2018

Research Proposal

ALESSANDRO COVIELLO

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1. INTRODUCTION

Nowadays, the rapid progress of technology and the data availability increase push businesses to continually adopting new approaches to obtain and utilise information in their planning. These approaches require coordination of information sharing, speedy transmissions and visibility in supply chain to allow the manager to react properly to the correct information. In the recent years, there has been a greater tendency to share information and use IT system to make inventory, transportation and pricing decisions.

However, the implementation of processes for effective information sharing is not widespread. Ali et al. (2017) summarised different questionnaires around the globe and notified that always less than one-third of the companies involved were sharing information in the supply chain. This is also the current situation in the case at issue, so it is important and interesting to consider an environment where data are not shared.

The project is focusing on the best forecasting method and replenishment policy to adopt in a single-echelon supply chain in order to reduce inventory costs. A “horse race” is conducted between the different models (combinations of forecasting method and replenishment policy). The analysis is carried out from the supplier perspective: firstly, no sharing information is considered and, secondly, the retailers point of sales (POS) data will be shared to the supplier.

Through this research a first solution to the current situation is proposed and, successively, a comparison with the collaborative supply chain is conducted to investigate how much the new approach reduce the costs and increase the supplier service level.

1.1 LIST OF ABBREVIATIONS

APEU	Absolute Percentage Error in units
BPS	Business Problem Solving
CIBE	Ciret Benelux
CIDE	Ciret Germany
CPG	Consumer Packaged Goods
ES	Exponential Smoothing
HW	Holt Winters
IT	Information Technology
LASSO	Least Absolute Shrinkage and Selection Operator
MA	Moving Average
MAPE	Mean Absolute Percentage Error
MOQ	Minimum Order Quantity
MTS	Make to Stock
PCA	Principle Component Analysis
SARIMA	Seasonal Autoregressive Integrated Moving Average Models

2. COMPANY

In this chapter a first introduction about Data2Move community is presented and the company description is following.

2.1 DATA2MOVE

The Data2Move initiative is a research community and eco-system on the interface of Internet of Things, Big Data and Logistics/Supply Chain Management. Academics and students from Eindhoven University of Technology and Tilburg University collaborate with prominent industry partners to deliver results that are both practically and scientifically relevant. From the partnership between Pro Alliance and Eindhoven University of Technology, this project took off.

2.2 PRO ALLIANCE

Pro Alliance is a start-up company that is offering a cloud-based platform to help customers solving their inefficiencies in your supply chain by making visible what they can not see. Through the collaborative platform, it is possible to connect people from different locations and companies in the supply chain and to give members access to more, better and real time information. The members of the supply chain do not need to belong to the same firm necessarily, different communities can be created from different members depending on the role in the supply chain and their collaboration. This makes the platform more accessible by customers.

3. PROBLEMS

In this section, a follow-up about the current problems is made. Since Pro Alliance is currently a third-party data-visualization platform provider, they are looking for proposing appropriate solutions for incoming customers that are facing problems in their supply chain. Ciret, a Pro Alliance's client, is currently facing huge difficulties regarding the inventory management. Consequently, the Ciret case study will be addressed and a solution proposed, which may be useful for those companies that are facing the same challenges. To follow, the company will be introduced, and its problems analysed.

3.1 CIRET

Ciret is a supplier for Painting Tool Systems. In 2011, Ciret Holdings AG merged with Storch Holding GmbH to form the Storch-Ciret Holding GmbH. This merger made Ciret the leading expert for the painting and decorating tools in the European market. Ciret holds five different brands in the sector: Color Expert, RKMP, Westex, Contractor and DOIT. These brands offer different products such as rollers, brushes, masking tapes, painting sets and accessories for painting. Ciret Benelux (CIBE) is responsible for its products demand forecast in the geographic area that concerns Belgium, The Netherlands and Luxembourg, serving a number of stores that exceeds 700. This forecast is successively forwarded to the headquarter in Germany; it is required to manage the production, the inventory, the replenishment and the incoming distribution processes.

3.2 INVENTORY

The main challenges CIBE is currently facing refers to the inventory management. The problems are shown below.

3.2.1 OVERSTOCKING

Overstocking is one of the major problems in the company. The excessive number of products on stock is highly increasing the related inventory costs. *Table 1* shows the stock worth in the last seven years compared to the company turnover. The stock worth and turnover located in the year 2018 refers respectively to the current inventory worth and the budget planned for the year, while the others stock worth correspond to the average values per year.

