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DESIGN OF A SUPPLY CHAIN MANAGEMENT DASHBOARD

Information sharing to mitigate the bullwhip effect

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Proposal for Project Work report presented as partial requirement for obtaining the Master's degree in Information Management

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INFORMATION SHARING TO MITIGATE THE BULLWHIP EFFECT

by

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Proposal for Project Work report presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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ABSTRACT

Supply Chain Management is perceived as a key success area to organizations. It has developed gradually through the last decades evolving from "the physical distribution to having a key role in organizations' competitiveness".

The Bullwhip Effect is a major Supply Chain Management challenge, caused by the uncertainty and variability in the demand that is amplified along the supply chain. This effect brings inefficiencies to the supply chain in financial and operational terms.

The focus of this project is the exploitation of Company X's Supply Chain Management data to develop a dashboard that can display the overall information to the different actors evolved in this supply chain, with the main goal of mitigate the bullwhip effect through information sharing.

This project starts with a literature review with two main focus: supply chain management and business intelligence. It presents a framework of the supply chain management, how it is described and its challenges. Besides that, it explores the best practices to develop effective information visualization in a dashboard context.

A research was carried out in order to choose the best measures and metrics to be presented in the dashboard, enhancing the use of the available data.

The output of this project is a dashboard displaying supply chain management measures and metrics of demand forecast, inventory information, order information and purchasing forecast.

This project was designed and it is ready to be applied in a real context.

KEYWORDS

Supply Chain Management; Bullwhip Effect; Information Sharing; Data Visualization

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LIST OF ABBREVIATIONS AND ACRONYMS

APICS	American Production and Inventory Control Society
APQC	American Productivity & Quality Centre
BI	Business Intelligence
BWE	Bullwhip Effect
CFT	Cosmetic, Fragrances and Toiletries
CSCMP	Council of Supply Chain Management Professionals
DSR	Design Science Research
IT	Information Technology
KPI	Key Performance Indicator
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
OFR	Order Fill Rate
SC	Supply Chain
SCM	Supply Chain Management
SKU	Stock Keeping Unit
SLA	Service Level Agreement
WAPE	Weighted Average Percentage Error
3PL	Third Party Logistics

1. INTRODUCTION

Supply Chain Management (SCM) is a key area that faces many challenges. This project focus on the supply chain (SC) and specifically on the bullwhip effect (BWE) mitigation. To reach it, this project will benefit from the use of information sharing and visualization, generating a great advantage to data analysis, turning this key task efficient and intuitive.

This project main goal is the development of a BI model solution to monitor and control the SC. The final delivery will be an SCM Dashboard aggregating relevant measures and metrics for information sharing and decision making.

1.1. BACKGROUND

In the early 80s, Michael Porter introduced the concept of value chain as a different perspective of looking to organizations. The main goal was to enhance customer value by adding it to products or services. The starting point is to consider that a company is divided in two major group activities: Primary activities and Support activities.

Primary activities are directly related with the creation, commercialization and support of a product or service and include Logistics, Operations, Sales and Marketing, while Support activities assist the operation of the Primary activities and include Human Resources, Procurement and R&D.

The value chain is presented as a valuable tool to identify where the great value lies in an organization and how to increase it (Porter, 1985).

SCM exists in a fundamental exchange relationship and as a complement to value chain. While value chain is providing the revenue that sustains supply chain, in parallel the supply chain is combining the efforts to create and deliver products or services to the final customers (Cox, 1999).

SCM changed from the physical distribution to a “cost-effective, reliable and predictable service”. (Arefin, Hoque, & Bao, 2015). This area is considered as a key role to stay competitive and to enhance profit in challenging global markets (Childerhouse & Towill, 2003).

The area gained attention from organization’s strategic roles so it lead to the development of SCM. At this point, the role of Information Technology (IT) has revealed as critical to the effectiveness of these developments, taking advantage of the increase of computer power (Arefin et al., 2015).

The opportunity of using computer power for improvement of SCM is also a challenge, since it is bringing more data and more efficient processes. To ensure these characteristics’ of excellence, the need to measure and evaluate the processes rises.

As consequence, the need to acquire data and organize it has become fundamental. Business Intelligence (BI) matches in this critical step, being defined as the whole process of managing data, gathering it and transforming it into information that may support the decision making process (Wieder & Ossimitz, 2015).

The analysis of data is supplied by Business Analytics through analysis models and data analysis procedures. It is the use of data, statistical and quantitative analysis which "provide inputs to decision making or even fully automated decisions" (Ittmann, 2015).

Davenport referred in 'Competing on Analytics'[1], that analytics focusing on SCM allows to "simulate and optimize supply chain flows" and also "reduce inventory and stock-outs" (Davenport et al., 2006).

Ittmann also identified that the better tools to perform simpler analysis, and the usage of advanced data visualization to present great volumes of data visually, are two focus of supply chain analytics (Ittmann, 2015).

A picture is worth a thousand words, and information visualization is proving it. As a research field in development, information visualization is being used to captivate users to analyse data in a more effectively way. In a combination of data, eyes and mind, the information that could remain unnoticed in tables or text, decreases when displayed by visualization (Few, 2008). The display of information through visualization encourages the user to be alert, critic and to take actions.

1.2. PROBLEM DEFINITION

Group Y is a North American multinational company in the beauty industry which develops, produces and sells cosmetics, fragrances and toiletries (CFT). The company operates with both own and franchising operations in eighteen countries beyond the country of origin.

The company has been developing its activity in Portugal for more than ten years as Company X, the first operation outside the origin country. With a multi-channel operation, the branch (with own operation) oversees more than fifty stores in Portugal and an E-Commerce channel.

It was identified a BWE in the SC as there is high variability in demand forecast versus the actual sales.

Group Y and Company X have a two-echelon SC. Group Y is the only supplier of Company X, which implies a huge dependence, and considering the geography of both organizations, a large lead-time that can reach up to six months.

Company X manages its orders with an Order Up-To Model, also known as P model. At each month, a replenishment order is submitted to Group Y, considering demand updates and on-hand/in-transit inventory. In the same period a previous order should be received if the lead-time is respected.

The challenge is that Company X demand is non-smooth since the company products are a seasonal choice for the final consumer, having peaks of sales that increase during festive seasons and commemorative dates.

[1] First time the term 'analytics' was used in an article title.

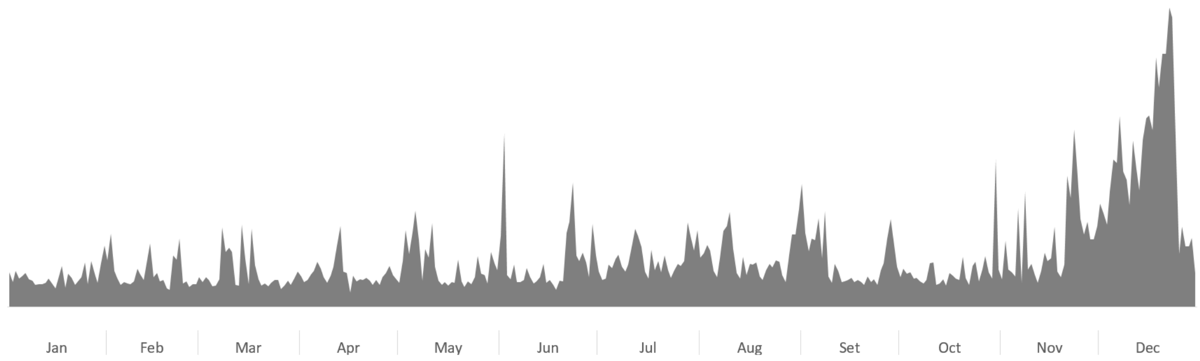


Figure 1 – Seasonality of Company X's customer demand

SCM is considered, in parallel of Sales and Marketing, a key driver for business success. Nevertheless, currently the company does not provide any SC information in a prompt and clear way.

Both Group Y and Company X systems are not integrated, meaning that all the products sold to Company X are only recognized as inventory after being at the Portuguese distribution centre. Any information about these products must be collected from offline support such as emails and excel files. As result Company X does not have the knowledge of the total volume and investment in inventory over the SC.

Besides the full track of the inventory, there is no sell-out or purchasing forecast available to the interested departments. This is a clear opportunity to monitor demand forecast accuracy and improve the process.

This lack of information creates a high dependency of different departments to the logistic and demand planning departments, increasing the workload to the teams with manual and repetitive tasks of data aggregation. In addition, this human intervention can easily drive to errors with high impact in the operation. It also reduces time for logistics and demand planning departments to perform core role activities like monitor and control the SC, identify problems and apply mitigation plans.

1.3. MAIN GOAL AND SPECIFIC OBJECTIVES

The main goal of this project is the design of a dashboard's conceptual model for information sharing to mitigate the BWE by focusing in the demand forecast, inventory and order information.

Figure 2 – Overview of inventory depot/status along Company X's SC

To achieve the main goal, the following specific objectives have been defined:

1. Define relevant metrics to be monitored;
2. Assess the demand forecast accuracy and share future customer demand forecast;

3. Identify and share the inventory information along the SC;
4. Monitor order information and share purchasing forecast.

1.4. STUDY RELEVANCE AND IMPORTANCE

This project is justified by the following rational and impact in the company:

Local Branch and Group Wide: SCM is one of the core areas of the company that currently does not beneficiates of the attention and investment needed to respond to the challenges proposed. It was considered as an opportunity to focus on the BWE problem and to develop a project targeting the mitigation of this problem. It was identified that sell-out information, inventory status and future orders sharing mitigate the BWE. This is a lack in the company since this information is not being shared. As a result, this is the major focus of this project.

Information Accuracy: nowadays all the reports are manual, through the compilation of data from multiple sources. The information reliability is compromised so it is important to bring a solution that can assure quality to the information shared.

Supply Chain: expected mitigation of BWE over the Company X and Group Y supply chains. By sharing the sell-out demand forecast, inventory information and purchasing forecast, Group Y will have more accurate information to plan, source and manufacturing activities.

Logistics Department: the department is bogged down in repetitive tasks, not having time to develop analytical tasks and continuous improvement projects.

Demand Forecast: this process is not being assessed and has a major impact in the SC planning. Without measuring it, the company doesn't have the confidence to support the whole operation in this data. It is considered critical to measure and share the results.

1.5. METHODOLOGY

The proposed methodology for this project implementation is the Design Science Research (DSR). This methodology was chosen considering the main objective of the project: the creation of innovative IT products or artifacts, useful and fundamental to understand and solve a question or a problem with utility in the application environment (V. Vaishnavi & Kuechler, 2008), producing knowledge and change.

In this project, the artifacts will be the dashboards and will be developed based in the knowledge flows, process steps and outputs.

