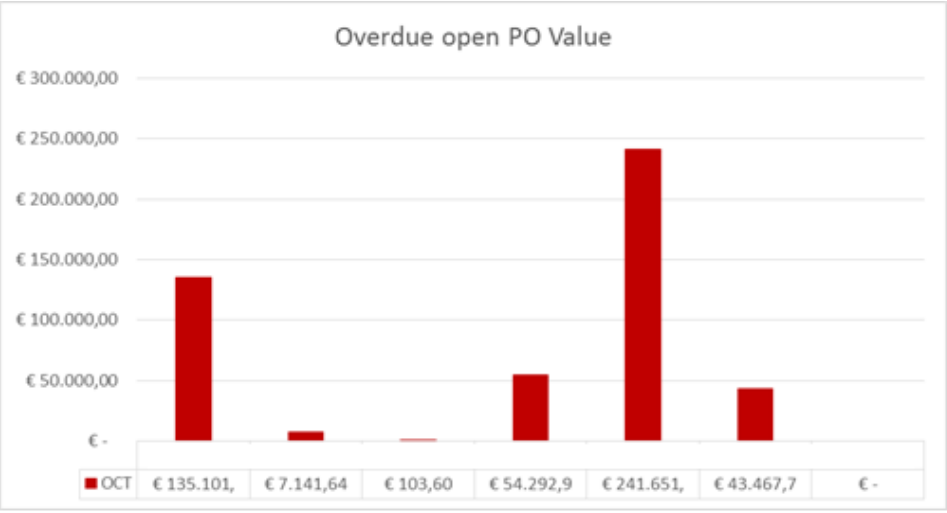


*Figure 4-5 Overdue open PO value October 2016*

Due to the effect of overdue open POs, the POs need to be updated in SAP, when orders are delayed the orders need to be re-planned and if the orders are canceled they should be deleted from the system. This should be done on a monthly basis. Every time the R&P material requirements forecast is generated the system should be clean from overdue POs. The same should be done with overdue purchase requisitions (Pur Rqs).The difference between a purchase order and a purchase requisition is that SAP generates purchase requisitions and when a material scheduler confirms such a purchase requisition it becomes a purchase order. Because this step should be integrated in the process of preparing and generating the raws and packs material requirements forecast this solution will be added to the forecast generating process solution group.

## 4.2 Procurement Vendor forecast

After the R&P materials requirements are generated the requirements for the different periods are combined with order lot sizing rules to generate the Vendor forecast. During this step the R&P material requirements are changed by lot sizing rules to form an inbound/ procurement forecast. The impact of the lot-sizing rule can be different for the different raw and packaging materials therefore the next section addresses the impact of the lot-sizing rule used at the company.

### 4.2.1 Order Lot-sizing rules

As mentioned earlier, ingredients are ordered based on the planning calendar, which determines the delivery moments, and indirectly the order moment and quantity. Next to the planning calendar, the company uses Minimal Order Quantities for many materials, this is a minimal threshold for the quantity that can be ordered. If the requirements are less than one MOQ only the MOQ will be ordered. For several items there is also an incremental OQ/rounding value in place. This means that an order should consist of an integer times the incremental OQ, every time the order quantity is above the MOQ threshold. It could for example be that the MOQ of a specific material is equal to 4 pallets and the incremental OQ is 1 pallet. In this case it is possible to order 4, 5, 6, etc. pallets but 5.3 pallets is not possible. As MOQ values mainly influence the items with low volumes and the items with a lumpy demand the MOQ value should be set correctly, otherwise it can negatively impact both the forecast and the costs.

#### INCREMENTAL ORDER QUANTITY OF OIL

For some types of oil at two factories the MOQ and incremental OQ settings were not correctly entered in SAP. For the different types of (bulk) oil there is an MOQ in SAP that equals one tank truck but there is no incremental OQ in the SAP system, without this incremental OQ the system was forecasting 1.1 trucks for some months although this is impossible. To correctly forecast the requirements for procurement, the settings in SAP need to be updated with the correct incremental OQ.

#### MOQ REDUCTION AND DEFINITION

Internally the company uses a policy that does not allow MOQs higher than 3 months of requirements, or the shelf life of the material. There are several reasons why this policy is in place, the most important reason is that marketing can decide on a three months' notice to discontinue a finished goods item or to change a recipe. If this

happens the stock remaining after the discontinuation of the product needs to be written off. For this reason the policy does not allow MOQs that cover more than three months of requirements. As mentioned earlier, an MOQ will be ordered as the requirements are less than an MOQ. If the requirements are a little bit more than a MOQ value, an MOQ will be ordered and the next MOQ will be ordered when the re-order point is reached again.

As there are many items used in the production processes of the company and all these items have their individual MOQ and shelf life, we built a report to measure the MOQ coverage, an impression of this report is provided in Appendix A. As the MOQ is not allowed to cover more than three months of demand at any time, the report has been built on the forecasted material requirements for the next year. The 2017 forecast from November 2016 has been used as in this forecast both the base demand and the promotional demand are included. The time it takes for an MOQ to be consumed is calculated for each month with requirements. Based on the requirements, it is calculated how long it takes to use an MOQ order. The depletion time is the number of months it takes to use the stock. For every month the total 3 months requirements are calculated by adding the demand in the current month and the 2 following months. Every time the stock depletion time is above 3 months it causes write off risks. As requirements can fluctuate over the year only the items that consistently cover more than 3 months of requirements should be identified. Together with the strategic materials planner (who coordinates many projects around raws and packs from a S&OP perspective), the decision has been made that structurally out of policy MOQs, are the MOQs that are out of policy in 6 or more of the 12 measurements (based on 14 months requirements forecast). In the reports generated in the months October-December 2016 there were between 330 and 360 items that have MOQs constantly covering more than 3 months of requirements. These items contributed to a total maximum risk exposure of around €1.5 million at any time. Based on the material requirements forecast in combination with the policy restriction the report proposes a new MOQ value that is in line with the policy and shows less risks.

Reducing these high MOQs will result in less lumpy demand patterns on these ingredients, which provides the buyers with a better forecast and more insights in the actual requirements. The reduction on the different materials goes from several percentage points till reductions of more than 90% of the MOQ. In situations where the MOQ should be reduced by more than 90% to be in line with the policy the current MOQ covers several years of requirements. There are different reasons why the company works with these high MOQs at the moment. The most important reason is that the demand forecast on many items is decreasing the last years. This means that the total required volumes go down, but due to the MOQ restriction on the forecast the buyers only see that the requirements are equal to one or two MOQs and they are not aware of the actual requirements, which might be only 1.3 MOQ a year. As these high MOQs result in higher holding costs and might result in write-off costs the company decided to introduce the maximum MOQ coverage of 3 months. With the new report we built, the buyers are able to see how much they should decrease the MOQs and can make a decision on the tradeoff between the additional costs to agree lower MOQs, and the holding- and write-off costs.

Next to the MOQs that cover more than 3 months of material requirements there seem to be different interpretations of the MOQ value. As the MOQs are put in the SAP system by the material schedulers at the production locations, their understanding of the MOQ value is important. As the company buys the ingredients on a DTP (Duties and Taxes paid) basis the transport is arranged by the supplier, a part of these agreements is that the supplier only should ship full truck loads to save costs. Some ingredients are supplied by the same supplier, in this case there can be mixed loads when shipments of individual material requirements are less than full truck loads.

When the material scheduler at a production location orders different materials at the same time at one supplier, the total amount should equal a full truck to reduce the transportation costs, but the amount of each item may differ from the MOQ. For these mixed load shipments there are different explanations of the MOQ used in the company. The explanations used are:

- The MOQ is the minimal quantity that needs to be ordered of the individual SKU, this can be several pallets. The shipment needs to be combined with other shipments to form a full truck load.
  - Example (Figure 4-6): A truck has a total capacity of 3 pallets, for the supplier it does not matter if these are pallets with the same items but the supplier only supplies full truck loads as agreed in the contract with the company. So the minimal order quantity for one products is 1 pallet and it needs to be combined with other products to fill a complete truck.

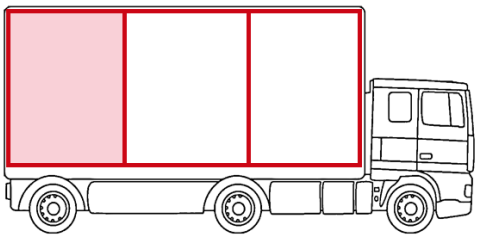

*Figure 4-6 individual MOQ*

- The MOQ on each material equals a full truck load but can be decreased by mixing different material requirements into one delivery.
  - Example (Figure 4-7): The truck still has a capacity of 3 pallets. The supplier only ships full trucks based on the contract so the minimal order quantity for each product is 3 pallets. Shipments can be combined but the system plans with an MOQ of 3 pallets.

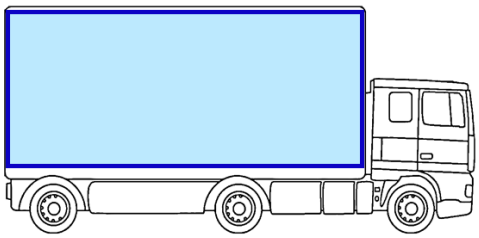

*Figure 4-7 Full truck MOQ*

As both of the explanations of an MOQ are used in the company the MOQs are set up differently. Especially the second explanation causes mismatches between the system forecast and the actual order placed. As the MRP material requirements forecast plans full truck loads to be delivered while actual deliveries are much smaller due to combined shipments that ignore the individual MOQs in the system. In this way the MRP system plans based on a more lumpy demand pattern due to the bigger lot size. The actual requirements are much less lumpy and more stable than the forecast will show. Therefore the individual MOQ of the different items needs to be implemented in

the SAP system. As the material scheduler places the final purchase order they have to check if the full truck restriction has been met. Changing these MOQ definition will impact many slow moving, low volume, items.

## 4.3 Short term stability and actuals

The last part of the forecast accuracy is the comparison of the forecast to the actuals. When time passes and the end of the contract comes closer, problems become clear and buyers need to act. As problems with total requirements are most critical at the end of the contract, the short term reliability of the forecast is an important part of the forecasting process for the procurement department. There are different ways to cope with system nervousness as mentioned in literature. In this part freezing methods and lead times will be addressed.