Year	Stock worth (K€)	Turnover (K€)	Stock worth / Turnover %
2012	405	2300	18%
2013	400	3000	13%
2014	436	3200	14%
2015	443	3100	14%
2016	500	3400	15%
2017	844	4700	18%
2018	1700	5000	34%

Table 1. Yearly Stock worth and Turnover

In this table it is possible to recognize how both the turnover and the stock worth increased smoothly throughout the years. However, the stock worth followed the same trend of the company's growth and the correlated inventory costs are continuing to increase from 2013. Another overview is proposed in *Figure 1,* which shows how the total inventory increased during the last winter period. The company managed to reduce by one hundred thousand unit the new articles at stock, as shown in *Figure 3*, but both the regular and old articles increased in the last 7 months. Even though the company do not apply any target for the inventory position, their goal is to obtain a value of inventory turnover above 4, which is far from reality as shown in *Figure 2* and *Figure 3*.

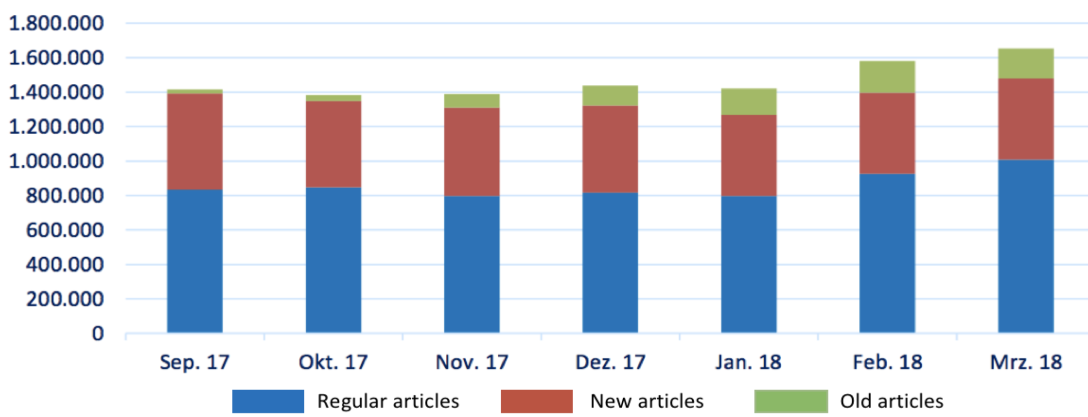

Figure 1. Inventory level in the last 7 months

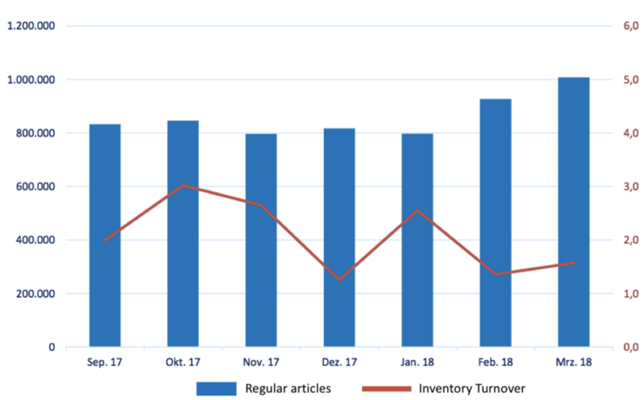

Figure 2. Inventory position of the regular articles

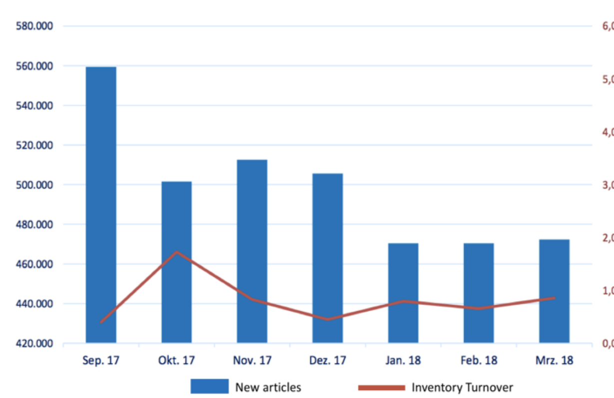

Figure 3. Inventory position of the new articles

Moreover, *Table 3*, in the following chapter, confirms that overstocking is the most frequently-occurring effect in the company: the overestimated values exceed more than twice the underestimated ones in the last 3 months, with a difference of 420 thousand pieces.

In conclusion, CIBE managers would like to reduce the inventory costs as much as possible and at the same time consider the required service level and the company's constraints.