This approach presents five different steps of implementation: 1) Awareness of Problem, 2) Suggestion, 3) Development, 4) Evaluation, and 5) Conclusion.

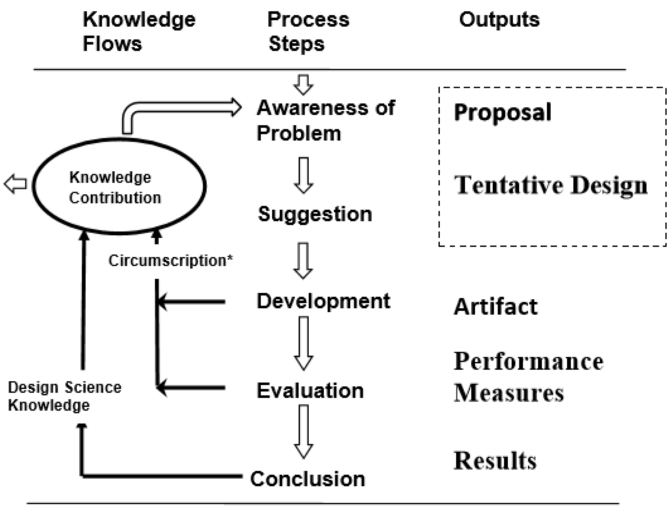


Figure 3 – DSR Process Model (DSR Cycle) (V. Vaishnavi & Kuechler, 2008)

Awareness of Problem: The knowledge, perception and concern of the problem. It was recognized a BWE in the SC, being required to share information of demand forecast, inventory and orders over the SC. This lack of knowledge undermines the welfare of the company by not knowing on time their risks and opportunities. This project will be critical to move from a contingency management model to a mitigation model with impact in operational departments (commercial and operational planning that rule the operation directly) and in the general management (that will be allowed to criticalize and dig in the data). The dashboard components' will be defined by the output of the literature review with focus in the BI in SCM (BWE). The awareness of the problem is explained in the Problem Definition section.

Suggestion: Presentation of the tentative design of how the problem will be addressed. The 'Suggestion' is the creative step of the process, where the prototypes (artifacts) will be developed. The design of the prototypes and the metrics will be chosen considering the best practices in the literature review.

Development: Implementation of the tentative design. At this stage, the tentative design is completed and developed. It will be necessary to define how to apply the designed solution. An analysis will be developed to identify the best tool to implement the artifacts, meeting the company needs and the available resources. The data that will feed the artifacts is property of the company and will be provided to the selected tool.

Evaluation: Presentation of the performance measures. In this step, an assessment will be made to identify the artifact implementation impact in the problem resolution. The evaluation may arise awareness in other subjects related with the problem and bring new suggestions. As a result, new developments and evaluation steps may concern possible adjustments.

Conclusion: Presentation of the research's results. It will be determined if the artifact suited or not the requirements for the problem resolution.

2. LITERATURE REVIEW

In this chapter is presented the literature review that served as theoretical fundamental to the development of this project.

In first place, it is presented a description of SCM and its importance as a critical area for organizations. The BWE explanation will be covered in this section.

The chapter follows with the interaction of the BI in the SCM area, and finally, it will be introduced performance measurement and the best practices in information visualization and dashboards.

2.1. SUPPLY CHAIN MANAGEMENT

The term SCM was introduced in the early 1980s as an improved stage of logistics management, looking outside the organization itself, and start focusing also in suppliers and customers including and considering them in the overall process flow. (Haraburda & Col, 2016)

The importance of the SCM switched in the moment that it went from the physical distribution to the insurance of a "cost-effective, reliable and predictable service". (Arefin, Hoque, & Bao, 2015)

The Council of Supply Chain Management Professionals (CSCMP) defines SCM as the area that "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies."(Vitasek, 2013)

On the other hand, APICS (American Production and Inventory Control Society) defines it as "the design, planning, execution, control, and monitoring of SC activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply and demand, and measuring performance globally." (Ariza, Buitrago, & R, 2008)

SCM evolved to a more complete area in an organization. Both CSCMP and APICS identify the following as critical to properly define SCM: planning, monitor the SCM activities within its different links and coordinate the supply and demand management.

It is demanding to have a good relationship with all the links involved – suppliers and customers – as the SC represents the path of a product from the supplier until the final customer. There are many steps before the landing product to the final consumer: they concern purchases, inventory control, handling, storage and transportation. (Langlois & Chauvel, 2017)

SCM is a distinct area of organizations, assuming an important role to a company to stay competitive and to enhance profit in challenging global markets (Childerhouse & Towill, 2003). SC costs may quash from 50% to 70% of a company's profit (Myerson, 2015), which shows a great opportunity to lower costs through the SCM.

The cost reduction may touch different areas such as procurement, production, financial capital and possession costs, transfer, breaking, product design and insurance costs. (Langlois & Chauvel, 2017)

For all of this, SCM presents itself as a key to figure out the continuous changing business environment. Organizations are facing multiple challenges as the competition increases, the expansion of markets arises, and the customers have more power and rising expectations. All of these challenges contribute to a high rate of demand uncertainty (Simatupang & Sridharan, 2009).

The supply and demand uncertainty are key points of improvement. By working directly on it and in the integration of activities, collaboration and information sharing through the different links of SCM, arises the opportunity to reduce on-hand stocks, shorten throughput times and get a more competitive SC (Millet, Schmitt, & Botta-Genoulaz, 2009).

The demand uncertainty causes the BWE, a phenomenon characterized by the variability in the demand that is amplified along the SC, causing inefficiencies (Bray & Mendelson, 2012) as:

- high inventory;
- low service level;
- low quality;
- increased operation cost. (Jeong & Hong, 2017).

These inefficiencies are a consequence of the distortion of demand information that propagates upstream through the different members of the SC causing mismatches such as the orders to the suppliers tend to have a greater variance than sales.

These distortions will impact the interpretation of purchase orders, inducing in error manufactures by the amplified demand patterns, leading to unplanned raw material purchases, hiring of resources to accomplish the demand fulfilment and rising of manufacturing expenses. Other related costs impacting all members propagate along the SC such as additional transportation and warehousing costs (Lee, Padmanabhan, & Whang, 1997).

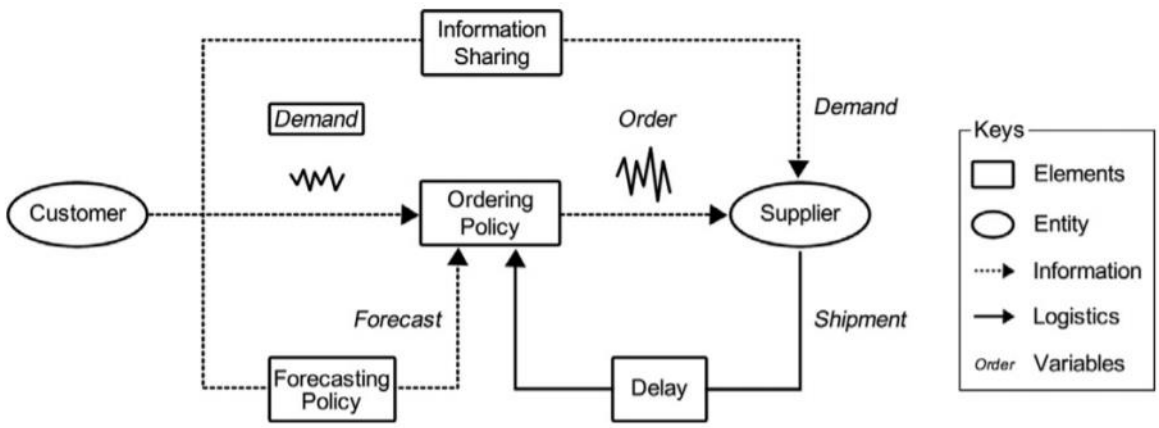


Figure 4 – Sketch of a typical bullwhip model (Wang & Disney, 2016)

The specific company of this project fits perfectly in a bullwhipped situation by its number of SC's echelon, order policy, lead-time and seasonal sales. Chen developed a study where it proves that BWE exists in a two-echelon SC with the order-up-to inventory policy, increasing when the lead-time is longer and forecast is less smooth (Chen, Drezner, Ryan, & Simchi-Levi, 2000).

A way to reduce BWE is by the decrease of demand distortion. The share of customer demand forecast information among the members is one of the most effective ways in the BWE mitigation. (Jeong & Hong, 2017) Besides customer demand forecast, also inventory and order information should be available to upstream members of the SC with the same effect (Cannella, López-Campos, Dominguez, Ashayeri, & Miranda, 2015).

As mentioned, one main critical element in the BWE cause is the unpredictability of the demand and the need to forecast it, arising the challenge to choose the best forecasting method. Also, lead time is a driving factor of demand amplification, which goes hand in hand with order policy. The information sharing turns to be considered as an element to mitigate the BWE by sharing inventory levels, sales data, sales forecast and order status (Wang & Disney, 2016).

2.2. SUPPLY CHAIN MANAGEMENT AND BUSINESS INTELLIGENCE

SCM gained prominence and attention from organizations' strategic roles, leading to the development of the area. The role of IT revealed to be critical to the effectiveness of these developments, taking advantage of the increase of computer power (Arefin, Hoque, & Bao, 2015).

The use of computer power for improving SCM is an enormous opportunity because it is making available more data, and "data now have the power to help business succeed". For instance, retail companies are dealing with huge volumes of data: "Wal-Mart handles more than a million customer transactions each hour" (Ittmann, 2015).

Still, it is also a challenge, since more data does not mean more information. Like Wal-Mart, nowadays companies are bogged down in data that continuously increases and it is mandatory to find a proper way to understand it and gain competitiveness. This gain may come from the analysis of relevant information, which desired output is how and when it may satisfy final customers (Langlois & Chauvel, 2017).

This take us to the need of having suitable tools and techniques to analyse and visualize data from multiple sources in order to generate insights, which aim is to maximize cost reduction and minimize the risks with direct impact in the operational agility (MHI; Deloitte, 2014).

Whereas in the past, data analysis was an area of competence which demanded specific technical skills from employees that could extract data and come up with insights, nowadays BI is used to do so in a quick, efficient way and on-time, providing reports and dashboards to support the decision-making process (Langlois & Chauvel, 2017).

Langlois and Chauvel identified in 2017 that the main objectives for SCM as inventory reduction and the full optimization of the SC cannot be possible without good information management, being necessary to move from the traditional operational systems to rely in decision-making systems as BI, concluding that "BI in management of SCM contributes to the differentiation of a business entity" (Langlois & Chauvel, 2017).

Bi is defined as the whole process of managing data, gathering it and transforming it into information that support the decision making process (Wieder & Ossimitz, 2015). BI is helping to "create knowledge from a world of information. Get the right data, discover its power, and share the value, BI transforms information into knowledge. BI is the application of putting the right information into the hands of the right user at the right time to support the decision-making process" (Reinschmidt & Francoise, 2000).