### 4.3.1 Freezing methods

The freezing method does not impact the long term forecast but the forecast accuracy is calculated based on the Vendor forecast generated at a specific horizon in combination with the actuals over the same period. Problems at procurement are related to total requirement differences over the total contract period. Most of these problems only show up at the end of the contract, therefore the stability of the material requirements at a short term horizon can have a big impact on the forecast accuracy and the costs of procurement.

As mentioned in Chapter 2, the company currently uses a period-based freezing method. The production plan until a 2 weeks horizon is called frozen and changes is this part of the production plan are rare. If the company chooses to apply an order-based freezing strategy where not the 2 weeks horizon, but for example the first 2 production batches of each end product, cannot be re-planned it will reduce the nervousness of the short term production plan. The impact will be different for items where production jobs are planned frequently, in comparison to products that are produced only a few times a year. Further, this way of working can result in planned jobs on a horizon of 6-7 weeks that could not be changed anymore. The nervousness in the production plan can be reduced, but it can impact the customer service level as production batches cannot be advanced anymore. The amount of stock-outs can increase as stated by Zhoa & Lee (1993). Further it will impact the holding costs if finished goods are produced when the actual demand went down. This higher inventory can result in write-off costs due to the high stock level in in combination with the trade shelf life of the product. This means that retailers only want to buy products if the remaining shelf life of the product is at least 6 months. The forecast accuracy on the ingredients that are used for the finished goods items with lumpy production patterns can improve a lot, because the period in which the items will be produced will not be changed on the short term. Due to the write off risk in combination with the impact it can have on the case fill rate, changing the freezing strategy will not result in a solution to the forecast accuracy problem without impacting the service level. As the service level is one of the most important KPIs used at the company, compromising the service level to reduce nervousness and improve the forecast accuracy is not a realistic option.

### 4.3.2 Lead times

For the company the internal production lead times are less relevant than the delivery lead times from customers as most production batches are processes where the complete process is executed in one run. This is mainly due to short production throughput times. The lead times of suppliers are more important, due to the focus on low costs ingredients have lead times of more than 3 months. As a result of the long lead times there is less flexibility on the short term and therefore the forecast on these ingredients needs to be correct. An incorrect forecast can lead to short term shortages if the differences are large. As lead times influence the material planning, it is important that these are set correctly in the system. In order to identify materials with possible lead time errors, we used the short term forecast accuracy report in combination with a supplier performance report that is available via the Business Intelligence reporting tool. Based on the data in those reports, where the requested delivery date and the actual delivery date for each purchase order are shown, we identified root causes of the short-term forecast accuracy. In general the lead times seem to be correct in the SAP system but for some items the report showed a mismatch between the requested and actual delivery dates. This means that the forecasted delivery date was always a few days/weeks earlier or later than the actual delivery date. The mismatch was visible for tomato paste, beans, and soya sauce at different factories. To get into more depth whether or not this was due to incorrect lead times we analyzed some items that are be described in the next sections.

#### TOMATO PASTE DELIVERY PERFORMANCE

Tomato paste has a long lead time of more than 3 months, as it is bought in the United States and shipped via China to keep the transportation costs as low as possible. Due to the long lead time in combination with the high dependency on tomato paste supplies, the deliveries should be as close to the requested delivery date as possible.

Due to historic delivery problems with the tomato paste inbounds, the transportation company sends a weekly tracking overview with requested arrival date, expected arrival date and actual arrival date of all the company shipments. As deliveries were always too late, in comparison to the requested time of arrival, the lead times had been extended by 5 to 10 days depending on the destination. The lead-time change has been made in June

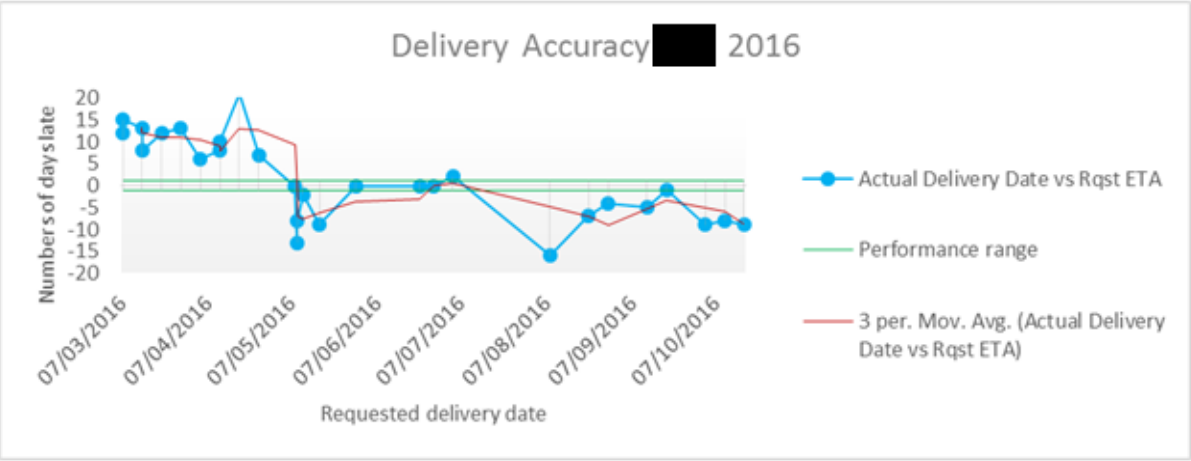


*Figure 4-8 Tomato paste delivery accuracy*

2016, so before this research. As can be seen in Figure 4-8, the lead time change has a big impact on the deliveries of tomato paste to the factory. As there was no visibility in the delivery performance we developed a tracking dashboard, a screen-print is shown in Appendix B. Due to this measurement tool it became clear that instead of delivering late the company started to deliver early, which is not ideal as well. But as the company currently accepts the early deliveries as well the transport company can deliver whenever they want as long as it is before the requested delivery date. The early delivery has an impact on holding costs, logistics capacity, etc. Therefore new liability arrangements where agreed between the transportation company and The company. The company does not have to call off the paste before the requested delivery date. The additional demurrage charges, that need to be paid when a container stays at the port, are paid by the transportation company. In this way the paste deliveries that are delivered early should not bring additional costs to the company. Although these agreements are from June 2016, not all material schedulers were aware of the agreements and kept calling off the deliveries before the materials were needed. This resulted in additional inventory costs and lead to a mismatch between forecasted volumes and actual volumes.

Liability agreements were made to solve the performance problems of this supplier. The material schedulers need to be aware of these agreements and act based on the agreement to force the supplier to improve their performance. Due to the large volumes a more reliable supplier performance will increase the short term accuracy, the total requirements over the period will stay approximately the same but for the short term phasing the impact will be large.

#### BEANS LEAD-TIME

Not only the tomato paste deliveries showed mismatches between the expected delivery date and the actual delivery date. Also the beans that are used at the factory show constant differences between the expected delivery date and the actual delivery date. The SAP system constantly showed historic purchase orders that were not delivered on the requested date, some orders were delivered several days later while others came in a few weeks later.

The company still uses an old agreement to freely store beans. They can still use this agreement to store beans as there is no end date on the agreement. Most of the beans are imported from Canada and delivered to the storage location in Liverpool. The factory was ordering beans to be delivered to Liverpool. But due to the agreement with the government the ownership of the stock is still at the supplier, the change of ownership only happens when beans are brought into the factory. Due to the “invisible” buffer in Liverpool, orders and forecast did not match due to the way of working. The lead time needs to be corrected because the system builds the complete forecast based on inventory levels and inbounds that are not according to the reality. Currently the system works with lead times of 1 week while the actual lead times are around 5 weeks.

### SOYA SAUCE PROCESS

The internal policy used at the company is that ingredients are bought including transport cost and all the duties and taxes paid (DTP). In the end this means that the ingredients are delivered to the factory by a transport company that has been booked by the supplier. The company has nothing to do with all the transport that needs to be arranged to get the ingredients. For soya sauce that needs to be supplied to the factory the situation is a bit different. Soya extract is bought in China and the supplier only arranges the transport until the harbor in China. When the ingredients are loaded on the sea vessel, the ownership of the goods is transferred to the company. At this moment the financial inbound takes place. At this moment the goods are added to the stock levels in the factory although the product is not physically there. To make sure that the factory keeps an overview of the physical stock at the site, the material scheduler in the factory blocks the stock in SAP. This means that the stock is no longer available for production. Normally this function is used to block stock that is still in quality inspection or stock that is rejected, because the quality of the ingredients is not complying with the required standards. By this way of working, the company loses visibility on which stocks will become available and which stock is rejected. This way of working impacts the forecast accuracy, as the lead times in the system are based on the transport times from the supplier in China till the freight arrives at the factory in the factory. The actual inbound takes place at the moment the order enters the sea vessel in China. In this case, the moment the ownership of the stock is transferred to the company is not when the stocks arrive at the production location. Because contracts are based on (financial) inbound dates, the difference of 4 to 5 weeks, due to the transport time of the sea freight forwarder, can make the difference between contracts. There are different solutions possible:

- Buy the goods DTP as financial inbound date and physical inbound date are at the same moment in that situation.
- Make a difference between financial lead time and physical lead time in SAP. In this way the forecast will show the correct number and the stock does not need to be blocked in the system anymore.

Because this is the only supplier where contracts are not closed based on DTP agreements it would be the easiest solution to align the contracts with this supplier to the contracts used at other suppliers. Unfortunately the supplier is not willing to change the way of working and because the ingredient is quite specific, the company is not able to change the agreement or to switch to a different supplier. The other option would be to enhance the SAP system to be able to put a financial lead time and a physical lead time in the system.

## 4.4 Forecast generating process

The current process around generating the vendor forecast is not built on checks, the forecast is extracted on the first Thursday of the financial month without checking if the system is ready or not. There are a few reasons why the forecast extraction process needs to be changed to the process as shown in Figure 4-9. Both the current and the improved process flow can be found in Appendix C.

When the forecast is extracted before the planners finish their tasks, the forecast quality can be reduced. The main problem that can arise is a requirements peak after the frozen period. Planners are able to place a time fence on the production plan, this means that the JDA system cannot add or change any production batches in the period prior to this time fence. If somehow the demand within this frozen time period increases a lot and stock levels drop below the safety stock, the system plans a high production directly after the time fence to recover the backlog or to recover safety stock. The supply planners normally increase the production quantities inside the period that the system cannot change and removes the peak after the time fence. So if the forecast is extracted too early, this production peak shortly after the time fence will influence the projected requirements on the short term (2-3 months horizon). As the forecast is only extracted once every month the impact can be large when buyers need to source additional volumes based on this planning peak. The additional materials bought turn out to be unnecessary while additional costs were made.