3.2.2 OUT-OF-STOCK

The other major problems that CIBE is facing is the inability to cover the 100% of the demand in time. This leads to very high costs, but also to other indirect effects that are not easy to quantify, such as brand imagine, sales and customer loss. *Table 3* shows how the company underestimated actual sales, which leads to further inventory issues. In the last 3 months CIBE underestimated 163 items, 58 of which have a 274% of deviation and cause a mismatch quantity of more than 250 thousand products. In total, in the last 3 months, one-fifth of the entire list of items in the catalogue were underestimated with a weighted average of 245%. This effect has an impact on the on time in full delivery (OTIF) values, shown in *Table 2*. January and February were marked respectively with almost 20% and 10% of delays, even though the inventory is currently stocking more than one-third of the annual sales. Everything points to inaccurate choices on the quantity, the time, and the type of item to stock.

	Month	OTIF in worth	Aggregate	Target
2018	January	80,2%	80,2%	97,0%
	February	90,9%	84,2%	
	March	97,3%	88,0%	

Table 2. OTIF in worth in the last 3 months

4. CAUSES

In order to solve the problems described, the causes need to be identified and analysed. The list of possible causes follows below.

4.1 REPLENISHMENT POLICY AND INVENTORY PLANNING

The high inventory costs and poor inventory KPI values are closely related to the replenishment policy and the inventory planning. In fact, replenishment process defines the review period for reordering and the ordering quantity, while the inventory planning process establishes the optimal inventory levels that must be maintained to meet expected service levels for demand fulfilment. The replenishment policy adopted by CIDE is described in the next paragraph. Both the safety stock and the ordering quantity required the forecast generated by CIBE.

4.2 FORECAST INACCURACY

The forecasting inaccuracy is another major cause that leads to overstocking and stock-outs. In fact, in all the supply chain under which the MTS strategy is adopted, the demand forecast plays a really important role, anticipating the production, replenishment and inventory phases in the supply chain process. The following table is showing the actual sales compared to the corresponding forecast in the last 3 months.

	Deviation Classes	Number of SKUs	Sum of the quantity deviation between actual and forecasted sales in the last 3 months	Average of percentage deviations in the last 3 months [%]	Weighted average of percentage deviations in the last 3 months [%]	Sum of the quantities at stock for those SKUs in the deviation class	Sum of the worth at stock for those SKUs in the deviation class [€]	Sum of the planned quantities for the next 12 months for those SKUs in the deviation class
	No Deviation	12	0	0,0	0,0	12.341	10.372	10.545
Underestimation	Less than 10%	37	-5.517	-5,2	-6,0	44.447	47.254	116.286
	From 10% to 25%	34	-12.773	-15,6	-15,7	44.171	38.779	86.626
	From 25% to 50%	34	-14.101	-34,2	-34,2	30.241	34.649	43.124
	More than 50%	58	-254.263	-163,5	-274,0	62.550	86.473	150.123
	Total	163	-286.654	-69,7	-245,6	181.409	207.154	396.158
Overestimation	Less than 10%	53	5.606	5,6	6,6	67.546	90.539	111.692
	From 10% to 25%	103	44.305	17,7	17,4	119.305	90.368	276.582
	From 25% to 50%	182	175.721	37,5	38,9	272.995	215.068	465.396
	More than 50%	282	482.946	76,6	81,1	693.366	706.331	657.795
	Total	620	708.579	49,2	66,0	1.153.212	1.102.306	1.511.465
	Total	795	421.925	24,5	-55,9	1.346.961	1.309.460	1.918.168

Table 3. Forecast and actual sales deviation

Through *Table 3* it is possible to evaluate the forecast accuracy. The second column already gives a good overview of the current forecast's meagerness: the demand forecast of only 102 over the 795 SKUs deviate less than 10% from the actual sales, while the demand forecast for the 70% of the SKUs exceed the 25% of deviation. The third column shows how in the last 3 months almost 1 million of pieces were not estimated correctly, with one-third of them were underestimated and two-third overestimated. Column 4, and 5 show respectively the average, and the weighted average of the percentage deviations in the last 3 months. In conclusion, column 5, 6 and 7 refer to the current inventory level, its worth and the forecasted quantities for the incoming 12 months for those SKUs in the deviation class in order to check how much the following year sales are already covered and how much has been stocked in the past years. These high deviations were also in part due to the non-inclusion of the promotions and installations disposal in generating the forecast. These incorrect forecasts that previously resulted in bad performances have meanwhile been corrected by newly calculated forecasts. The new calculation resulted in an average decrease in demand forecast of 13% compared to the previous version.

4.3 NEW CONCEPT

In 2017 the company introduced a new shelf concept, which carried new articles and new substitutes with it. Switching the ERP system in the same period makes retrieving the data even more complicated.

Moving from old to new products concept results in creating a double SKUs inventory. For example, Table 4 shows an article that is currently present in the warehouse with both old and new version.