The possibility of expansion of SC analytics is naturally rising as an opportunity opened by the following events (Ittmann, 2015):

- Growing SC data;
- Cheaper data storage;
- Faster and ever-increasing processing power;
- Anywhere, anytime connectivity as mobile data is available almost everywhere;
- Better tools, making analysis simpler;
- Advanced visualization with tools and techniques to show and present huge volume of data visually.

Ittmann elected in 2015 two major trends for SCM: big data and analytics, "the scientific process of transforming data into insights for making better decisions". Also referred that analytics is the use of data, statistical and quantitative analysis to "provide inputs to decision making or even fully automated decisions". SC analytics focus is the usage of better tools to perform simpler analysis and the usage of advanced data visualization to present great volumes of data visually.

Analytics focusing on SCM allows to "simulate and optimize SC flows" and also to "reduce inventory and stock-outs" (Davenport et al., 2006).

Some companies started using BI tools to improve data visibility so as to reduce inventory levels and also to better understand the sources of variability in customer demand to improve forecast accuracy (Stefanovic & Stefanovic, 2009).

Furthermore, BI and analytics were identified as a top prospective areas of future involvement by millennials working on SCM in a survey presented in figure 5 which was conducted by Peerless Research Group in conjunction with SCM Review, APICS and APQC (American Productivity and Quality Centre).

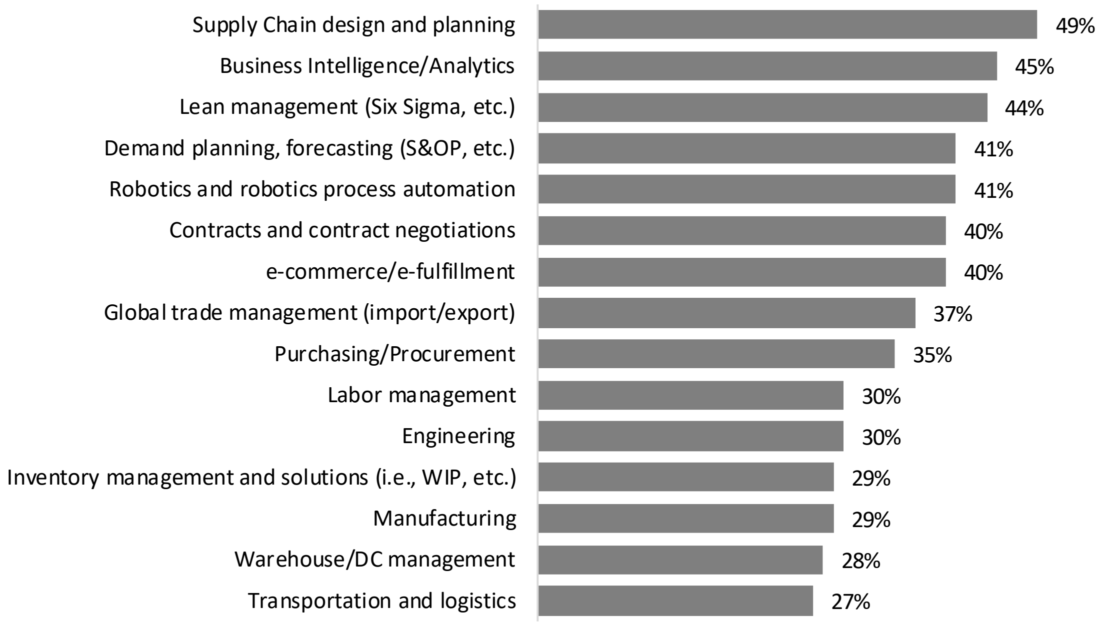


Figure 5 – Prospective areas of future SC involvement[2] (Daniels, 2017)

APQC also launched a different survey where were identified the areas of focus for SC analytics (figure 6). Above 70% of the respondents consider cost reduction, data visualization, improve customer satisfaction and productivity as areas of focus for SC analytics (Partida, 2017).

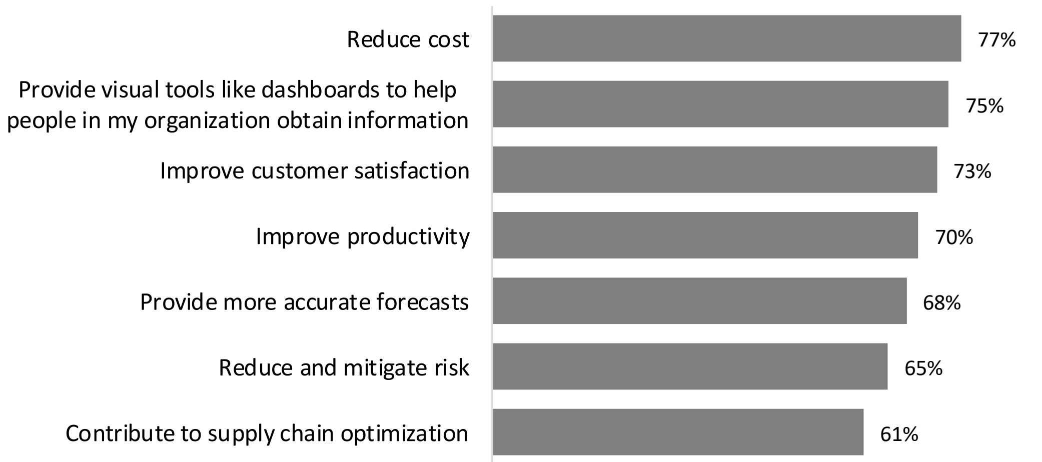


Figure 6 – Areas of focus for SC analytics (Partida, 2017)

Nevertheless, only a few studies are available on the interactions between SCM and BI, which raised the need to relate the two concepts in order to identify its complementarity in a problem-solving perspective:

[2] 676 respondents working in SCM with ages between 22 and 37

Table 1 – BI benefits in the support of SCM challenges

	SCM **CHALLENGE**	BI **BENEFIT**
GROWING SC DATA	"Today, as companies are drowned in information which doubles every two to three years, they have to find the best way to understand it and gain a competitive advantage." (Langlois & Chauvel, 2017)	"Being able to consolidate and analyse this data for better business decisions can often lead to a competitive advantage, and learning to uncover and leverage those advantages is what business intelligence is all about." (Stefanovic, Majstorovic, & Stefanovic, 2006)
STOCK REDUCTION	"Stock reduction and optimization of the supply chain cannot be conceived without good information management." (Langlois & Chauvel, 2017)	"Beyond the traditional operational systems that automate processes, it is without doubt necessary to rely on an appropriate decision-making system like BI." (Langlois & Chauvel, 2017)
BWE	"One (…) common phenomenon exhibited by most SC systems is the BWE. (…) BWE is generally viewed in extremely negative terms because of its negative impacts on information distortion, excess inventory levels, higher raw material costs, overtime expenses, and added shipping costs." (Cannella, López-Campos, Dominguez, Ashayeri, & Miranda, 2015) "It has been advocated that the bullwhip effect can be mitigated by information sharing." (Wang & Disney, 2016)	"(…) BI helps you to (…) get the right data, discover its power, and share the value, BI transforms information into knowledge. BI is the application of putting the right information into the hands of the right user at the right time to support the decision-making process." (Reinschmidt & Francoise, 2000)

2.3. PERFORMANCE MEASUREMENT

The performance management is essential to a company, being one of the key success factors of management in today's competitive business environment.
Regarding the SCM, performance measurement provides how a company can assess whether its SC has improved or degraded. "If a company does not have a clear understanding of how well its supply chains are performing, it will be very hard to manage them successfully" (Stefanovic & Stefanovic, 2009).

The performance measurement plays a big role in an organization. According to Mahidhar, the following five dimensions are the key of performance measurement (Mahidhar, 2005).

- **Monitoring**: measuring and recording actual performance;
- **Control**: identifying and attempting to close the gap between expected performance and actual performance;
- **Improvement**: identifying critical improvement opportunities;
- **Coordination**: providing information for decision making and enabling internal communication across processes as well as external communication with stakeholders;

- **Motivation**: encouraging behaviour and continuous improvement.

A metric can be defined as an observation that reduces uncertainty and it is expressed in a quantitative form. (Hubbard, 2014) Being quantitative also provide the notion of progress when compared with the objectives of the company. A measure should also be qualitative to provide understanding of the value of the specific metric and strategic in order to be aligned with the company objectives (Nightingale, 2005).

With such importance in the performance measurement, a metric should be chosen considering that it must be actionable, with easy interpretation, accessible and reliable for users, and transparent (figure 7).

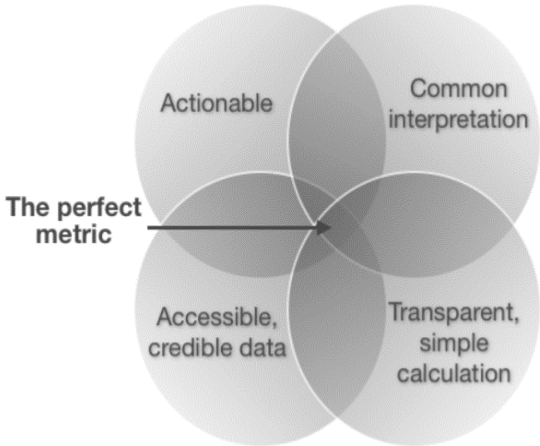


Figure 7 – The perfect metric (Juice, 2009)

Being actionable means that the problem is clear and it is possible to take actions whenever the metric changes to values that requires that. It is advisable to focus on total measures rather than in changes on those measurements.

The metric must be recognized and be transparent, using simple calculation that will be shared and easy to understand. Create metrics by combining numerous measures will only bring confusion and loss of engagement with the analysis.

The data that is leading to measures and metrics must be reliable and must come from sources that users trust.

2.4. INFORMATION VISUALIZATION

A picture is worth a thousand words, and information visualization is proving it. As a research field in development, information visualization is being used to captivate users to analyse data in a more effectively way. In a combination of data, eyes and mind, information that could remain unnoticed (in tables or text) decreases when displayed by visualization (Few, 2008). Displaying information through visualization encourages the user to be alert and critic. As a result, it promotes call to action.

The visualization is an important part of the cognitive system, allowing us to acquire more information through vision than from all the other senses combined, with multiple abilities:

- Visualization provides comprehension of large amount of data;
- Allows the perception of not anticipated data;
- Reveals errors of data treatment when applied in a suitable plot;
- Enhance the large-scale and small-scale features of data;
- Support hypothesis formation.

With this potential, visualization has become a very important part of the analysis and decision-making (Ware, 2013).