Next to the supply planners tasks that need to be completed before the forecast is extracted, also all the material inbounds should be placed in the correct period. The most important part of this are the overdue purchase orders. SAP assumes that all the

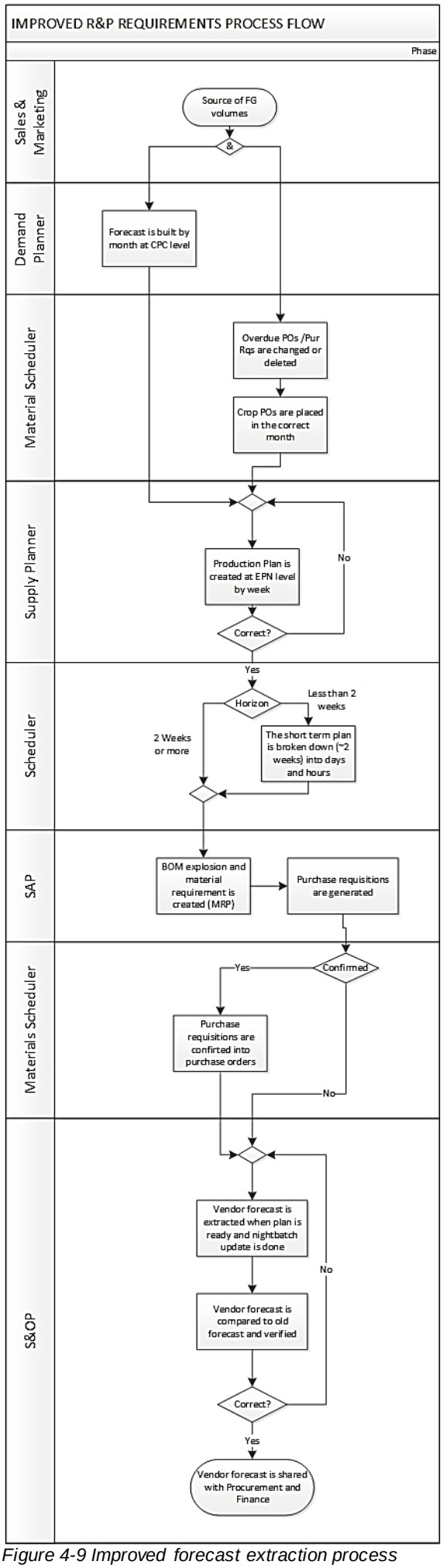


*Figure 4-9 Improved forecast extraction process*

open material orders with an historic delivery date arrive tomorrow. These order arrival moment in combination with order amount can have a large impact on the next order moment. Therefore the system needs to be cleaned from overdue POs before the material requirements forecast is extracted. In order to identify the overdue PO's and Pur Rqs we developed the report as shown in Appendix D. During this research we started the cleaning process with the material schedulers at the sites. In SAP there where overdue purchase orders from 2012. Most of the open POs where directly deleted but some were related to issues with suppliers or invoices and could not be deleted directly. As the system is has almost completely be cleaned until the last 3 months it is important that all the production locations keep track of their POs and re-plan or delete overdue POs if needed.

These two activities should be finished before the material requirements forecast is generated. Generating the forecast before the previous activities are finished will result in a less accurate forecast.

## 4.5 Conclusions

In this chapter several solutions are presented to improve the R&P forecast accuracy. Different processes and parameter settings need to be changed in order to reach a higher accuracy.

LONG TERM FORECAST ACCURACY IMPROVEMENTS

***The promotional demand forecast should have a rolling horizon of at least 1 year or the ingredients should only be contracted after AOP (Section 4.1.1)***

- Because the R&P material requirements forecast has a horizon of one year the input processes should have an equal or longer horizon.
- Currently promotional demand is not taken into account in the R&P material requirements forecast during some periods of the year.
- After AOP the complete forecast is taken into account, if contracts are based on these volumes the accuracy is higher.

***The production plan should be finished before the R&P material requirements forecast is generated (Section 4.1.2)***

- If the production plan is not finished the material requirements will not reflect the latest and correct information. Therefore the system needs to be cleaned from overdue purchase dorders and the supply planner should have finished the production plan.

***Crop related production jobs and inbounds should be planned based on the most recent information (Section 4.1.2)***

- Crop PO delivery dates need to be updated if harvests dates change. Both the crop related production batches and the alternative production batches should be re-planned.

***The BOM of new products should be set up as soon as possible or the items need to be mapped to existing BOMs (Section 4.1.3)***

- Without a BOM there are no material requirements generated for new items.

***The SAP system needs to be cleaned from overdue POs and Pur Rqs before the R&P material requirements forecast is extracted (Section 4.1.4)***

- If orders will not be delivered the stock levels as used to determine the material requirements should not uses these inbounds.

***Based on the global the company policy, MOQs are not allowed to cover more than 3 months of material requirements. This policy should be applied as it reduce the lumpiness of material requirement patterns for procurement (Section 4.2.1)***

- High MOQs result in lumpy demand patterns, which make it much harder to forecast when new deliveries are needed.

***A clear definition of the MOQ should be set and implemented in the business (Section 4.2.1)***

- The individual MOQ as defined in Order Lot-sizing rules, will probably give the best results

***The total process should be changed to make sure the R&P material requirements forecast is built based on the most up-to-date information. (Section 4.4)***

- See Figure 4-9 for the complete improved process flow

### SHORT TERM FORECAST ACCURACY IMPROVEMENTS

***The currently applied a period-based freezing methods fits better to the The company process than the order-based freezing method (Section 4.3.1)***

- The order-based freezing method can have a negative effect on the service level and stock levels, therefore the current freezing method should be maintained

***Delivery performance needs to be tracked for the tomato paste supplier as lead times are long and the transportation company is not able to deliver on the requested date (Section 4.3.2)***

- All the material schedulers at the sites should be aware of the liability agreements between The company and the transportation company

***The lead time on beans needs to be changed into the correct lead time of 5 weeks (Section 4.3.2***

In the next chapter an overview will be presented to compare the improvements and the costs of the proposed solutions to improve the forecast accuracy and provide a better forecast to procurement.

# 5 Costs, benefits and implementation

In this chapter we analyze the impact and costs of the proposed solutions in Section 5.1. In Section 5.2 the solutions we place the solutions in a framework to support which solutions should be implemented. In Section 5.3, we present the decision process on which solutions bring more benefits than costs and should be implemented. We also formulated the conclusions of this chapter in this section.

## 5.1 Impact assessment

In this section the impact of the different solutions is analyzed, the improvement proposals and the impact of the different solutions are assessed in order to make a trade-off between costs and improvements in Section 5.2. To quantify the cost we made use of 5 groups:

- Low € < 500
- Low-medium € 500 -1,000
- Medium € 1,000-5,000
- Medium-high € 5,000 – 10,000
- High € > 10,000

Further we take €50 as the cost of one employee working hour for the company, in this cost is the salary of the employee and the loss of time as this time cannot be used for other tasks. For reporting tasks we assume that the report needs to be made for the next 2 years to reach stable results. The costs are based on these 2 years.

### CONTRACTING PERIOD

As the forecast accuracy is much higher after the AOP plan has been built, contracted amounts would be much better aligned with actual requirements if all the contracts are closed during this period. But because price can fluctuate heavily and volumes need to be secured as well this can result in shortages, as contracts can only be closed 3 months before the next calendar year starts. Therefore implementing this solution can lead to much higher prices and more supply risks. Cost cannot easily be estimated but will be more than €50,000 and are therefore classified as high.

### PROMOTIONAL DEMAND FORECAST

To assess if the proposed solution really improves the forecast accuracy of the raw and packaging materials we checked whether the impact is as expected. First the impact of the promotional forecast. As mentioned earlier, the promotional forecast is added in the period August-September, therefore the August 2015 and September 2015 reports were compared to see the difference on the forecast accuracy over the requirements of 2016 for a group of items. As can be seen in Table 5-1, most items have a higher forecast accuracy in September than in August. The average increase of the forecast accuracy on these items is more than 15%.

| Factory | Itemname | FC August 15 | FC Sepember 15 | Actuals 16 | August accuracy | September accuracy |
|---|---|---|---|---|---|---|
| Kitt Green | Potatoes, Oasis, Soups, Fresh | 2,342,000 | 3,323,000 | 3,328,500 | 70% | 100% |
| Utrecht | Sugar, Bulk | 15,180,000 | 20,460,000 | 20,347,260 | 75% | 99% |
| Utrecht | Cocoa, Liquor | 1,340,000 | 1,560,000 | 1,699,540 | 79% | 92% |
| Telford | Mustard, Dijon | 113,000 | 191,000 | 137,149 | 82% | 61% |
| Elst | Oil, Rapeseed | 5,025,000 | 7,450,000 | 10,959,033 | 46% | 68% |
| Elst | Tomato Paste, 36/38 Brix, CB, Drums | 1,478,200 | 1,925,550 | 2,400,070 | 62% | 80% |
| Kitt Green | Beef, Sp95, Pre-Dice 13mm, IQF | 280,800 | 410,400 | 477,144 | 59% | 86% |
| Alfaro | Tomatoes, Diced, 9-12mm, Aseptic | 245,960 | 335,400 | 279,529 | 88% | 80% |
| Alfaro | 14 Spice | 400 | 600 | 550 | 73% | 91% |
| Alfaro | Garlic, Heads and Cloves, Fresh | 24,800 | 27,251 | 26,600 | 93% | 98% |
| Pudliszki | Parsley Leaves, Ground, Dried | 820 | 1,290 | 1,120 | 73% | 85% |
| Pudliszki | Beef, Stomach, Frozen | 588,000 | 835,000 | 1,043,772 | 56% | 80% |
| Pudliszki | Tomatoes, Diced, 14 mm | 335,400 | 559,000 | 514,858 | 65% | 91% |
| Worcester | Molasse, Syrup | 1,632,000 | 2,328,000 | 2,425,730 | 67% | 96% |
| Worcester | Xanthan Gum | 400 | 600 | 500 | 80% | 80% |
| Worcester | Anchovies | 100,000 | 160,000 | 180,137 | 56% | 89% |
| Telford | Egg Yolk, Powder | 47,628 | 79,380 | 74,256 | 64% | 93% |
| Telford | Mix, Mayonnaise 70% | 13,828 | 23,705 | 21,979 | 63% | 92% |
| Utrecht | Starch, Wheat, Big Bag | 73,800 | 103,050 | 97,200 | 76% | 94% |
| Elst | Molasse, Syrup | 2,000,000 | 2,425,000 | 2,597,430 | 77% | 93% |
| Elst | Honey, Liquid | 25,200 | 39,600 | 57,000 | 44% | 69% |
| Elst | Mix, RIBOFLAVINE, 0.095Kg | 1,180 | 1,700 | 1,890 | 62% | 90% |
| Kitt Green | Oil, Sunflower Seed, Organic | 6,400 | 7,040 | 5,760 | 89% | 78% |
| Kitt Green | 77 Spice | 9,000 | 12,000 | 13,945 | 65% | 86% |
| Pudliszki | Vinegar, Spirit, 15%, Kosher | 1,725,000 | 2,553,000 | 2,727,081 | 63% | 94% |