Type	Article	Stock (Qty)
Old version	81283044	2.148
New version	81283099	16.260

Table 4. Double stock example

Ciret's customers are now asking for the new product version and they also expect the supplier to take the old ones back. Consequently, the stock level of the old version could continue to increase because of return goods from the stores.

4.4 EXPANSION

The strong position of the company in the market and the new concept make Ciret's products more attractive for the customers, who decide to adopt them in their stores from day to day. Only last year, CIBE has gained more than 200 new stores. Consequently, the products sale increase required from the market leads Ciret to order directly from China due to limited capacity of the local suppliers and stocks. This solution gives a higher lead time and MOQ, and, therefore, higher future costs in case of errors on forecasting the sales.

Supplier	LT (weeks)	Share <2017	Share 2017	Share 2018	Evolution
Local suppliers and stock	2	72%	56%	45%	-27%
Internal European production	6	22%	22%	20%	-2%
Asian and external production	24	6%	21%	35%	29%

Table 5. Suppliers evolutions over the years

Table 5 displays the evolution of the quantities ordered from the different suppliers over the years. The table shows how in the last three years almost a third of the supply moved from Europe to Extra-EU factories, increasing the corresponding lead time. Moreover, expansion also results in higher quantity of goods return, consisting of old articles version and competitors' products. In conclusion, demand forecasting for those new stores is even harder to estimate because the turnover forecasts given by the customers in the tender processes turned out to be unrealistically high.

4.5 OUT OF ASSORTIMENT

CIDE, the headquarter in Germany, decide to stop certain articles because of a variety of reasons such as limited turnover, limited margin or problems with the supplier. However, some of these articles are still required by CIBE and, due the production downtime, it is no longer possible to buy them in small quantities from the stock in Germany, but higher orders are directly required from the production. This means that forecast errors now have an even larger impact on the overall costs.

5. PROCESS

In order to locate the limits of the CIBE forecasting model and CIDE replenishment policy, the supply chain structure and its processes need to be understood and analysed. This is the first step to understand the current forecast and replenishment models, their limitation and evaluate which kind of changing could help to improve them. Accordingly, the following chapter will focus first on the CIBE forecast process and then on the CIDE replenishment policy.

5.1 SUPPLY CHAIN STRUCTURE

As already introduced before, Ciret Benelux is responsible for the geographic area concerning Belgium, The Netherlands and Luxembourg. Everyday CIBE receives and manages the orders from those customers in these three countries. Moreover, twice a year, CIBE creates the sales forecast for the incoming 12 months and sends their predictions to CIDE. The German headquarter needs this forecast, as the ones from the other regions, to organize the replenishment process. The orders are sent to the 4 different factories, depending on the product type and on the urgency. These factories are located in Struth (DE), Pelhřimov (CZ), Beijing (CN) and Zheijang (CN). Successively, the quantity ordered is shipped to the CIBE Distribution Center in Belgium, ready to be delivered as soon as one customer in the Benelux area generate an order. It can happen that, for a certain product and for a certain quantity, the shipment to the CIBE DC would arrive from the CIDE DC. The information (dotted lines) and goods flows (solid lines) are represented in the *Figure 4*. The corresponding lead times are expressed in the previous *Table 5*.