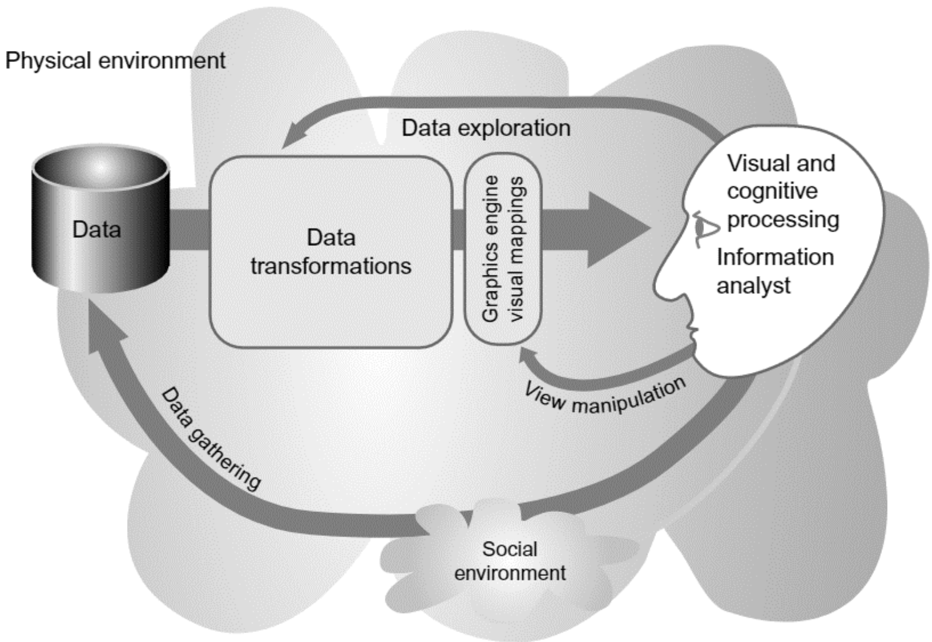


Figure 8 – The visualization process (Ware, 2013)

Colour is a big ally of information visualization, playing an important role to ensure a soft presentation of the display. "Colours must enhance data comprehension, not distract" (it is recommended to use a maximum of six colours).

- Opposite colours should be used for comparison;
- Smaller values should be presented with less saturation and greater values with more saturation;
- It is also recommended to use soft colours, except in a situation that the focus is to highlight data. For backgrounds, neutral colours should be elected (Few, 2005).

2.5. DASHBOARD DESIGN

This project focus on the ability of BI to assist the analysis for the decision-making process – considering the research study – of the SCM. The easy access to data analysis with proper metrics and performance indicators to measure the SC are the aim of this project. For this reason, this section of the literature review will focus on dashboard design guidelines.

In this project, the artifact to be developed is a dashboard. A dashboard, as a visual tool, arise to assist and support people in the difficult task of understanding data.

Stephen Few identified in “Dashboard Confusion” in 2014 that a dashboard “is a visual display of the most important information needed to achieve one or more objectives”. If a dashboard presents only measurements it would be difficult to measure if the objectives are being achieved or not, how far we are from them or how good performance we have. That is why metrics must be included in a dashboard, because “what gets measured, gets managed” (Schmenner & Vollmann, 1994).

The information must be “consolidated and arranged on a single screen so the information can be monitored at a glance” and the use of dashboards “to work faster and smarter” (Few, 2004) .

Few also identified in the same publication the attributes required to a dashboard to be effective:

- **High-level summaries**: effective communication, with information of what is happening but not the root of the problem. The diagnostic may happen in the dashboard or not, since it is not mandatory for a dashboard to drill-down into detail;
- **Concise and intuitive display mechanisms**: use of relevant and appropriate display mechanisms according to the type of data and message;
- **Customized**: information must be presented to satisfy specific objectives defined for a person, group or function;
- **Metrics or Key Performance Indicators (KPI’s)**: sometimes a dashboard only presents measurements (aggregation of data through operations as sum or average) but since it is displaying information to achieve an objective, it should also monitor such performance. Metrics and KPI’s should be included to compare achievements versus goals, but not in an exclusive way since other information might be needed to complement the communication;
- **Real-time information**: only available in the dashboard if it is needed to achieve the objectives;
- **Web Browsers**: internet or intranet are the best available structures to present a dashboard, though it is not mandatory to present it in such platform.

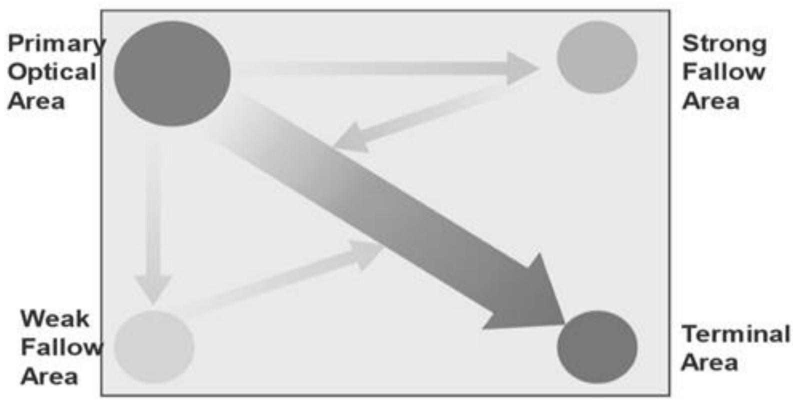


Figure 9 - Reading Gravity (Pham, 2014)

A dashboard must be well organized with information placement and size considering its importance: important items appear larger and in strong reading areas (figure 9), and less important items appear smaller. Related information should also be close and items that have ordered between them should also be positioned in a way that can communicate that (Few, 2007).

As referred, one of the requirements for a dashboard to be effective is to have "concise and intuitive display mechanisms". Graphical representations are the elected artifacts to take advantage of the users visual perceptions. Still, information should only be presented in this form if it brings more perception to the user than presenting it on a table or text (Few, 2008).

Abela presents a chart suggestion considering the main objective of showing data and its specific characteristics in order to have concise and intuitive display mechanisms (figure 10).

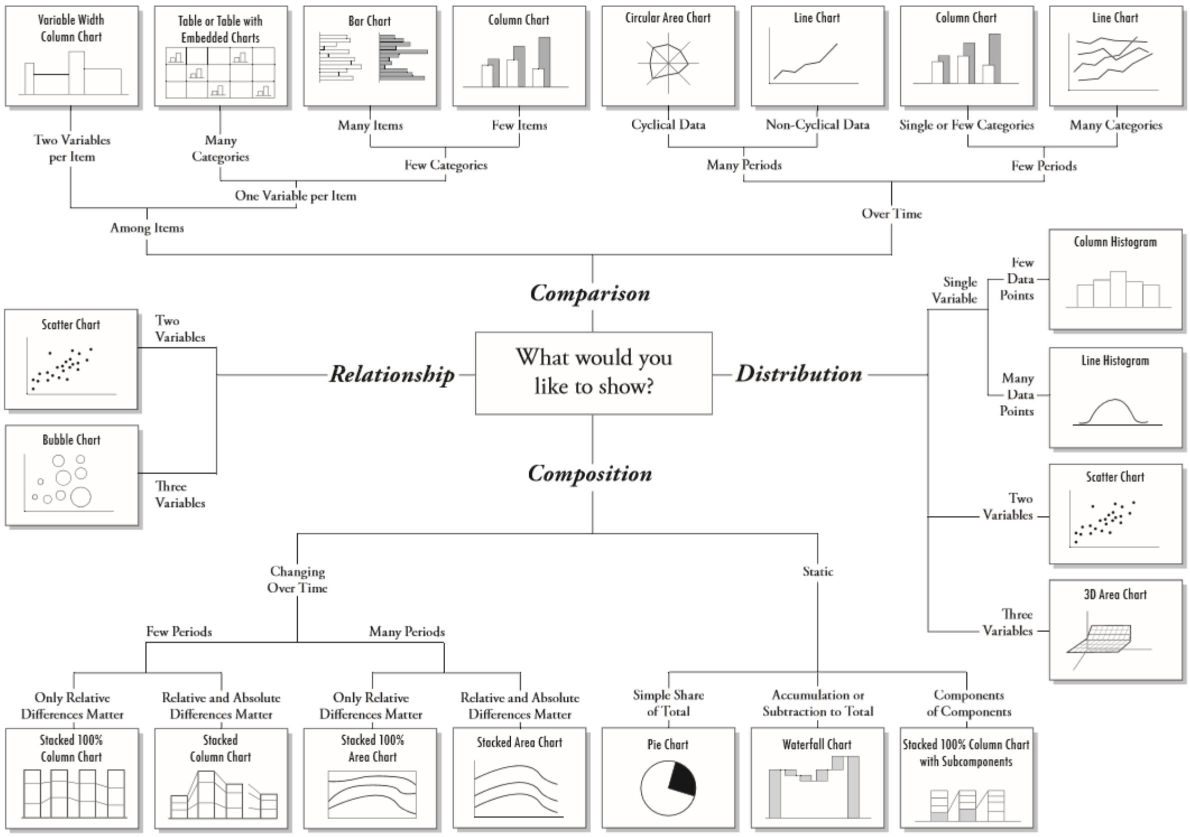


Figure 10 – Chart Suggestions – A Tough-Starter (Abela, 2009)

3. CONCEPTUAL MODEL PROPOSAL

In this chapter is presented the conceptual model proposal as the ‘Suggestion’ step of the DSR methodology.

Initially it is made an introduction to the company context and process flows, followed by the measures and metrics definition that will be based on a literature review. At the end of the chapter, the tentative design is complete, and the conceptual model proposal is developed, being ready to be materialized in the next chapter – “Development”.

3.1. CONTEXT

Considering the application of the project on the Company X’s SC, it is presented the SC of Group Y in an overall perspective in figure 11. Group Y is responsible for the procurement and sourcing of raw materials, as well as the production. Group Y detains all the factories (industry phase) and warehouses to store products before selling them to branches.

The SC breaks down in the distribution phase, according to the products destination. If the destination is the production country, the products are distributed by means of land until reach each retail unit. On the other hand – and it is what concerns this project – the distribution of products that will be exported is mainly made by maritime transport but, in case of emergency it can be transported by air. Reaching the destination country, the product will be stored. The distribution makes it reach to the retail units and to the final customer.