*Table 5-1 Forecast accuracy August and September 2015*

We determined the financial impact to be able to calculate the total forecast accuracy. After applying the forecast accuracy formula from Equation 2-3, the forecast accuracy on this collection of items increased from 65% (August 2015) to 85% (September 2015) forecast accuracy over the 2016 volumes. Due to the higher weight on expensive items the total accuracy increases more than the average improvement per item. Due to the large improvement on the total forecast accuracy and the fact that 84% of the items in the sample show improvements the promotional forecast horizon might be changed to improve the raws and packs material requirements forecast. The question is what the impact of adding this promotional forecast would have been if it was included in the forecast from August. At The company the promotional demand adds up to approximately 20%, so if 20% of the total demand is missing in the August forecast, the August forecast should be increased by this missing 20% of the total year requirements. As this is only a process change, as it has been agreed to do it during AOP, it is an easy improvement. Adding the promotional forecast earlier is just adding an over layer from the previous year. Based on Table 5-2, the total forecast accuracy increases from 69% to 82%, an increase of 13%. Adding the promotional forecast during the complete year will result in an improvement on the mid- and long term forecast accuracy of more than 10%. The costs of implementing this solution will be a change in the way of working and a monthly task to add one more month of promotional forecast. As there is no financial investment, and only one department needs to change the way of working, the costs of implementing this solution are low-medium in comparison to the other solutions presented. This is because it takes the demand

planners around 15 minutes a month to update the forecast, so for 15 demand planners the total costs to update the forecast each month for the next 2 years will be around € 4,500.-.

| Factory | Itemname | FC August 15 | FC August 15 + 20% promo | Actuals 16 | August accuracy | August promo accuracy |
|---|---|---|---|---|---|---|
| Kitt Green | Potatoes, Oasis, Soups, Fresh | 2,342,000 | 2,927,500 | 3,328,500 | 70% | 88% |
| Utrecht | Sugar, Bulk | 15,180,000 | 18,975,000 | 20,347,260 | 75% | 93% |
| Utrecht | Cocoa, Liquor | 1,340,000 | 1,675,000 | 1,699,540 | 79% | 99% |
| Telford | Mustard, Dijon | 113,000 | 141,250 | 137,149 | 82% | 97% |
| Elst | Oil, Rapeseed | 5,025,000 | 6,281,250 | 10,959,033 | 46% | 57% |
| Elst | Tomato Paste, 36/38 Brix, CB, Drums | 1,478,200 | 1,847,750 | 2,400,070 | 62% | 77% |
| Kitt Green | Beef, Sp95, Pre-Dice 13mm, IQF | 280,800 | 351,000 | 477,144 | 59% | 74% |
| Alfaro | Tomatoes, Diced, 9-12mm, Aseptic | 245,960 | 307,450 | 279,529 | 88% | 90% |
| Alfaro | 14 Spice | 400 | 500 | 550 | 73% | 91% |
| Alfaro | Garlic, Heads and Cloves, Fresh | 24,800 | 31,000 | 26,600 | 93% | 83% |
| Pudliszki | Parsley Leaves, Ground, Dried | 820 | 1,025 | 1,120 | 73% | 92% |
| Pudliszki | Beef, Stomach, Frozen | 588,000 | 735,000 | 1,043,772 | 56% | 70% |
| Pudliszki | Tomatoes, Diced, 14 mm | 335,400 | 419,250 | 514,858 | 65% | 81% |
| Worcester | Molasse, Syrup | 1,632,000 | 2,040,000 | 2,425,730 | 67% | 84% |
| Worcester | Xanthan Gum | 400 | 500 | 500 | 80% | 100% |
| Worcester | Anchovies | 100,000 | 125,000 | 180,137 | 56% | 69% |
| Telford | Egg Yolk, Powder | 47,628 | 59,535 | 74,256 | 64% | 80% |
| Telford | Mix, Mayonnaise 70% | 13,828 | 17,285 | 21,979 | 63% | 79% |
| Utrecht | Starch, Wheat, Big Bag | 73,800 | 92,250 | 97,200 | 76% | 95% |
| Elst | Molasse, Syrup | 2,000,000 | 2,500,000 | 2,597,430 | 77% | 96% |
| Elst | Honey, Liquid | 25,200 | 31,500 | 57,000 | 44% | 55% |
| Elst | Mix, RIBOFLAVINE, 0.095Kg | 1,180 | 1,475 | 1,890 | 62% | 78% |
| Kitt Green | Oil, Sunflower Seed, Organic | 6,400 | 8,000 | 5,760 | 89% | 61% |
| Kitt Green | 77 Spice | 9,000 | 11,250 | 13,945 | 65% | 81% |
| Pudliszki | Vinegar, Spirit, 15%, Kosher | 1,725,000 | 2,156,250 | 2,727,081 | 63% | 79% |

*Table 5-2 Promotional impact August forecast*

### FORECAST GENERATING PROCESS

If the forecast is generated before the production plan is finished, and the night batch has been updated, this will impact the forecast accuracy. In December 2016 the forecast has been extracted too early, so before the night batch was updated with the latest information. The total impact on the forecasted costs of ingredients (December forecast[5]) was only 3 million on a total of around 515 million for the complete year 2017. But on an item level the impact was larger. From the 3579 items in total, the material requirements increased for 1092 items, the average increase on these items was 15% with a median of 10%. There were 841 items for which the forecast decreased with an average of 17% and a median of 7%. The impact on the yearly amount of money spent on these materials was only 0.6% but the impact on the individual items is much bigger.

There are no additional costs because the BI system can send automatic messages after the night batch has been updated, this should be the checked before the forecast

[5] Demand Forecast – Keystone CY2016 P12 08-12-2017 vs. Demand Forecast – Keystone CY2016 P12 12-12-2017

is extracted from the systems. The impact on the total requirements is only 0.6%, but as mentioned this can have an impact of +/- 10% on specific items and therefore this solution should be implemented. Next to the planning status, also the overdue/open purchase orders and requisitions that are not re-planned impact the forecast generated. On the total yearly requirements the impact will not be significant, but regarding the phasing over the periods the impact can be large if ingredients are ordered less than 12 times a year. Therefore the total impact of changing the forecast generating process will have an impact of around 0.6% on the total but the impact on the monthly forecast will be larger depending on the overdue/open purchase orders in the system. Getting the checks in place and making sure all predeceasing steps are closed before the forecast is generated takes around 15 minutes each month for one person. Based on this the total costs for the next 2 years will be around €300. At the same time this investment is easily earned back as now the complete forecast needs to be regenerated when the system was not ready.

### CROP PROCESS

In the current situation the crop inbounds are planned at once in the beginning of the season. If we look at the impact of replanning the inbound dates of the Fresh tomatoes (see Table 5-3) and Fresh sweetcorn (see Table 5-4), it becomes clear that although the total volume of the forecast on these items is 94% accurate, the phasing is extremely inaccurate. Therefore the inbound dates of the crop products need to be updated when new information becomes available. For the long term procurement contracts the impact will be small on these seasonal crop items as the total requirements are accurate already. The main impact will be seen at all items related to these crop production jobs and the alternative production jobs. For example, the requirements of cans to pack the products in combination with the salt and sugar requirements. So not only the crop ingredients forecast is impacted by the current crop process but also alternative production items required.

| Fresh Tomatoes (Pudliszki) in KG | | | |
|---|---|---|---|
| | **Forecast** | **Actual** | **Accuracy** |
| July | 46,037,000 | 4,004,090 | -950% |
| August | 2,358,513 | 20,635,850 | 11% |
| September | 210,375 | 21,327,909 | 1% |
| **Total** | 48,605,888 | 45,967,849 | 94% |

*Table 5-3 Fresh Tomatoes forecast*

| Fresh sweetcorn (Pudliszki) in KG | | | |
|---|---|---|---|
| | **Forecast** | **Actual** | **Accuracy** |
| July | 5,655,809 | 0 | 0% |
| August | 376,235 | 4,201,362 | 9% |
| September | 0 | 1,513,343 | 0% |
| **Total** | 6,032,044 | 5,714,705 | 94% |

*Table 5-4 Fresh Sweetcorn forecast*

This improvement takes time from the material schedulers to update the inbound dates. There are no financial investments that need to be made to implement this solution. The impact of this solution will not significantly improve the accuracy on the total requirements over a year as this accuracy is already above 90%. On the other hand the phasing of these orders have a large impact on the costs during the crop season. On the monthly bucket forecasts these crop items contribute to 10 to 27%[6] of the monthly forecast error. As this equals an error between €2 and €5 million (10-27%of

[6] Forecast Accuracy report The company Jan-Dec 2016

the monthly costs), decisions of the buyers on sourcing additional volumes are impacted a lot by these errors. Implementing the solution will mean that material schedulers at 3 sites need to invest additional time to reschedule the inbounds. If we assume it takes them on average 2 hours to re-plan the crop inbounds, and this needs to be done during 6 months of the year the total cost are around €3,600.-