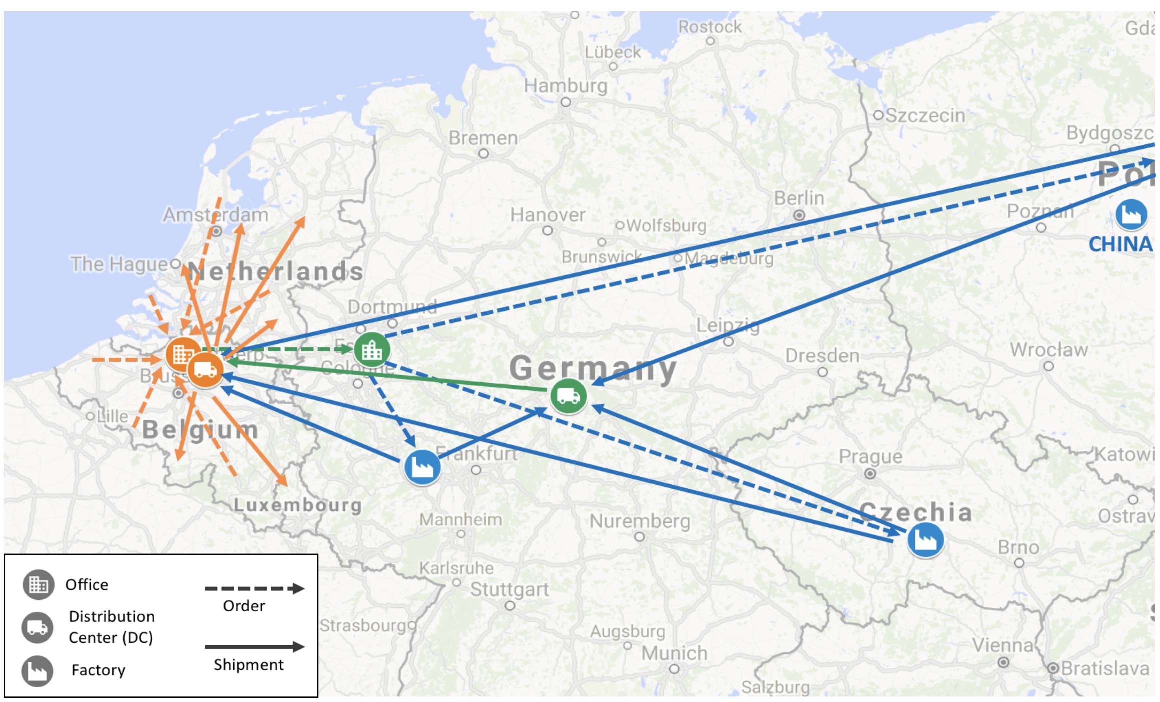

Figure 4. Supply Chain Structure

5.2 FORECASTING MODEL

The forecast process currently used in the company is shown at page 14.

Ciret Benelux is not using any time-series method to forecast the future sales. The forecast is a yearly forecast that is updated twice a year, generally in May and September, right before the high and low season respectively. In summary, CIBE forecast is based on checking the same six months of the previous year and adjusting these values based on the company market growth, new concept, new opening stores and further promotions. All of these adjustments are manually made.

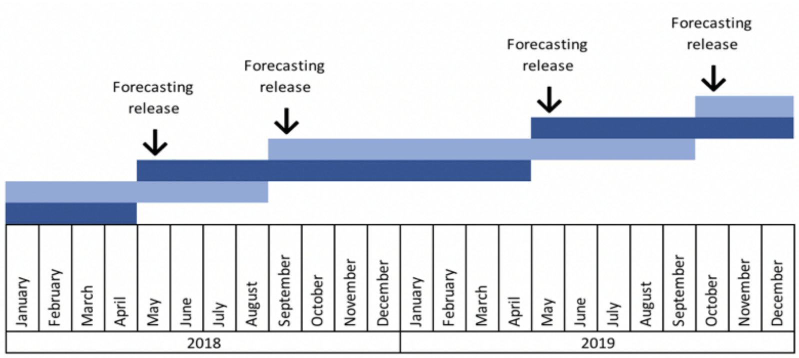

Figure 5. Forecasting release over time period

5.2.1 DATA USED

The data used in the forecast creation are the historical sales, current company growth/budget in the market and past company turnover per month. In fact, for those new articles, CIBE has past information only starting from September and it makes hard to tell the product seasonality. Successively, adjustments for any incoming promotional events or new installations are made by the managers based on their experiences.

5.3 REPLENISHMENT POLICY

The replenishment policy applied by CIDE is the traditional continuous review policy (s,Q) inventory policy. When the inventory level gets underneath a certain level s, which is defined by the safety stock (SS) and expected demand during the supplier lead time, CIDE places an order Q, which mirrors the EOQ method. The ordering quantity is identified with the following formula:

$$Q = \sqrt{\frac{2 \cdot A \cdot F}{p \cdot (i + s)}} \qquad [1]$$

With:

Q: optimal order quantity
A: fixed ordering cost
F: yearly forecast for the article
p: unit price
i: interest rate
s: storage cost rate

$$s = \frac{storage\ cost\ rate\ per\ cm^3 \cdot article\ Volume\ (mm^3)}{1000} \qquad [2]$$

The safety stock, instead, is calculated as follow:

$$SS = z \cdot \sqrt{E(L) \cdot \delta_F^2 + \left(E(F)\right)^2 \cdot \delta_L^2} \qquad [3]$$

It considers the supplier unreliability and the forecast uncertainty, in particular:

E(L): mean lead time
δ_F^2: Standard deviation of the forecast
E(F): Mean forecast
δ_L^2: Standard deviation of the lead time