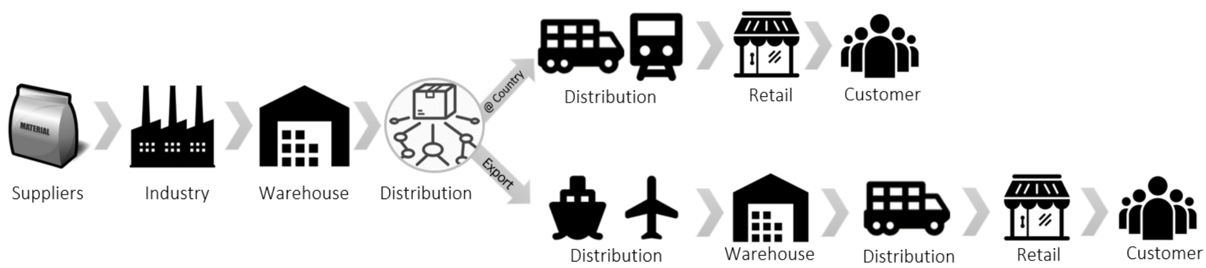


Figure 11 – SC of Group Y

In fact, Group Y and Company X are different companies. Company X depends entirely of Group Y since it is its only supplier of products, which means that collaboration must be a key to this company’s business. As such, Company X provides the forecasts of what will purchase to Group Y with a horizon of eighteen months. This allows Group Y to plan the procurement, sourcing and manufacturing activities. The SC of Company X is presented in the figure 12.

Figure 12 – SC of Company X

The supplier (Group Y) satisfies the Company X's order request and the products are exported to the destination country. Reaching the destination country, the product is centralized and distributed according to the points of sale demand, where it will be available to final customers.

The development of this project will concern the Company X's SC, with focus on demand forecast, inventory information and order information, which were previously identified as critical to the company.

3.2. MEASURES AND METRICS

As previous stated, a way to reduce the BWE is by decreasing the demand distortion. The share of customer demand forecast information among the members is one of the most effective ways in the BWE mitigation (Jeong & Hong, 2017). Besides customer demand forecast, also inventory and order information should be available to upstream members of the SC with the same effect (Cannella, López-Campos, Dominguez, Ashayeri, & Miranda, 2015).

The project will focus on dashboarding it and the target users are presented in the table 2.

- **Demand Forecast**: considering the major impact on Company X supplier to plan their SC and the BWE that both Company X and Group Y are noticing, it was decided to assess the past demand forecast and share future demand forecast information in order to decrease distortion over the SC and measure results to manage the process;
- **Inventory Information**: it is critical to have knowledge of inventory status over the Company X SC and the investment that it represents. It was also identified that the BWE has a major impact in inventory. The inventory information analysis and sharing will allow to identify variations in the inventory levels;
- **Order Information**: it was also identified as critical to share the forecast of purchases to upstream members of the SC to mitigate the BWE. Since Company X only has a supplier, it makes it even more critical, besides sharing, to assess past orders. A failure in orders can lead to disruptions and delivery problems, affecting directly logistics, retail operation and planning of activities. The project will present past order information and purchasing forecast.

Table 2 – Targeted users to the SCM dashboard

Theme	*Sub-theme*	*Target Users*
SCM Summary	n.a.	Operations' Director, SCM Manager, Supplier
Demand Forecast	Demand Forecast Accuracy Assessment	Demand Planners
	Future Demand Forecast	Demand Planners, Marketing, Logistics, Supplier
Inventory Information	Inventory Information	Logistics, Supplier

Order Information	Requested/Invoiced Orders	Logistics, Supplier
	Purchasing Forecast	Supplier

For each metric it will be defined an alias for the original measure or metric to promote its comprehension. The alias will be mostly in Portuguese language, since it is the official language of the dashboard's users.

The measures and metrics will be displayed for comparison over the historic time periods and presented by different aggregations of product analysis by category and ABC analysis (the Pareto principle: 20% of the products represent 80% of the sales). Any exception will be identified in the specific section.

3.2.1. DEMAND FORECAST

Measuring demand forecast shows how well the Company X is predicting its upcoming demand. By improving the prediction process, demand variation will decrease reducing the BWE.

The demand forecast is made in strategic and tactical levels. The time horizon of the demand forecast is of 30 periods (approximately two years), which applies to the strategic forecast and it is used for Business Planning of Company X but also to Group Y procurement, sourcing, manufacturing and warehousing capacity planning.

On the other hand, the tactical demand forecast with a short-term horizon, serves the purpose of planning the replenishment of point of sales by Company X.

The customer demand forecast will be presented and measured by campaign period. Each campaign period has specific product launches (new product introduction), marketing actions and highlights.

CSCMP identified in the book "Suggested Minimum Supply Chain Benchmarking Standard" the following as a good practice to measure forecast accuracy (CSCMP, 2010):

- Performance is measured against forecast;
- Historic is maintained for comparison purposes;
- Ability to measure forecast accuracy at the Stock Keeping Unit (SKU) level.

To define the demand forecast accuracy metrics, a literature review was made and it's presented in table 3.

Table 3 – Demand Forecast Accuracy Metrics

Author, Year	*Title*	*MAE*[3] *Mean Average Error*	*MAPE* *Mean Average Percent Error*	*WAPE*[4] *Weighted Average Percentage Error*	*MSE* *Mean Square Error*	*MASE* *Mean Absolute Scaled Error*
(Kim & Kim, 2016)	*A new metric of absolute percentage error for intermittent demand forecasts*	-	"MAPE remains the preferred method of business forecasters and practitioners, due to (…) its intuitive interpretation. (…) It produces infinite or undefined values when the actual values are zero or close to zero."	"(…) the mean absolute error can be scaled by the WAPE in order to overcome the problem of division by zero."	-	"The MASE is obtained by scaling the forecast error based on the in-sample mean absolute error using the näive (random walk) forecast method, and can overcome the problem of the MAPE generating infinite or undefined values."
(Prestwich, Rossi, Armagan Tarim, & Hnich, 2014)	*Mean-based error measures for intermittent demand forecasting*	"Doubt has been cast on the suitability of MAE for intermittent demand"	"Percentage errors are undefined if any sales = 0 and have very skewed distributions when sales ≈ 0. (…) Despite these drawbacks MAPE is recommended by most textbooks"	-	-	"An advantage of MASE over WAPE is that it is more reliable on demand with seasonality, trends or other forms of non-stationarity. However, note that the MASE of two series with identical forecasts and identical demands during the forecast horizon will differ if the two-series differed in their historical demands. This is counter-intuitive so MASE is not always easy to interpret."

[3] MAE is also referred as MAD (Mean Average Deviation) in the literature. It will be defined as MAE in this project;
[4] WAPE is also referred as Weighted MAPE, WMAPE, MAD/Mean Ratio, MAE/Mean Ratio or MMR in the literature. It will be defined as WAPE in this project.

Author, Year	**Title**	**MAE** Mean Average Error	**MAPE** Mean Average Percent Error	**WAPE** Weighted Average Percentage Error	**MSE** Mean Square Error	**MASE** Mean Absolute Scaled Error
(Hoover, 2009)	*How to track forecast accuracy to guide forecast process improvement*	"Overcomes many problems with low-demand SKUs and provides consistent measures across SKUs."	"MAPE is the primary forecast-accuracy metric. Because is scale-independent (since it is a percentage error, it is unit free), it can be used to assess and compare accuracy across a range of items. (…) MAPE is also a very problematic metric in certain situations, such as intermittent demands"	"You want better accuracy when forecasting those items that, for whatever reason, are more important than other items. (…) Weighting permits the forecaster to prioritize efforts at forecast-accuracy improvement"	-	"Compares the error from a forecast model with the error resulting from a naïve method."
(Hyndman, 2006)	*Another look at forecast-accuracy metrics for intermittent demand*	"For assessing accuracy on a single series, I prefer the MAE because it is easiest to understand and compute. However it cannot be compared between series because it is scale dependent."	"Percentage error have the advantage of being scale independent, so they are frequently used to compare forecast performance between data series. The most commonly used metric is MAPE."	"(…) scales the errors by the in-sample mean of the series instead of the in-sample mean absolute error. This ratio also renders the errors scale free and is always finite unless all historical data happen to be zero."	-	"The MASE can be used to compare forecast methods on a single series, and, because it is scale-free, to compare forecast accuracy across series. (…) The MASE is suitable even when the data exhibit a trend or a seasonal pattern."
(Hyndman & Koehler, 2006)	*Another look at measures of forecast accuracy*	"If all series are on the same scale, then MAE may be still be preferred because it is simpler to explain."	"If all data are positive and much greater than zero, the MAPE may still be preferred for reasons of simplicity."	-	"Historically, the RMSE (root mean square error) and MSE have been popular, largely because of their theoretical relevance in statistical modelling. However, they are more sensitive to outliers than MAE or MdAE (median absolute error), which has led some authors to recommend against their use in forecast accuracy evaluation."	"In situations where there are very different scales including data which are close to zero or negative, we suggest the MASE is the best available measure of forecast accuracy."

Other metrics that are more difficult to interpret were found during the literature review (Hyndman & Koehler, 2006; Kim & Kim, 2016; Prestwich, Rossi, Armagan Tarim, & Hnich, 2014). It was decided not to consider those since it is a concern to have clear metrics. If the problem and the metric are clear to all users, it will be easy to take actions whenever the metric changes to values that doesn't satisfy company's expectations.

Table 4 – Demand forecast metrics comparison, adapted (Kolassa, 2015)

Metric	*"Robust"?*	*Defined?*	*Comparable[5]?*	*Intuitive?*
MSE	χ	√√	χχ	χ
MAE	√√	√√	χ	√
MAPE	√	((√))	√	√√
WAPE	√	(√)	√	√√
MASE	√√	√	(√)	χ

Considering the characteristics of each metric identified in the tables 3 and 4, and the requirements for a perfect metric identified in the 'Performance Measurement' section of the literature review, **MAE** (Men Absolute Error), **MAPE** (Mean Absolute Percentage Error) and **WAPE** (Weighted Average Error) were chosen as the metrics to assess the demand forecast accuracy.

- **MAE – Mean Absolute Error**

  This metric measures the distance between the forecast and sales in absolute quantities, it is a simple metric to understand (Hyndman & Koehler, 2006) and "provides consistent measures across SKUs" (Hoover, 2009). When displayed at SKU level presents the specific error in quantity of the SKU and when displayed in and aggregated level it shows an average of the absolute error of observations.

$$MAE = \frac{1}{n}\sum_{t=1}^{n} |A_t - F_t|$$

- **MAPE – Mean Absolute Percentage Error**

  This metric measures the absolute deviation between forecast and sales in percentage.
  In first place MAPE was chosen because of its simplicity and intuitive interpretation, with a simple calculation, making it a clear metric (Hyndman & Koehler, 2006; Kim & Kim, 2016).
  When displayed at SKU level presents the specific error in percentage of the SKU and when displayed in and aggregated level it shows an average of absolute percentage error of the observations.
  MAPE is not advisable to be considered as a demand forecast accuracy metric when actual sales are zero or close to zero (Hoover, 2009; Hyndman & Koehler, 2006; Kim & Kim, 2016).

[5] Comparability between groups/series on different levels, e.g. fast vs slow selling products.