### NPD PROCESS.

As the impact of the New Product Developments is hard to quantify we took the impact on the total for the 2017 forecast. The value that was added to the forecast was 3%. We assume an accuracy on these items of 50%, a bit less than the current forecast due to the uncertainty related to the launch timing of these items. Still the total forecast accuracy will improve by 1.4% as these requirements are not reflected in the current forecast at all. It will take a long time to implement this solution as the process of different departments needs to be changed and dummy codes need to be set up in all the systems. Therefore this solution can be implemented but it depends on the total forecast accuracy the company wants to reach. The costs are also high as different departments need to change their way of working and system changes might be necessary, further the new process needs to be developed and employees need to be trained. We assume that 5 people need to invest 20 hours to develop the new process flow and to educate the employees. System changes are not taken into account in this estimation, therefore the cost will be at least € 5000,-

### MOQ REDUCTION AND DEFINITION

As addressed in earlier chapters, lumpy demand patterns are harder to forecast. Based on the policy used at the company, raw or packaging MOQs are not allowed if they

| Factory | Material Description | Purchasing Group | MOQ Size | MOQ value | FC August 15 | FC September 15 | Actuals 16 | August accuracy | September accuracy |
|---|---|---|---|---|---|---|---|---|---|
| Elst | Starch, Maize, Novation 4300 | Starches | 20000 | [redacted] | 60000 | 20000 | 38000 | 42% | 53% |
| Utrecht | Compound, KC 0% Citrusmix | Fruits / Nuts | 10000 | | 60000 | 70000 | 33000 | 18% | -12% |
| Pudliszki | Flavour, Lemon, Aquaresin Liquid | Food Additives | 1000 | | 0 | 0 | 0 | 100% | 100% |
| Kitt Green | Pimentos, Red, 5mm, Frozen | Vegetables | 22000 | | 44000 | 44000 | 36300 | 79% | 79% |
| Elst | Ginger, Ground, Powder | Herbs,Spices&Misc. | 10000 | | 30000 | 30000 | 30000 | 100% | 100% |
| Kitt Green | Beans, Baby Lima | Beans / Pulses | 18144 | | 17000 | 36288 | 18140 | 94% | 0% |
| Pudliszki | Orange Juice, Conc. 63Bx Liquid | Fruits / Nuts | 10000 | | 0 | 0 | 4000 | 0% | 0% |
| Utrecht | Flavour, Lemon, (A), 15.91.8587 | Food Additives | 1500 | | 4500 | 6000 | 6120 | 74% | 98% |
| Elst | Flavour, Onion Powder, (Allergen) | Food Additives | 2000 | | 2000 | 2000 | 2000 | 100% | 100% |
| Alfaro | Mixed Red Kidney Beans (Red Kidney/Navy) | Beans / Pulses | 20000 | | 40000 | 60000 | 62000 | 65% | 97% |
| Telford | Laminate, Hz BK TK North 10g Back W | Flexible Resin | 150000 | | 150000 | 0 | 135991 | 90% | 0% |
| Telford | Laminate, Hz BK TK North 10g Front W | Flexible Resin | 150000 | | 150000 | 0 | 135991 | 90% | 0% |
| Alfaro | Mustard, Micronized, Flour Ref.106 | Food Additives | 18000 | | 72000 | 36000 | 39000 | 15% | 92% |
| Utrecht | Sweetness Improver BC-002-535-7 | Food Additives | 3000 | | 6000 | 6000 | 8500 | 71% | 71% |
| Alfaro | Citrus Fibre, Powder, ConCel CF 05 | Food Additives | 3000 | | 12000 | 12000 | 9000 | 67% | 67% |
| Kitt Green | Celery, Diced, 10mm, Frozen | Vegetables | 20000 | | 60000 | 80000 | 58000 | 97% | 62% |
| Elst | Flavour, Garlic Powder | Food Additives | 2000 | | 4000 | 4000 | 4000 | 100% | 100% |
| Alfaro | Tomato Paste,SHB,27-29,1300kg | Tomatoes | 22000 | | 0 | 176000 | 68893 | 0% | -55% |
| Pudliszki | Oil, Rapeseed, Liquid, Tank | Oils & Fats | 21000 | | 42000 | 63000 | 59320 | 71% | 94% |
| Alfaro | Mixed Pinto Beans (Pinto/Navy) | Beans / Pulses | 20000 | | 20000 | 40000 | 41000 | 49% | 98% |
| Kitt Green | Starch, Heinz No.2 (Bags) | Starches | 20800 | | 83200 | 83200 | 104000 | 80% | 80% |
| Utrecht | Blackberry Concentrate | Fruits / Nuts | 1500 | | 3000 | 6000 | 6000 | 50% | 100% |
| Utrecht | Cocoa Powder, Red | Oils & Fats | 5250 | | 15750 | 21000 | 21000 | 75% | 100% |
| Elst | Garlic Purée, Chilled | Food Additives | 5760 | | 5760 | 5760 | 5670 | 98% | 98% |
| Telford | FOIL, Sqz, 26ml, Hnz TK, CET, PAV1P | Flexible Resin | 25000 | | 25000 | 25000 | 50738 | 49% | 49% |
| Alfaro | Tocopherol | Food Additives | 140 | | 280 | 280 | 140 | 0% | 0% |
| Worcester | Flavour, Gentian Extract, Liquid | Food Additives | 100 | | 300 | 300 | 300 | 100% | 100% |
| Utrecht | Flavour, Raspberry, (E), 031922 | Food Additives | 850 | | 1700 | 3400 | 3400 | 50% | 100% |
| Utrecht | Roosvicee Flavour FZ-774-242-4 | Food Additives | 1000 | | 4000 | 3000 | 3000 | 67% | 100% |
| Kitt Green | Milk Powder, Skimmed, High Heat, Organic | Dairy | 2250 | | 4500 | 2250 | 4450 | 99% | 51% |
| Elst | Flavour, Baked Onion, Liquid | Food Additives | 510 | | 2040 | 2550 | 3060 | 67% | 83% |
| Elst | Flavour, Onion Oleoresin Liquid | Food Additives | 1000 | | 3000 | 4000 | 4000 | 75% | 100% |
| Pudliszki | Jalopeno, Dried Granulated | Herbs,Spices&Misc. | 1000 | | 0 | 0 | 600 | 0% | 0% |
| Telford | Flavouring, Hickory Smoke 10814556 | Food Additives | 500 | | 1000 | 1000 | 1400 | 71% | 71% |
| Kitt Green | Citric Acid, E330, Monohydrate | Food Additives | 10000 | | 30000 | 50000 | 70000 | 43% | 71% |

*Table 5-5 High MOQ impact*

cover more than 3 months of requirements. To show the impact of these high MOQs we took a selection of the items with MOQs that are not allowed based on the policy. Again we took the forecast from August and September 2015. In Table 5-5 it can be seen that for all the items in the overview the forecasted quantities for the complete 2016 equal between 0 and 10 MOQs. For the first item in the table for example the MOQ equals 20,000 kg, which equals a value of € 64,000. In August 2015 the forecast showed that the requirements equaled 3 MOQs for the complete year 2016. In September the forecast changed to only 1 MOQ. In the end 2 times an MOQ was ordered in 2016, so the accuracy is low with 42% and 53%. Based on this example the possible outcomes would have been 0%, 42%, 100% 53% and 0% accuracy if the forecast would have been 0 to 4 MOQ values. By reducing the MOQ, the MOQ impact on the forecast error quantities will be smaller and the accuracy will improve. As the steps become smaller the purchase requirements will be more aligned with the actual requirements and the impact of the lot sizing MOQ will be reduced. Instead of steps of 40 to 50% the steps will be reduced and the accuracy will increase. Reducing the MOQs will reduce the lumpiness of the forecast and increase the total accuracy and the phasing. As can be seen in Figure 5-1 the lumpy demand pattern will be much harder to forecast because when the requirements for the total year drops with only 10 the ordered quantity reduced from 150 to 100 with an MOQ of 50. If the MOQ is reduced to 20 the forecast would have been 120 and the actuals would have been 100 so the accuracy with the lower MOQ is 80% while the accuracy with the old MOQ would have been 66%

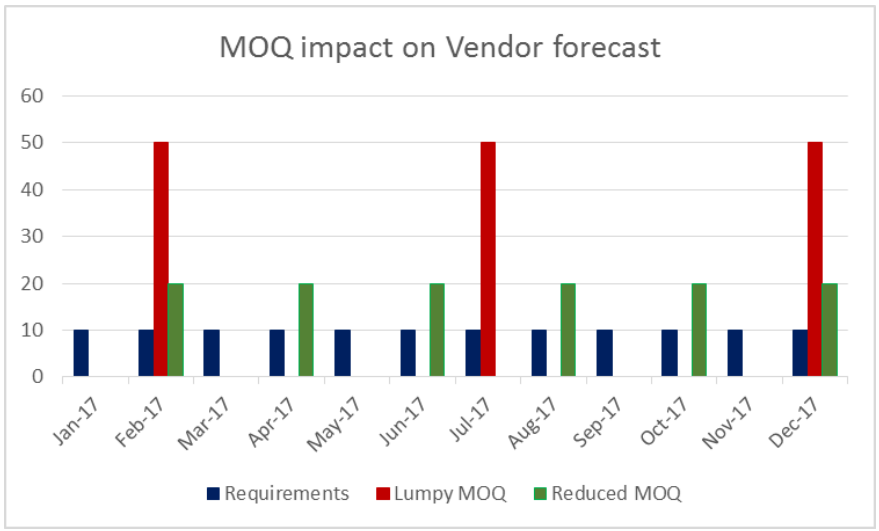


*Figure 5-1 Lumpy and reduced MOQ*

The costs of this improvement can be different for each material as the purchasing costs might increase when the MOQ needs to be renegotiated with suppliers. As the MOQs are only allowed to cover 3 months of material requirements based on the global the company policy, these costs are not directly related to the forecast accuracy improvements. Next to the improvement on the forecast accuracy this solution has a positive side effect on stock levels and write-off risks. As the 350 items contribute to a total value of around 3.5 million it is only 0.7% of the total costs of raws and packs. But because these items are so specific and the volumes are low, an inaccurate forecast can result in sourcing problems on these items. Not only the forecast accuracy will improve by this solution but also the write-off risk and the holding costs will be reduced.

Implementation of this solution can be high as contract prices can go up when MOQs need to be renegotiated. Further it will cost time to build the report on a monthly basis

and to convince the buyers. Building the report takes around 30 minutes a month so that will be €600 a year. Further, there will be at least 5 meetings necessary with each buyer, which will take two people an hour, with 8 buyers the result cost will be at least €4,000, So without the price increases the cost will already be more than €5,200 and we reserve at least €10,000 to cover the price increase. Therefore the cost of implementing the reduced MOQs are high.