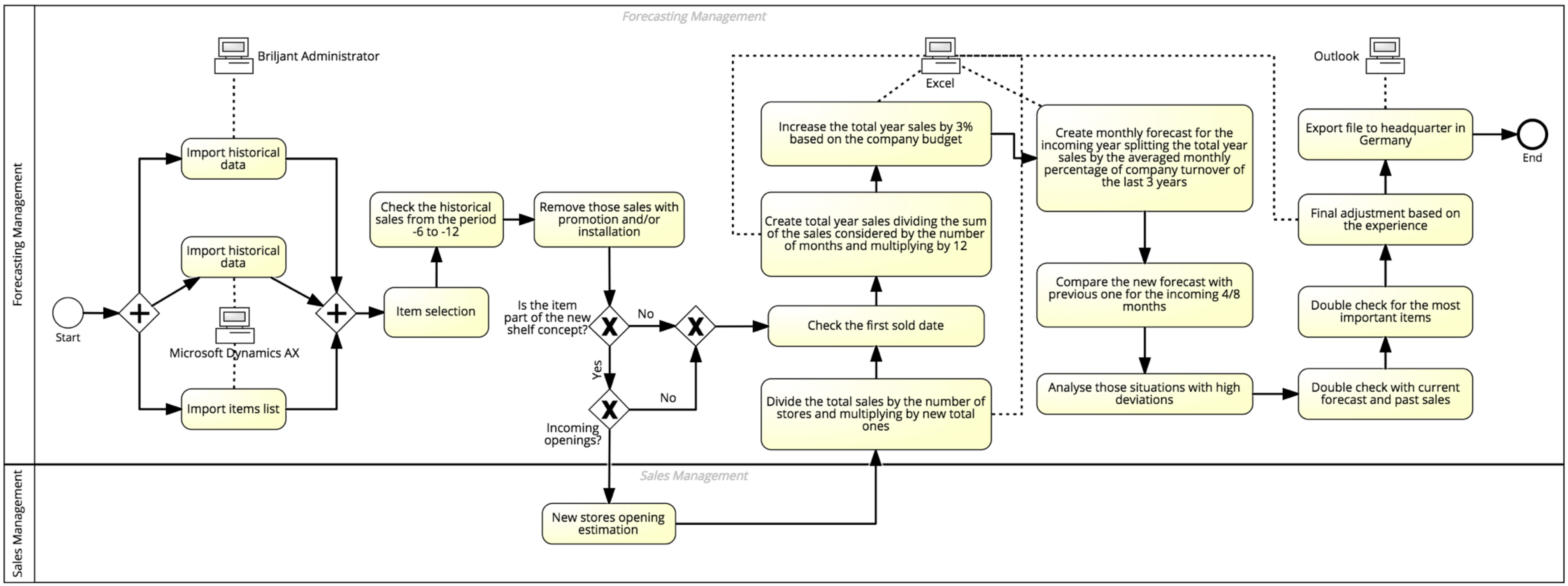

Figure 6. Ciret forecasting process

6. RESEARCH QUESTION

The Master thesis is going to answer the following question:

"How can the supplier reduce the inventory costs by the use of accurate forecasting model and replenishment policy regarding the Do-It-Yourself and home products in the retailing industry?"

6.1 SUBQUESTIONS

- *Which forecasting tool is Ciret Benelux currently using and its effects on the inventory?*
  In order to improve the current approach, it is important to understand which kind of forecasting tool is CIBE using, how the process works, what it considers and which problems it is leading to.

- *Which factors are relevant for the forecast?*
  In order to get the best forecast model to be used, it is important to identify which factors are actually affecting the demand and, then, are relevant to the forecast.

- W*hich model and data can be used to improve the forecast?*
  Different forecasting models will show which model performs the best and which kind of data of the available ones need to be considered to achieve this result.

- *Which replenishment policy is CIDE currently using and its effects on the inventory?*
  As for the forecast before, it is important to understand which kind of replenishment policy is CIDE using, how it works and which problems it is leading to.

- *Which costs are involved in the inventory replenishment process?*
  The main objective of an inventory replenishment system is to minimize the total costs. Therefore, the costs that will be taken into account have to be defined first.

- *Which replenishment policy can be used to decrease the inventory costs?*
  A simulation approach will be used to determine which replenishment policy guarantees the best inventory performances.

- *How can the supply community improve the forecast and the inventory performances?*
  Pro Alliance is offering a collaborative cloud-based platform to connect different people/parties in the supply chain and to give them access to more, better and real time information. Thus, it would be interesting to understand and evaluate how and how much a supply chain community and their information shared can improve the forecast accuracy from the supplier perspective and the inventory performances.

7. METHODOLOGY

In this section the methodology used to identify, analyse and solve the problems is discussed. The first part of this chapter focuses on the methodology, the remaining ones concern the following steps in this Master thesis.

7.1 BUSINESS PROBLEM SOLVING

According to van Strien (1997), this project can be addressed using the Business Problem Solving (BPS) approach, the so-called Regulative Cycle. Improving the performance of a business system, department or a company, is the aim of the BPS projects. The basis is identifying a set of issues from which a problem definition will be created. As shown in *Figure 7*, the classic problem-solving cycle consists of five separated parts: problem definition, analysis and diagnosis, plan of action, intervention and evaluation. For the present case, however, only the design part is considered (problem definition, analysis and diagnosis and plan of action). The remaining steps, instead, intervention and evaluation, are not added because they are not within the aim of this project.