If the actual sales (A_t) are zero the formula is undefined and in case of stock outs it may produce high error values.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|A_t - F_t|}{A_t}$$

- **WAPE – Weighted Average Percentage Error**
  This metric reflects the SKU importance through the assignment of weights according to the most valuable business perspective to the analysis (Hoover, 2009). In this case the weights will be assigned by revenue.
  This metric solves the problem of undefined values when actual sales are zero or close to zero (Hoover, 2009) since, instead of dividing the error by sales (that may assume zero in case of stock outs or intermittent demand), it sums the errors and divides it by the sum of sales avoiding undefined values.
  MAE and MAPE are calculated both in SKU and aggregated levels, but WAPE is only calculate at an aggregated level.

$$\text{WAPE} = \frac{\sum_{t=1}^{n}|A_t - F_t|}{\sum_{t=1}^{n}A_t}$$

Where:

A_t =Actual value for t observations;
F_t= Forecasted value for t observations;
t = number of observations.

In table 5 it is presented a summary of the measures and metrics that will be part of the Demand Forecast section of the dashboard. This section has two different reports:

- Demand Forecast Accuracy Assessment – presenting past demands assessments;
- Future Demand Forecast – visualization of the upcoming demand forecasts.

Table 5 – Demand Forecast: Measures and Metrics

Report	*Alias Report*	*Measure / Metric*	*Description*	*Alias*	*Observations*
Demand Forecast Accuracy Assessment	Monitorização de Previsão	Metric	MAE	n.a.	Measure by period
			MAPE	n.a.	Measure by and over periods
			WAPE	n.a.	
		Measure	Past Demand Forecast	Previsão	
			Actual Sales (quantity)	Vendas	
			Actual Sales (revenue)	Receita	
Future Demand Forecast	Previsão de Vendas	Measure	Future Demand Forecast	Previsão	

3.2.2. INVENTORY INFORMATION

Inventory information was identified as critical to mitigate the BWE (Cannella, López-Campos, Dominguez, Ashayeri, & Miranda, 2015) because one of the inefficiencies in the SC caused by the BWE is specifically the increase of inventory ownership (Jeong & Hong, 2017).

It is considered critical to share the inventory status over the SC in this project. Inventory means investment, especially for a company like Company X with a rigid SC, which works with long lead-time, non-smooth customer demand and inventory depots in more than fifty points of sales beyond the warehouse.

The knowledge of inventory volume allows to have a clear notion of the operation's capacity. Valuating the inventory as per cost of goods gives us an estimate of investment in inventory.

A clear picture of all inventory depots over the SC will be available in the artifact.

Figure 13 - Overview of inventory depot along Company X's SC

Table 6 – Inventory Information: Measures and Metrics

Report	*Alias Report*	*Measure / Metric*	*Description*	*Alias*	*Observations*
Inventory information	Informação de Stock	Measure	Inventory Volume	Volume	Total units in stock
			Inventory Investment	Valor	Total stock investment

3.2.3. ORDER INFORMATION

As third element of this project, it will be shared the order information. The share of order information was also considered as a factor of BWE mitigation (Wang & Disney, 2016).

As mentioned before, the demand amplification causes the BWE and lead-time is a driving factor of demand amplification (Wang & Disney, 2016). It impacts the Company X SC, making it rigid, which demands a high capacity of inventory and operation planning to react to market with the inventory resources available in destination country.

Lead-time is crucial in the order information since it reflects a clear understanding of the supplier capacity at the time of the order placement (CSCMP, 2010).

Table 7 – Order Information: Measures and Metrics

Report	*Alias Report*	*Measure / Metric*	*Description*	*Alias*	*Observations*
Requested/ Invoiced Orders	Encomendas	Measure	Number of orders	Num. Encomendas	
			Invoice volume	Volume	Units by order (confirmed)
			Invoice cost	Valor	Cost by order (confirmed)
			Lead-time	Lead-time	Time between order request and distribution centre arrival
			Days to ship	Preparação	Days from the order request to shipment
			Days in transit	Trânsito	Days in transit
		Metric	Order Fill Rate	Order Fill Rate (OFR)	The percentage of quantity met according to client specifications versus the total quantity
Purchasing Forecast	Previsão de Compra	Measure	Forecast of future orders	Previsão	Volume forecast in future orders with eighteen months horizon

3.3. CONCEPTUAL MODEL

Following the methodology, a conceptual model was developed as a suggestion of the final artifact. Supported by the literature review, the conceptual model shows how to architect the dashboard.

At this stage, the development of the prototypes was determinant to ensure a coherent graphic display of the information and to define how to combine the different visualizations.

This dashboard's conceptual model is divided in six different modules, respecting the dashboard rules and best practices identified in the literature review. The summary module compiles the most important information of all themes and is presented in figure 17. The others five modules are focusing on the different approaches of this project – demand forecast accuracy assessment (figure 18), future demand forecast (figure 19), inventory information (figure 20), requested/invoiced orders (figure 21), purchasing forecast (figure 22).

Following it is presented a generic structure of the dashboard to each module.

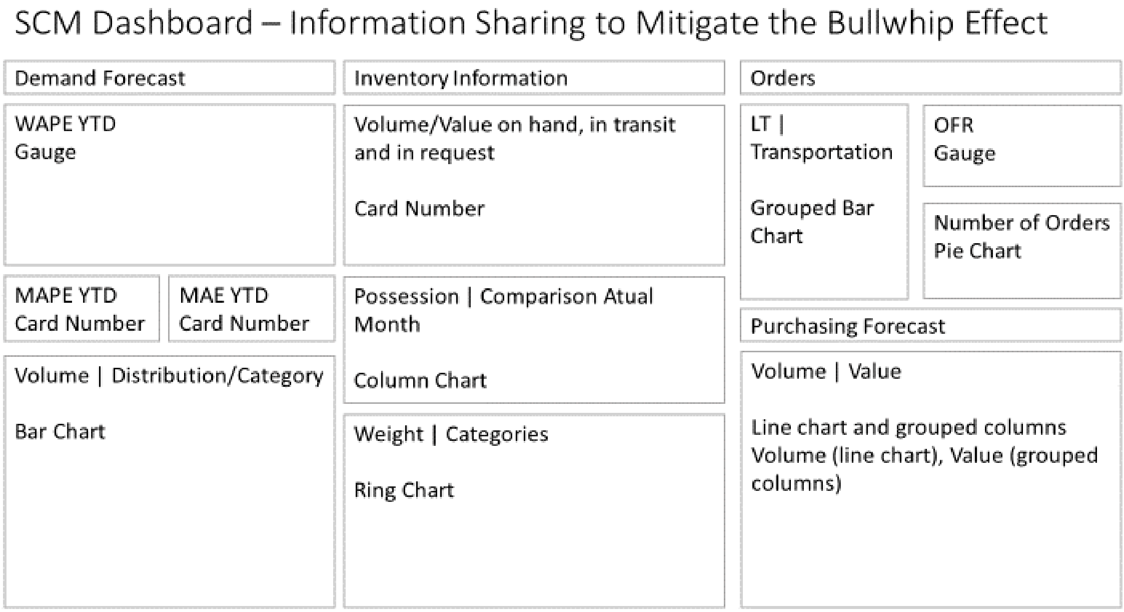


Figure 14 – Conceptual Model – Summary Module: Information Sharing to Mitigate the BWE

Instead of having only one module to present all information from demand forecast it was decided to divide it in two modules: a module to assess the demand forecast accuracy and explore those indicators with a past perspective and a module to present future demand forecast.

Although both modules have demand planners has target users, the Future Demand Forecast is a module of interest to Marketing, Logistics and to the supplier so it was better to isolate it from Demand Forecast Accuracy Assessment.