The change of the definition will not bring any improvements on its own. The definition has to be applied to the items that currently use the different definition. Based on the current situation there are discussions on what the MOQ should be as the definition is not clear. By having a companywide definition these different interpretations will no longer exist and the accuracy can increase but this is not guaranteed.

### Tomato Paste delivery performance

As shown earlier the tomato paste supplier started delivering to early after the lead times have been changed. Keeping track of the performance of the supplier in combination with the new liability agreements will result in a higher forecast accuracy. Because the company does not need to unload the goods before the requested arrival date, all the early deliveries can result in a forecast accuracy close to 100%. The costs are only the investment to keep generating the report and to push the transportation company to improve. On the total year accuracy the impact will not be large as the current year accuracy is already around 80% for the main items, calculated for the months the promotional forecast has been added. Improving the delivery performance will only impact the shipments at the beginning and end of the year. For the monthly buckets accuracy the impact will be much higher as there are only 1-2 deliveries per month that have a large impact on the monthly volumes. If the delivery performance of the supplier can be improved this will probably result in a total accuracy improvement of around 0.8%. But again the monthly phasing needs improvement as 10 to 15% of the monthly forecast error is related to inaccuracy on Tomato paste. There is no direct investment related to this solution. Further, the impact will not only have a positive impact on the forecast accuracy but also impact the financial hedging effectiveness, which is based on the forecasted monthly costs. As generating the report takes around 30 minutes each time for 1 person, so the total cost of keeping track of the tomato paste suppliers performance for the next 2 years will be around €600.- which is low.

### Incremental order quantity of Oil

The incremental order quantity for oils needs to be set to one truck as currently the system generates material requirements based on an MOQ of one truck and no incremental order quantity. This results in a forecast that is not reflecting the real requirements and inbound restrictions. As these changes already have been applied in Alfaro the results on the forecast accuracy from Alfaro are used. In Alfaro the inbound in the period October- December were batches from around 26,000 kg, which equals the MOQ/incremental OQ. The old settings show a less lumpy demand pattern but as it is impossible to inbound half a truck the system should only plan with full truck loads. For some months the forecast accuracy decreases as the forecast becomes lumpier. Although this change is not improving the forecast accuracy in this case, without the incremental OQ the system is forecasting amounts that are not feasible.

So this solution is not per se improving the forecast accuracy percentage, but it changes a not valid forecast into a valid forecast which is an improvement but a small one. The costs are a onetime change of the system settings which will take not more than 1 hour, so the cost are around €50,- and qualified as low.

### BEANS LEAD-TIME

The lead time of beans is currently not correct in the system, the current settings give a lead time of one week while the actual lead time is around 5 weeks. The difference of 4 weeks is approximately one month so to assess the impact of this improvement the current forecast is compared to the situation were the forecast from August 2016 is used for September 2016 etc. So, as the lead times are approximately one month longer the forecast currently shown should be delayed with one month. Based on the forecasts from July to December 2016 is can be seen in Table 5-6 that the accuracy improves in 3 out of the 5 months, and all the months are above the target of 70%. Over the complete period the cumulative forecast accuracy over this item was 89% in the current situation and 97% in the improved situation. The impact for the beans

| Beans Pea Navy Soft forecast in KG | | | | | |
|---|---|---|---|---|---|
| | August | September | October | November | December |
| Current Forecast | 2044233 | 3283313 | 1678283 | 1457778 | 1603153 |
| Improved Forecast | 2424627 | 2044233 | 3283313 | 1678283 | 1457778 |
| Actuals | 2065439 | 2514962 | 2851059 | 1845886 | 2002127 |
| Current accuracy | 99% | 69% | 59% | 79% | 80% |
| Improved accuracy | 83% | 81% | 85% | 91% | 73% |

*Table 5-6 Beans lead time impact*

forecast is approximately 8% and the costs are minimal as only the lead time in SAP needs to be changed once. As the total value of these beans is around 37 million a year an improvement of 8% would mean an impact of around 3 million which would be an improvement on the total accuracy of 0.6%. Changing these lead times takes a bit more time as the oils incremental order quantity change due to the communication with the material schedulers. The schedulers needed to be convinced about the mismatch which took around 2 hours for 3 people and 1 hour to make the system change so the total costs are around €350,-.

### SOYA SAUCE PROCESS

To make the change between financial lead time and actual physical lead time, changes need to be made to the SAP system. The cost of this changes can be high and a business case needs to be built to get budget to make the changes. Based on information from the SAP analyst the costs of this change will start from €10.000 to €15.000 if only system configurations need to change. As the total accuracy on this item in September was 82% there is no need to change the system to improve the forecast accuracy. But in order to get more visibility on the status of the stock this solution can be implemented and will have a positive impact on the forecast accuracy as well.

## 5.2 Additive impact of proposed solutions

In the previous chapter we presented several solutions to improve the forecast accuracy. In order to be able to define an order of improvements that should be implemented, the solutions are ordered based on their impact. The impact on the total accuracy is given behind each solution.

Based on the list provided it becomes clear that 2 solutions have a large impact of more than 10%. Changing the contract period and the improvement to add the promotional forecast in an earlier stage will result in the needed improvement to reach the targeted forecast accuracy of 70%. If the contract period is changed the forecast accuracy will improve more than 15%. If the promotional forecast is added to every month's forecast the other solutions can be added to improve the accuracy further.

- Changing the contract period + >15%
- Adding the promotional forecast + >10%
- Changing the crop process + 2%
- Changing the NPD process + 1.4%
- Tomato paste delivery performance tracking + 0.8%
- Beans lead time system change + 0.6%
- Forecast generating process change + 0.6%
- MOQ reduction and definition + 0.2%
- Oil incremental order quantity change + 0%

Based on this list of solutions, a mid- and long term forecast accuracy of more than 70% can be reached. But next to the improvements there are also costs that need to be taken into account in order to make a tradeoff between the improvement in forecast accuracy and the costs. The costs of implementing the solutions are summarized to place the solutions in the framework presented in Figure 5-2.

- Contract period > €50,000 High
- Promotional forecast € 4,500 Medium
- Crop process € 3,600 Medium
- NPD process € 5,000 Medium-high
- Tomato paste performance € 600 Low-medium
- Beans lead time € 350 Low
- Forecast generating process € 300 Low
- MOQ reduction and definition € 15000 High
- Oil Incremental OQ € 50 Low

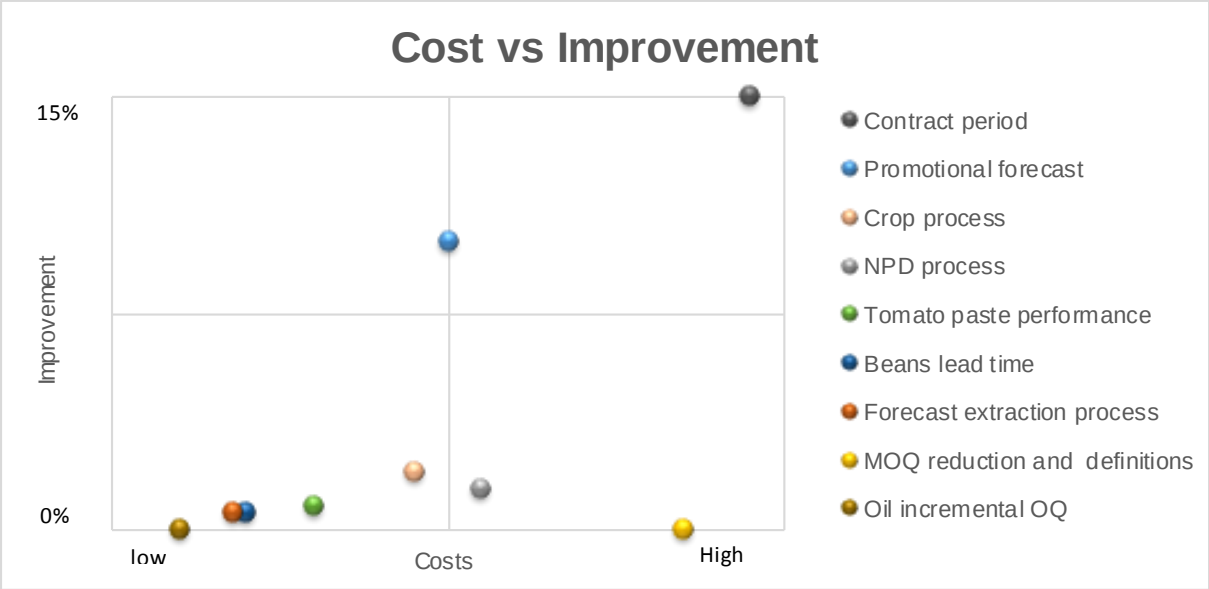


*Figure 5-2 Cost versus Improvement framework*

Based on the position in the framework some solutions are interesting to implement while other solutions are not. Below all the solutions will be addressed shortly to identify which should be implemented and which not.

### CHANGING THE CONTRACT PERIOD

As the mid- and long term forecast accuracy is at its highest level shortly after the AOP plan has been made, an improvement of more than 15% can be reached if contracts are only closed during this period. In September, shortly after AOP, the forecast accuracy is more than 75% which is an improvement of more than 15%. But contracting only once a year, on a 3 months horizon for the starting date, reduces the flexibility of the buyers and increases the cost of the contracted ingredients. As prices can fluctuate heavily procurements needs to have the flexibility to contract all the year. One single contract period around September will bring much more costs. Furthermore, it is physically impossible for the buyers to close all the contracts at the same period of the year. Although the costs are hard to estimate it is likely it will be more than €50,000. Therefore this solution is not a realistic one to implement and improvements need to be reached by other solutions.

### PROMOTIONAL FORECAST.

This improvement only needs a small change in the way of working, there is no investment in system enhancements etc. required. The time investment for the next two years will equal a value of approximately €4,500. This amount is not that much in comparison to the 10% accuracy improvement. As many items from all factories are influenced and due to the large increase in accuracy of more than 10% this solution should be implemented.

### CROP PROCESS

Not every factory uses crop ingredients but still the total impact on the accuracy is around 2%. Changing the delivery dates can be time intensive therefor the costs for

the next two years are estimated on approximately €3,600. System enhancements might be requested in the future if crop ingredients are bought from small suppliers, therefore the costs are placed in the overview as medium. Additional benefits can be reached at the financial department when crop volume inbounds are more reliable. A more reliable crop forecast creates possibilities for finance to make better hedging decisions and safe money. Therefore this is an interesting solution to implement but it is not the first priority.