Figure 7. Regulative Cycle by van Strien

7.2 IDENTIFY AVAILABLE DATA

The first step to obtain positive outcomes is a set of interviews with CIBE's managers. The semi-structured interviews are needed in order to collect information about products/markets, the company's organizational structure, the supply network structure, promotions, the forecasting method adopted, the replenishment policy followed, information and communication technologies. The documents collection concerns documents on process and product structures, useful data concerning the research, the company's organizational structure, the supply network configuration and reports on performance measurement.

7.3 DATA PREPARATION

The historical order sales are the core of the dataset required for testing the different forecasting and replenishment methods proposed in the Master thesis. Ciret Benelux is currently going through a period of dramatic change, due to the switch from one to another ERP system (from Briljant Administrator to System Dynamics 2012 AX R3) last September and the introduction of new articles and new shelf concept for the retailing stores. Consequently, these changes require further data preparation to create a dataset useful for the project.

First, the analysis would be based only on those items/families that cover the 75/80% of the yearly company turnover, in order to reduce the number of items to test and only concentrate on the most important ones. Second, the data preparation consists of implementing together the two databases from the two ERP systems, creating the historical sales only for those items currently on sale and assisting it with separated datasets that include all those relevant information for the demand forecast. Two versions of the historical sales dataset are created: one for the forecasting method that is not considering negative values and the other for the replenishment policy with the negative values. The third step is focusing on splitting the data into a train and validation set. The train set is used to develop the forecasting and replenishment models, while the validation set is used for the validation of the results. The fourth and last phase is the identification of the outliers in the dataset.

7.4 FORECASTING MODEL

In this chapter, a solution for the first part of the problem and the associated change plan is designed. To solve the business problem the existing literature is used to get a range of solution concepts. Out of this range those models that are the more appropriate ones are chosen, whereupon specific variants could be designed. These variants are adapted to the specific problem and its context. In this research different models are tested in order to find the one that best fits the corresponding situations.

The first forecasting methods proposed are the time-series, which are widely spread and used in the PCG industry, especially to forecast the order demand. Since the orders demand presents seasonality, only those forecasting methods that are able to identify the seasonality are selected. Holt Winters (HW) forecasting method (Taylor, 2007; Bayraktar et al., 2008; Williams & Waller, 2010; Costantino et al., 2016) and SARIMA (Choi et al., 2011; Ramos et al., 2015; Box et al., 2015) are widely used in the literature for those sales that present seasonality patterns. Moving forward, a second forecasting method can be proposed for the demand forecast: the stepwise linear regression. With the increase in technology and data availability in the last decade, the linear regression increasingly gained ground for the sales forecast. The LASSO Granger causality test can be conducted, due to the high dimensional time series that need to be analysed to discover causal relationship among the articles (Ma et al., 2016). Successively, different approaches can be used to deal with the high dimensional information: manual predictor selection or Principle Component Analysis (PCA) (Ma et al., 2016). And, finally, the multistage LASSO process is proposed.

7.5 REPLENISHMENT POLICY

The most common replenishment policy used in CPG contexts are the continuous (s,Q), (s,S) and periodical (R,S), (R,s,S) policies. Instead, for a lost sales system with periodic review and a service level restriction, an (R,s,nQ) policy has been shown to perform close to optimal

(Bijvank, 2011). Consequently, the latter is considered as traditional order up to (OUT) policy in the project. Lately, other three approaches are introduced and proposed. The Smoothing Order-Up-To policy was widely used and tested among the researchers (Dejonckheere et al., 2004; Disney et al., 2006; Costantino et al., 2015; Costantino et al., 2016). Another method that it would be worthwhile also to examine is the statistical process control (SPC) based replenishment method (Costantino et al., 2015, Cheng & Chou, 2008). The last method that is considered is the Joint Replenishment Policy (JRP) (Kiesmüller, 2009).

These methods are examined to evaluate which one fits the best with the present case.

7.6 RESULTS

The new forecasting models and replenishment policy will be tested and compared with the previous one using actual data of CIBE, successively the benefits and further room of improvements will be identified. To evaluate these new models, different error measures can be utilized, respectively for the forecast and replenishment part.