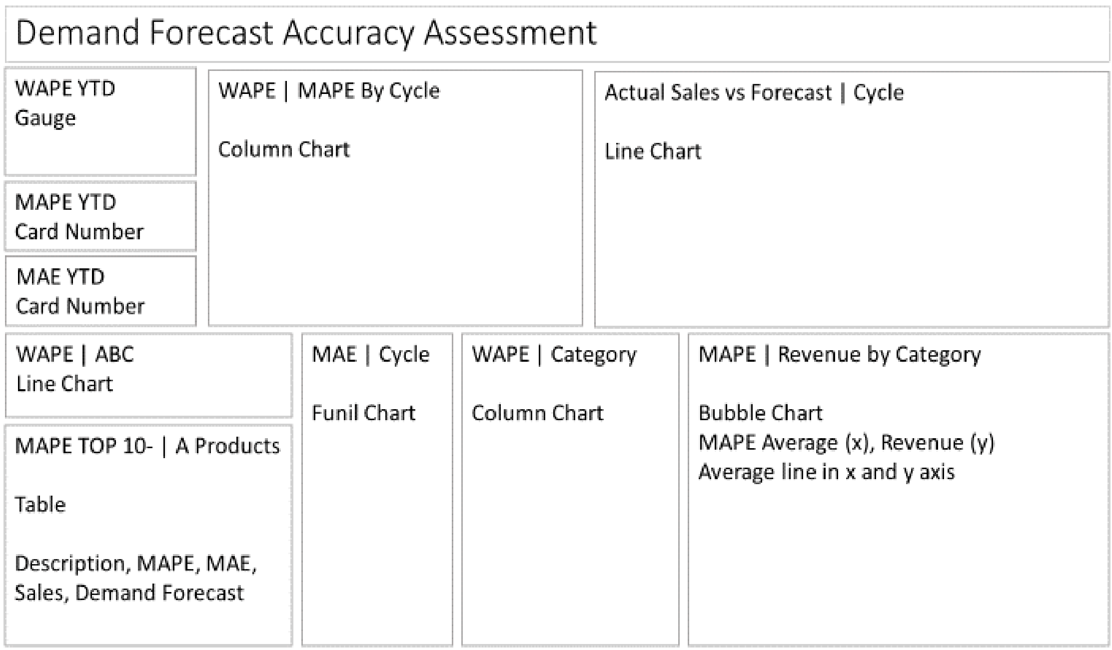


Figure 15 – Conceptual Model – Demand Forecast Accuracy Assessment Module

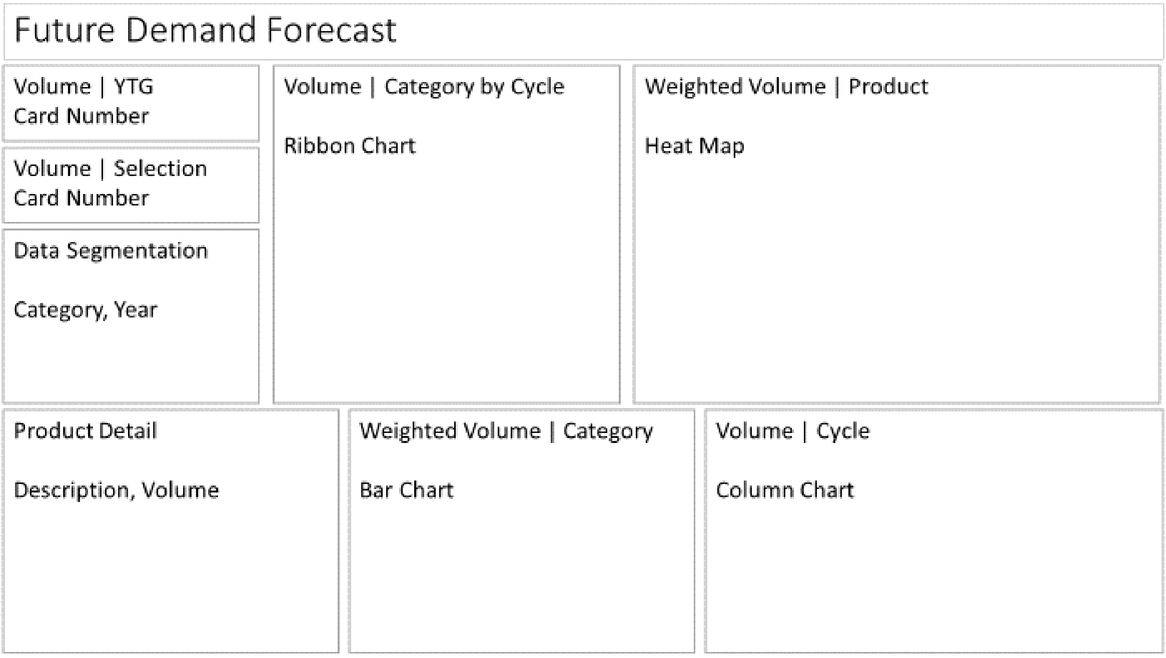


Figure 16 – Conceptual Model – Future Demand Forecast Module

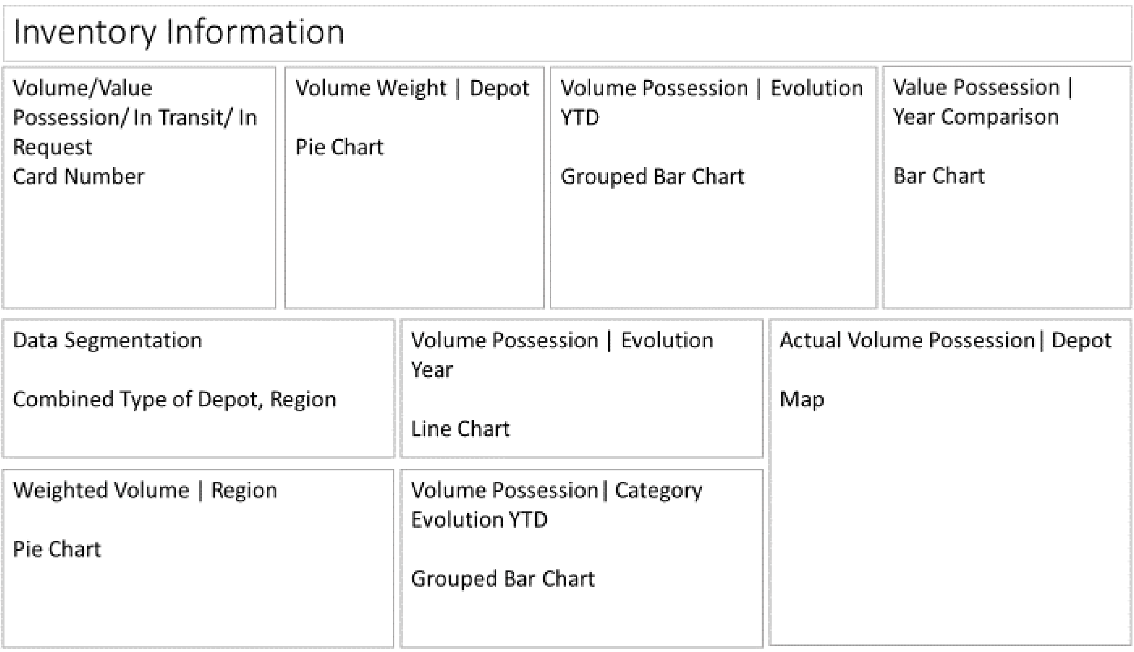


Figure 17 – Conceptual Model – Inventory Information Module

Similar of what happened with the demand forecast, the same logic was applied in the order information, having two modules: one for actual orders (requested, invoiced or delivered) and other for the purchasing forecast (future orders).

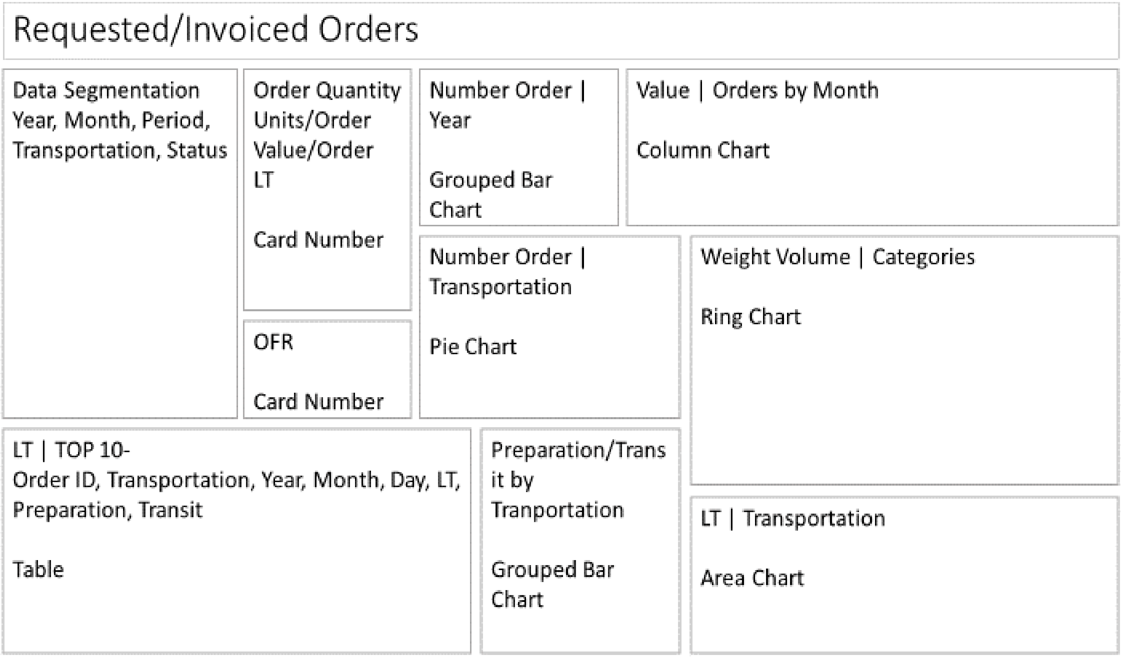


Figure 18 – Conceptual Model – Requested/Invoiced Orders

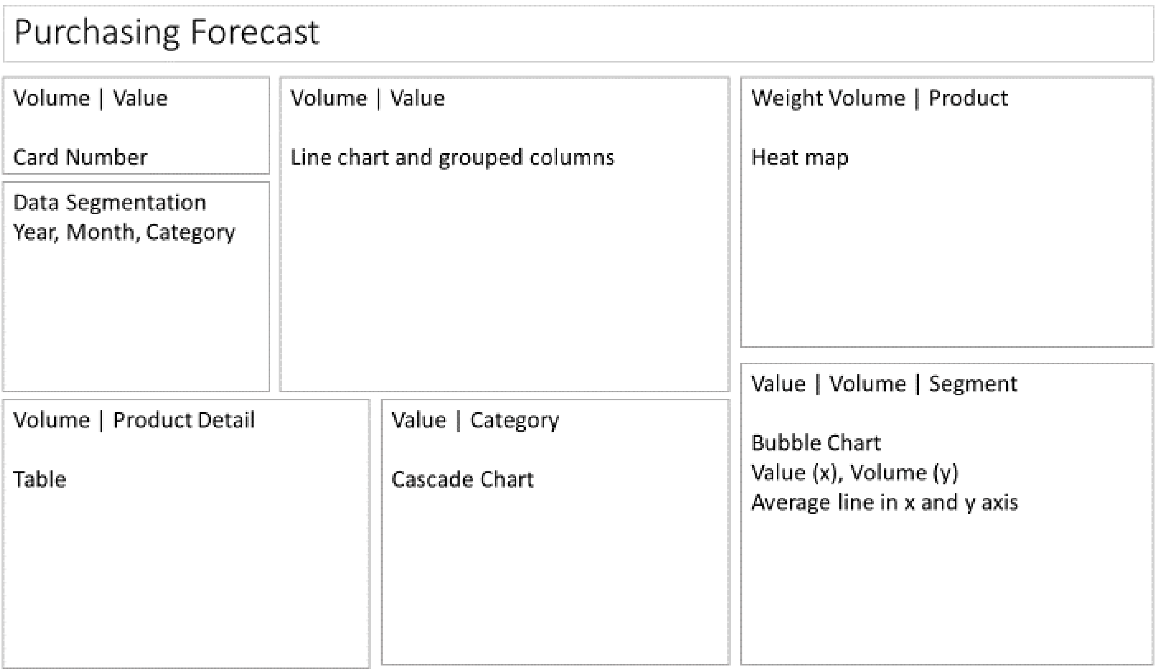


Figure 19 – Conceptual Model – Purchasing Forecast

4. DEVELOPMENT

This chapter presents how to materialize the designed solution. In first place, an analysis will be performed to identify the best tool to develop the artifact. Also, a comprehension of the data sources will be presented followed by a graphic and a display rules manual. The chapter ends with the presentation of the dashboard and analysis of the information displayed.

4.1. PLATFORM

The project will be developed using a Power BI platform from Microsoft. It was considered to be the best solution for this project based in the Gartner Magic Quadrant for Analytics and BI Platforms (Howson et al., 2018) (figure 20).

Since 2016 Microsoft was sharing the "leaders" quadrant with Tableau and Qlik. In that specific year Microsoft was better in Completeness of Vision but was losing to the others in the Ability to Execute.

Figure 20 – Magic Quadrant for Analytics and BI Platforms (Howson et al., 2018)

During the last two years, Microsoft continued to be distinguished in the quadrant from the other players in the Completeness of Vision and equated in a highest-level Tableau in the Ability to Execute.

Nowadays Microsoft has the highest composite scores for their Completeness of Vision and Ability to Execute and a consistent position in the "leaders" quadrant, showing that Power BI has a differentiated market position. This solution is a visionary product of a credible company and has high levels of customer interest and adoption. It is also a competitive solution in terms of investment (Howson et al., 2018).