### NPD process

Improving the new product development process, and making sure that the material requirements are visible as soon as possible, requires changes in the way of working for several departments. The investment to make it work will be at least €5,000 and the impact will be small on the total portfolio. But because some specific items are impacted a lot, as new products are mainly launched in new product groups, it might be an interesting improvement.

### Tomato tracking

As only the tomato paste sourced from the United Stated of America faces the delivery problems, the impact on the number of items is not so large. But due to the huge amounts of tomato paste a correct forecast is required and the impact on the total will be around 0.8%. Tracking the tomato paste deliveries does not require large investments and all the data required is already provided by the transport company. Only the time to make the report needs to be invested which will equal around €600. Therefore this tracking should be continued until the transport company delivers on the requested dates.

### Beans lead-time

Changing the lead time in SAP requires almost no investment but the improvement is also limited with 0.6% as only beans in one factory are influenced. Due to the one time change the investment is around €350 and therefore the 0.6% improvement is easy to reach.

### Forecast generating process

Changing the process on how the Vendor forecast is generated has a small impact on the total accuracy of only 0.6%. Still the demand forecasting and production planning processes needs to finish before the R&P material requirements forecast is extracted to have a reliable phased forecast. These process changes impact the complete forecast of all items and the investment to change this process is only €300 as automatic system messages can be send. Further the costs of executing the complete process twice (if the system was not ready the first time) are much higher.

### MOQ reduction and definition

Reducing the out of policy MOQs results in less lumpy patterns and therefore easier forecast patterns. A drawback of lowering the MOQ is that it can result in higher costs of the ingredients. This solution needs to be implemented based on the policy and it will reduce the write-off risk. So Implementation of this solution is not directly necessary to reach a higher forecast accuracy but it is more important to implement it in order to reduce holding costs and write-off risks.

The company needs to choose a MOQ definition that is aligned with how the MOQ is used. The only investment that needs to be made is that the definition needs to be agreed and communicated. The improvement will probably not be visible on a total level as it only impacts some slow moving items. To improve the forecast accuracy this solution will not bring large improvements but the company should have a clear definition on the MOQ and how to apply it.

#### OIL ROUNDING VALUE

The impact of correcting the rounding values for oils in SAP is small as only the last incremental OQ is impacted. The accuracy can go up or down as the forecast pattern will become lumpier. The investment is only €50 as some input parameters need to be changed

## 5.3 Conclusions and solutions to be implemented

With the overview of last section we came to the conclusions that some improvements should be implemented and others not. Some solutions should be implemented because it will improve the forecast accuracy or because the side effects related to the solution are profitable for the company. We will start with the current forecast accuracy and add the improvements to see what the final raws and packs forecast accuracy will be that can be reached by implementing the proposed solutions.

| | | | |
|---|---|---|---|
| • Current forecast | | | 59.8% |
| • Adding the promotional forecast | + | 10% | 69.8% |
| • Changing the crop process | + | 2% | 71.8% |
| • NPD Process change | + | 1.4% | 73.2% |
| • Tomato paste delivery performance | + | 0.8% | 74.0% |
| • Beans lead time change | + | 0.6% | 74.6% |
| • Forecast generating process change | + | 0.6% | 75.2% |
| • MOQ reduction | + | 0% | 75.2% |
| • MOQ definition | + | 0% | 75.2% |

If these solutions are implemented the expected forecast accuracy on the mid-and long term horizon will be 75.2%. This is an improvement of 15.4% in comparison to the 59.8% accuracy in the current situation. An accuracy on 75.2% will be above the target of 70% and therefore the goal will be reached. As not all solutions are easy to implement there is an implementation plan presented in the next section.

# 6 Implementation and performance measurement

In this Chapter we describe the implementation plan and the related measurements. In Section 6.1 we address how the process should be changed, a timeline for implementation is provided, and the new way of working is explained. Then we describe new or improved performance measurements in Section 6.2. We provide motivation to show which indicators should be used to measure the performance and why these measurements should be used. Section 6.3 provides the conclusions regarding the implementation and performance measurement.

## 6.1 Implementation

In this section the implementation plan of the different solutions is presented. In Table 6-1 the total overview is given, all the solutions that should be implemented are given in the first column. The second column shows if the solution is a one-time change or a recurring process, for the solutions that are related to a report the report name is given. Then the implementation start date is provided together with the current status and some comments.

| Solution | Reoccurring | Report | Start implementation | Status | Comments |
|---|---|---|---|---|---|
| 1. Promotional forecast process | Yes | - | Nov-16 | Implemented | 24 months rolling forecast |
| 2. Forecast extraction process | Yes | Overdue PO/Pur Rqs | Mar-17 | Ongoing | Night batch update implemented |
| 3. Crop process | Yes | - | Mar-17 | Open | Waiting for the season to start |
| 4. MOQ reduction | Yes | Out of policy MOQ | Nov-16 | Ongoing | First meetings planned and information from suppliers requested |
| 5. MOQ definition | No | - | Mar-17 | Pending | Decision should be made |
| 6. Tomato Tracking | Yes | Delivery performance | Nov-16 | Implemented | Sites are informed, tracking continues |
| 7. MOQ/rounding value | No | - | Oct-16 | Implemented | All items are updated |
| 8. Beans lead-time | No | - | Dec-16 | Pending | Lead time change confirmed |

*Table 6-1 Implementation overview*

### PROMOTIONAL FORECAST PROCESS

In October 2016, we presented the provisional findings to the Strategic Materials Planner, Supply Chain Excellence Lead, and the Head of Integrated Business Planning Europe. Some of the improvements currently presented in this report were already mentioned in that presentation. The promotional forecast horizon was one of these solutions and after the meeting the Supply Chain Excellence Lead informed the demand planners that the promotional forecast horizon should become a rolling forecast with a horizon of 24 months. From December 2016 this has been applied by the demand planners and the rolling 24 months horizon has been implemented.

### FORECAST GENERATING PROCESS

The complete forecast generating process needs to be redesigned in order to improve the quality of the raws and packs material requirements forecast. It is essential that overdue purchase orders and purchase requisitions are updated or deleted before the vendor forecast is extracted. The overdue purchase orders and requisitions influence the total forecast as SAP expects all the overdue orders to arrive tomorrow. When the overdue purchase orders and requisitions are not cleaned before the material requirements forecast is extracted the system does not show these requirements because they are in the past, at the same time SAP assumes the goods come in as soon as possible and takes these amounts into account in the planning for the next material requirements. The overdue POs are also related to the fresh crop process were orders should be re-planned based on the most recent estimation. The overdue PO report will show the fresh crop orders that need to be re-planned if the expected inbound date is in the past.

Because the MRP vendor forecast is extracted on the Thursday of week 1, the system needs to be cleaned by the sites before Wednesday evening. We designed a report to identify overdue POs and Pur Rqs to be build and send to the material schedulers on Monday in week 1 to notify the sites of their overdue purchase orders and purchase requisitions. The report shows which purchase orders and requisitions are still open for each site, the quantity and the planned delivery date.

In the current situation the MRP vendor forecast is extracted at a specific day, Thursday week 1. The status of the production plan is not taken into account when the forecast is extracted. In this way the forecast could include the forecast for a production line that is heavily overloaded during a specific month. Therefore there needs to be a confirmation of the supply planners that the production plan is ready to be exploded to calculate the material requirements. Normally all the planners are able to finish their production plan before Wednesday. If it is not possible, they have to inform the Strategic Materials Planner that the production plan is not ready to be exploded.

#### MOQ REDUCTION AND DEFINITION

Based on the out of policy MOQ report, meetings need to be planned with the buyers to validate if the report is showing the correct information. Based on the out of policy value per portfolio, meetings have been held with the buyers of herbs and spices, food additives, metals, corrugates, proteins, starches, and aseptic cardboards. Some buyers directly agreed on lowering the MOQs of several items, for other items it will be harder and therefore information from suppliers on packaging sizes, truckloads and delivery moments was gathered. At the end of this study, a start was made and the information is available, now The company needs to keep track of the out of policy MOQs and the sales and operational planning department needs to work together with the buyers to see on which items the MOQ can be reduced and what the additional costs will be. Most out of policy MOQs are related to the food additives portfolio, as this portfolio consists out of many slow moving, high costs items. Next meetings need to be planned with the beans and vegetables buyer to see how the MOQs in this portfolio can be decreased. The report has been implemented and progress has been booked on some items already. This ongoing process has been implemented and a monthly report will be sent. For the MOQ definition the Strategic Materials Planner should sit together with buyers and material schedulers to see how the MOQ can be defined in the best way to make sure all the sites use the same definition and apply the same logic. After this decision has been made, the MOQs that are in the system but are based on different explanations should be changed.

#### TOMATO TRACKING, MOQ ROUNDING VALUE AND BEANS LEAD TIME

These solutions only comprehend a few products, still the changes proposed should be made as the volumes involved are large. For the tomato paste, all the information about the new liability agreements has been shared with the sites and the tracker report has been developed. The MOQ rounding values for the oil items are changed in SAP and the system currently works with these correct input parameters. For the beans lead times the agreements have been made to change the lead time. Now it is necessary to track whether the material scheduler at the factory keeps working based on these new agreements.

## 6.2 Performance measurement

Currently, the company only measures the short term (lag-1) forecast accuracy. As the initial problem stated by procurement was that the actual requirements were not aligned with the contracted requirements, this was the basis of the proposed measurement. There are two measurements that will be mentioned in this part of the research, the backward-looking reports to track the performance and a proactive report

to identify mismatches between the forecasted requirements and contracted amounts in an early stage.