7.6.1 FORECAST PERFORMANCES

Even if the final goal is to reduce the total inventory costs and increase the service level, a performance measure to identify which forecasting method perform the best can be useful. The literature presents a wide variety of error measures, from which a generic one is selected: Mean Absolute Percentage Error (MAPE) (Divakar et al., 2005; Fildes et al., 2009; Williams et al., 2014; Huang et al., 2014; Ramos et al., 2015). Another error measure to take into account is the Absolute Percentage Error in units (APEU). In fact, APEU focuses on case errors and, consequently, it could be more useful when the ordering is done in case unit (Cooper, 1999).

7.6.2 REPLENISHMENT PERFORMANCES

Regarding the best replenishment policy to adopt, tests will be conducted to locate the best process that guarantees the higher performances and, at the same time, respects the service level required from the company. Different performance measures can be considered. The most common and relevant ones are the inventory costs, averaged inventory and fill rate. (Disney et al., 2006; Lee & Wu, 2006; Kelepouris et al., 2007; Broekmeulen & van Donselaar, 2009; Cho & Lee, 2013; Grewal & Rogers, 2015; Costantino et al., 2015; Costantino et al., 2016; Pacheco et al., 2017)
However, other measures can be used, such as bullwhip effect ratio, order variance, inventory variance and inventory turnover. (Dejonckheere et al., 2004; Disney et al., 2006; Kelepouris et al., 2007; Cho & Lee, 2013; Costantino et al., 2015; Costantino et al., 2016; de Oliveira Pacheco et al., 2017).

8. SCHEDULE

The MSc thesis can be programmed as follows:

Object	Time
Identify available and used data	
Interviews	week 1
Data preparation	
Merging two datasets	week 1
Adding extra dataset	week 2
Cleaning datasets	week 2
Forecasting model and Testing	
Time-series approaches	week 4
Linear regression approach	week 5
Testing and discussion	week 7
Replenishment Policy	
Building up different replenishment models	week 8
Simulation and parameters identification	week 9
Results and discussion	week 10
Sharing Information	
Time-series approaches	week 11
Linear regression approach	week 12
Replenishment models and simulation	week 14
Results	
Analysing the results obtained from the tests	week 15
Discussion and conclusion	week 16

The Gantt chart in the following page shows these steps.

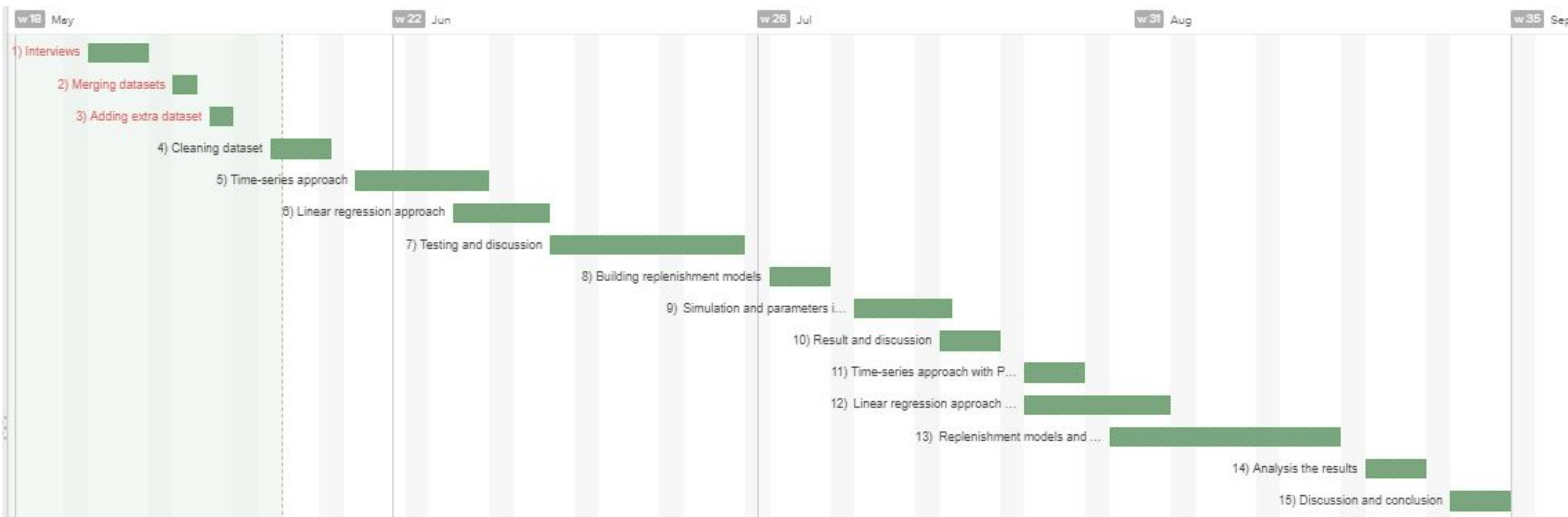

Figure 8. Gantt chart

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