The accuracy of the short-term vendor forecast should be measured on a monthly basis for the 1 month forecast lag in order to identify incorrect parameters and forecast errors. The new reporting tool is shown in Appendix E. For the different materials the short term forecast accuracy target should be different, for fast movers with long lead times like tomato paste the forecast accuracy goal should be around 85 to 90% as is should be almost perfectly predictable. For the slow movers the accuracy target can stay at 70% if the out-of-policy MOQs are reduced, which will be a challenging goal already due to the influence of lot sizing rules. Next to the short term measurement that is communicated to procurement and finance, the S&OP department can use a mid- and long term forecast accuracy measurement internally to see how much the volumes change over time. This measurement does not have to be used each month, but when procurements asks for confirmation on volume increases or decreases it is easier to identify when the change came through. For the mid and long term forecast over the period 3-12 months, the phasing of the requirements is less important. Therefore the accuracy should be measured on a cumulative basis. Instead of comparing the forecasted requirements over one month to the actual requirements over the month, the cumulative requirements can be taken into account. As all these measurements are backward-looking on the performance of historic forecast in comparison to the actuals this measurement is not directly related to problem solving. It can only identify mismatches between the forecasted and actual requirements. Therefore this research proposes a proactive measurement to identify overloads or shortages in contracts at an earlier stage.

Based on two existing reports in the Business Intelligence tool used at the company, we developed a report (See Appendix F) that combines the data from these 2 sources. The reports used are the contract status report used at procurement and the material requirements forecast. By combining these two reports the available contracted quantities of specific materials can be compared to the forecasted requirements until a contract ends. For the coordination and communication between the sales and operational planning department and the procurement department this is the most important measurement as it links material requirements and contract volume status. The measurement consists of two performance indicators. The first one is time in the contract compared to the used volumes from the contracts. The second one is showing the expected under or over material requirements. The outcome of this report is an overview that shows the available volume for each material until the contract end date.

$$Available\ volume = Used\ volume + expected\ required\ volume - contracted\ volume$$

This report can be shared with buyers and supply planners. It is up to the buyer and supply planner to see if actions should be taken. Production volumes can be moved forward if there is much contract volume left at the end of the contract period. In the case of shortages decisions need to be made on what volumes need to be bought at

spot rates. In this way the knowledge of the buyer and the supply planner are combined in the decision making process that influences both departments.

Further, we would recommend the sales and operational planning department to inform procurement directly when production volumes change more than 15% on the midterm (3 months) horizon. As procurement has indicated that suppliers can handle a short term variation in material requirements up to 15% of the communicated volume. For the short term horizon (less than 3 months) the change percentage cannot be more than 10% on the items that contribute to a large part of the total volume requirements for a material.

## 6.3 Conclusions

As most solutions already have been implemented or the first steps of the implementation process have been started the most important part is to keep the focus on the improvement. Based on the improvements that have been implemented already the current mid-and long term forecast accuracy should be around 71%. As can be seen below.

| | | | | |
|---|---|---|---|---|
| • | Current forecast | | | 59.8% |
| • | Adding the promotional forecast | + | 10% | 69.8% |
| • | Beans lead time change | + | 0.6% | 70.4% |
| • | Forecast generating process | + | 0.6% | 71.0% |
| • | MOQ Reduction | + | 0% | 71.0% |
| • | MOQ definition | + | 0% | 71.0% |

As the small, one time, improvements have been implemented and the promotional forecast horizon has been extended the next two improvements that need to be focused on are the tomato paste delivery performance and crop process that can bring another 2.8%. As the tomato tracking has been started the impact of this improvement will be reached in when the supplier starts delivering on the requested delivery date. Further, the current short term measurement is a good indicator of process flaws and improvement areas but due to the backward-looking focus this performance indicator will not directly result in less problems. Therefore the forecasted material requirements should be compared to the contracted volumes with a specific contract end date. Based on the outcomes of this report the supply planner and buyer can decide together to move production batches or to source additional materials.

# 7 Conclusion and discussion

In this chapter the general conclusions of the research conducted at the company are formulated in Section 7.1. In Section 7.2 some additional insights for new studies are mentioned and discussed.

## 7.1 Conclusions

This research focused on improving the Raws and Packs material requirements forecast. The problem statement as formulated in Chapter 2 is:

*How can the Forecast on Raw and Packaging materials at the company be improved in order to improve the reliability of the forecast volumes for procurement?*

1. *What is the current procurement and planning structure and which items face the biggest inaccuracy issues?* The forecast accuracy depends on the master data input in the SAP system to generate the Raws and Packs material requirements forecast. Then, this forecast is combined with lot-sizing rules to create the Vendor forecast to be used by procurement. Based on this Vendor forecast procurement contracts materials and the effectiveness and accuracy of this forecast become clear at the end of the contract horizon when the actuals are known. The items that face the biggest problems based on the total requirements are fast moving high volume items like tomato paste, sugar, beans, and oil. Some slow moving items with lumpy demand patterns face problems related to their phasing or timing.

2. Which solutions are known in literature to forecast raw material requirements and which factors have a large impact on the forecast generated? The raws and packs material requirements mainly depend on the finished goods demand forecast. Literature advises to forecast demand on a commercial product code and spread it over EPNs later. Next to the input from the demand forecast several other factors have a large impact on the reliability of the forecast. These factors are the Bill of Materials, safety stocks, safety lead time/ planned lead time, Lot-sizing rules, planning horizon and the frozen period.

3. How should the current R&P materials forecast be changed in order to improve the accuracy? This study has shown that the low forecast accuracy, of 59.8% on the mid- and long term horizon, on raw and packaging materials at the company is mainly driven by incorrect master data that is provided to the system. In order to improve the forecast, to reduce the contracting issues at procurement, the horizon of the promotional forecast needs to be changed to a rolling horizon. This horizon has been changed to a rolling 24 months forecast horizon and this will result in a more stable and improved forecast. Next to this there were many minor system settings that were not entered correctly. These incorrect lead time and lot sizing rules have been changed and improve the quality of the R&P forecast. From March 2017 onwards a process needs to be implemented to make sure that crop inbounds and production jobs are updated to make sure that the material requirements for these and alternative batches are forecasted in the correct periods. Some new processes need to be followed in order to make sure that the forecast is not extracted before the supply planner finishes the production plan and the night batch has been updated.

Further, there are a few processes that have been started to increase the Vendor forecast accuracy even more. When the forecast is converted into the Vendor forecast, used by procurement, high MOQs generate lumpy demand patterns. These lumpy demand patterns make it harder to forecast the timing of requirements, reduce the forecast accuracy, and bring write-off risks. Therefore a reporting tool has been developed to track the high MOQs. In the end, less planning nervousness on the short term horizon will increase the effectiveness of the decisions made at procurement to cope with the differences between contracted and actual requirements.

4. Does the proposed solution solve the errors and meet the needs of procurement? Based on the current solutions that have been implemented a forecast accuracy on 71.0% should have been reached already. Actions to improve with 2.8% more have been started and another 1.4% can be improved by changing the NPD process. The target of 70% has been reached and can be improved even further. Until now the cost related to the implementation and recurring activities related solutions are €10,000-€15,000 in total over the next 2 years.

5. How should the solution be implemented and how can it be sustained? Most proposed improvements have already been implemented. To make sure the improvements are tracked, the measurement tool has been updated and a new measurement has been developed to proactively identify overloads and shortages in contracted amounts. In the end these solutions will enable the company to maintain a stable raw and packaging material requirements forecast accuracy above the targeted 70%.

## 7.2 Discussion and additional research.

This research focused on the forecast accuracy on raws and packs for the internal the company factories in Europe. Although there are many external factories that produce for the company, these factories were not taken into account and also the non-Keystone factories were out of scope. It would be interesting to see if the same analysis that has been made for the Keystone locations also applies to the BPCS locations in Latina and Seclin. Also the repack locations Nabuurs, and the NDC, can be included in the reporting. In this section we will summarize some additional findings that can be interesting for the company for further research.

The current research has shown that the forecast accuracy on raws and packs can easily be improved to reach the targeted 70% of forecast accuracy. As shown there are short term issues that are mainly related to master data and communication, for the long term forecasted quantities system parameters and process changes played the most important role. In this section we will summarize some additional findings that can be interesting for the company for further research.

1. Study if experienced supply planners are able to deliver a more stable and less nervous production plan than newly hired Supply planners.

As the S&OP department consist of many young graduates who get promoted quite fast there are a lot of supply planners that are on the job for less than a year. Due to the lack of experience and all the different tasks that need to be fulfilled, their focus can be more on the short term problem solving then on the long term planning. Further,

they might not be fully aware of all the system settings and parameters they are responsible for even though parameters like lot sizing rules, safety stocks and lead times have a large impact on the forecast generated. Their portfolios can be quite large and due to the short term problem solving focus, the system settings are not the most important focus point. It would be interesting to see if experienced planners are able to compose a production plan with a smaller degree of nervousness.

2. Can a decision model help the Supply planners with the decision making whether or not to change the production plan on a short term horizon?

It could be assessed if a decision model should be implemented to estimate the impact of production plan changes. Changes on a short horizon can bring additional cost. Not only additional ingredients might be sourced but also overtime and logistical costs can be involved. It might be good to develop a model that is able to decide whether or not large impact changes should be made to the production plan if the savings of the plan change do not outweigh the costs.

3. Is it better to apply safety time or safety stock to raw and packaging materials with lumpy demand patterns?

There are opportunities to assess whether the weeks cover safety stock template for raws and packs that is currently used for many items, is the most optimal one for lumpy demand patterns. This template uses a minimal weeks of cover that needs to be maintained instead of a minimal stock level, so safety time is used instead of safety stock. Based on literature, safety time should be used when there is uncertainty in timing and safety stock should be used when there is uncertainty in quantities. If demand fluctuates heavily over the weeks the stock cover may look perfectly fine but when the demand peak falls in a different week this can result in out of stock situations, short term changes, and nervousness in the production plan. It would be good to execute a study to see which kinds of safety stock work the best for the different kind of demand patterns.

4. Can safety stocks be decreased by using one central warehouse to store ingredients that are used at different factories to make use of the risk pooling effect?

As some ingredients are used at several factories, these factories have material requirements on this item and place individual purchase orders for the ingredients at the supplier. It might be interesting for the company to aggregate the orders from the different sites and place one bigger order at the supplier. Tomato paste is for example ordered by 2 sites, both orders are supplied from the United States and shipped to Rotterdam. From Rotterdam the orders are shipped by an inland vessel to Nijmegen or the orders are shipped by train to Poland. In the current situations both production locations keep large amounts of safety stock due to the long lead times and high degree of dependency on these ingredients. It might be interesting to study whether it would be more profitable to keep smaller amounts of safety stocks at the factories and more in a central warehouse close to Rotterdam. Based on the buffer in Rotterdam and due to the risk pooling effect the arrivals to the factories can become more stable

and probably the total amount of safety stock can be reduced due to the risk pooling effect.

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