4.2. DATA SOURCES

The data that will feed the artifacts is property of the Company X and will be provided to the Power BI.

Due to compliance issues and data protection, it was required to replicate the company's database in Microsoft Office Access to run the project proposal.

The entities and attributes of the database are presented in the table 8 and the physical database model is displayed in the figure 21.

Table 8 – Entities and Attributes of the database

ENTITY	ATTRIBUTE
PRODUCT	Product_ID; Description; Category; Segment; Unit Cost; Inventory Quantity; Sales quantity; Sales revenue; Sell-in forecast; Sell-out forecast; ABC.
INVOICE	Invoice_ID (Inv); Transportation; Status; Order request quantity; Date of order request; Date of shipment; Date of destination arrival.
DEPOT	Depot_ID; Depot; Type; District; Municipality; City; Latitude; Longitude;

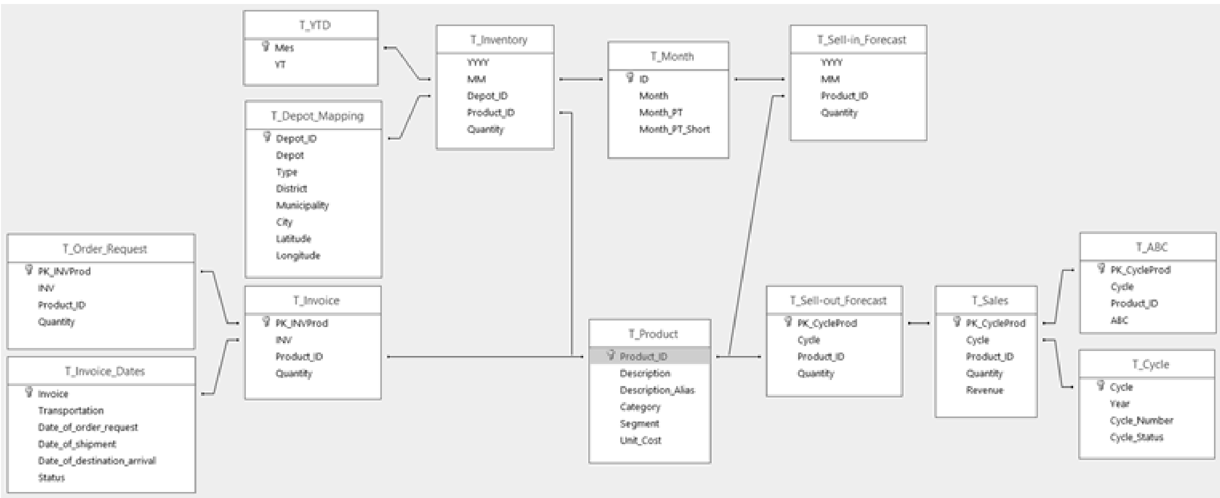


Figure 21 – Database Physical Model

The initial database was considered in the Power BI data model (figure 22), where calculated measures were added to the model.

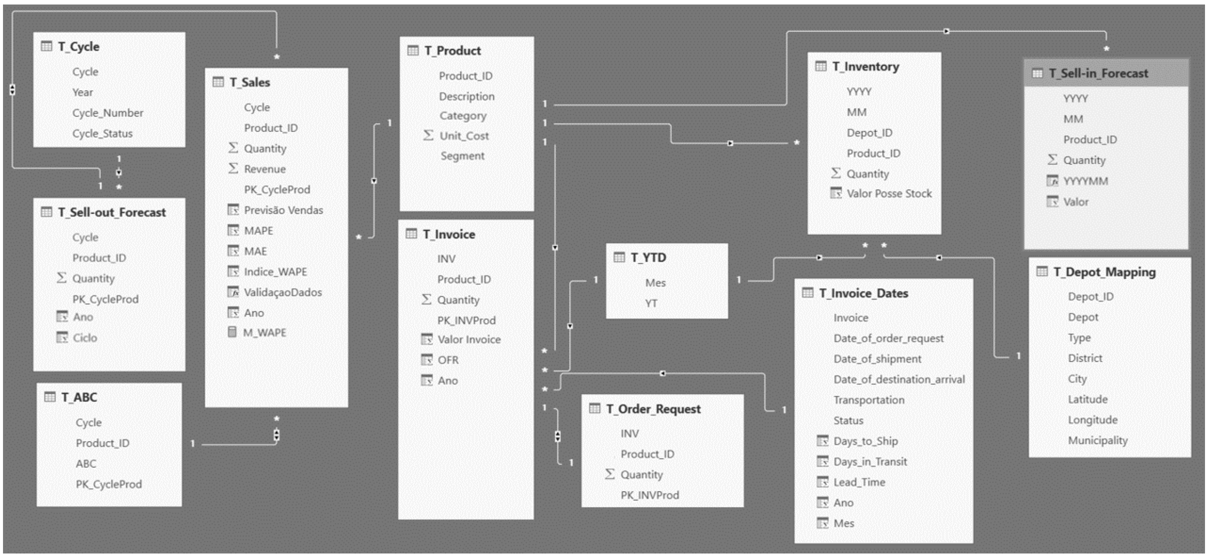


Figure 22 – Tables' Relationships at Power BI

It is displayed in the following table the data required to produce the measures and metrics available at the dashboard.

Table 9 – Summary of data required to measures and metrics

Data	*Table*	*Measure/Metric*	*Observation*
Customer Demand Forecast	T_Sell-out_Forecast	MAE, MAPE, WAPE, Future Demand Forecast	
Actual Sales quantity	T_Sales	MAE, MAPE, WAPE	
Actual Sales revenue	T_Sales	WAPE	
Inventory quantity	T_Inventory	Inventory information	
Cost of Products	T_Product	Inventory investment	Used to calculate the investment in inventory
Order Request quantity	T_Order_Request	OFR	
Invoice quantity	T_Invoice	OFR	
Date of order request	T_Invoice_Dates	Lead-time	
Date of shipment	T_Invoice_Dates	Lead-time	
Date of destination arrival	T_Invoice_Dates	Lead-time	
Forecast of future orders	T_Invoice_Dates	Lead-time	

4.3. GRAPHIC AND DISPLAY RULES

The development of the prototypes will consider the importance of the information to define its specific placement (Pham, 2014). Also, the information display will be chosen considering the chart suggestions by Abela.

To guarantee the normalization across the different visualizations, the project will follow the following graphic rules map, concerning font framework (table 9), backgrounds definition (table 10) and Colour Charts (table 11).

Table 10 – Adaptation from Juice's Simple Font Framework (Juice, 2009)

	Purpose	*Size*	*Font*	*Colour*	*Style*
Body	Clean readable text, 50-80% of the text will look like this.	12 pts	Verdana	Black (Neutral) #000000	Normal No bold, no italic 1.2 line spacing
Header	Separate and name major sections of the writing. Always start with upper case. Left alignment.	18 pts (150% of body)	Verdana	Black (Neutral) #000000	Bold Whitespace above
Sub-Header	Create a level of attention between the Header and Body. Always start with upper case. Left alignment.	14 pts (117% of body)	Verdana	Black (Neutral) #000000	Bold Whitespace above
Notes	Additional things a user should be aware of, data sources, metric calculations. "Fade into the background".	8 pts (85% of body)	Verdana	Grey (De-emphasized, lower contrast) #C8C8C8	Normal (no bold, no italic).
Emphasis	Draw the eye to key points that need to make.	Same as body	Verdana	Orange (High impact colour) #FF5314	Bold

The Sub-Header format was added to the Graphic Rules Map to create a different level between the Header and the Body. The format of Emphasis was not considered to this level because the main objective is to identify a sub-theme, not to highlight data.

Table 11 – Backgrounds definitions

	Colour	*Observation*
Page	#FFF Transparency: 0%	For backgrounds, neutral colours should be elected. (Few, 2005)
Header	#FFF Transparency: 0% Applicable for all modules but "Dashboard" that has no fill.	Bar header positioned in the upper of each module. Position X: 4 | Position Y: 1 Width: 1.271 | Height: 58 Applicable for all modules.
Charts	#FFF Transparency: 0%	No limits defined.
Tables	#FFF Transparency: 0%	No limits defined. Table style: predefined.

Table 12 – Colours Chart

Number of data identification	***Colours by priority of user***	***Observation***
1	#01B8AA	Columns Chart, Dispersion Chart
2	#01B8AA, #374649 (contrast for comparison)	Line Chart & Columns, Pie Chart, Grouped Bar Cart, Gauge
3	#01B8AA, #374649, #99E3DD	Line Chart, Pie Chart, Map (according to depot type)
4 to 8	#015C55, #018A80, #34C6BB, #67D4CC, #99E3DD, #E6E6E6, #AFB5B6, #7F898A	Pie Chart, Grouped Columns Chart
More than 8	Use colours presented in the "4 to 8" section and predefined on the 9th colours onwards due to comparison	Ribbon Charts, Heat Map
Others	Use predefined colours	Ribbon Charts

4.4. DASHBOARD

The SCM Summary module (figure 23) presents an overview of the SC performance that allows the user to identify where the useful information for his perimeter is and focus on the subjects of his interest. This way of presenting information benefits the decision makers to get faster the information needed to manage the operation by reducing the time for consultancy. This allows the user to be agile, focusing their attention in the interest information and avoiding the waste of time.

All the modules are presented in Portuguese since it's the official language of the target users.

The **Demand Forecast Accuracy Assessment (alias "Monitorização de Previsão")** module (figure 24) presents the three most important metrics to assess the demand forecast accuracy on a YTD (year to date) basis: WAPE, MAPE and MAE.

The WAPE is of 0,52 when the target is 0,40 (company's goal), which shows that there is space to improve the process of demand forecast. When comparing the MAPE and WAPE, having a better WAPE than MAPE indicates that the process of demand forecast is more accurate for items with more weight in revenue, which indicates that the financial impact of the error is minor. That is obvious to the user in the chart "WAPE | ABC" that shows that the error WAPE overall on A items is the smallest, followed by the B items and C by last.

The cycle where MAPE and WAPE errors are the closest is 201808 with both metrics' results improved, hitting the best score on the YTD analysis. It is possible to see in the "WAPE | ABC" chart that all items got more accurate demand forecast. Also, the MAE was the lowest in this cycle with 60 units (MAE shows the units in average that the forecast is deviated from the actual sales).

The cycle with best results in terms of metrics is also the only cycle where the actual sales exceeded the forecast, alerting the user to the fact that highest forecast is causing the error to increase.

Analysing the category's performance, it is notorious that "Praia" and "Beleza" categories have the highest WAPE ("WAPE | Categories" chart).

To better understand the impact of each category on the global WAPE it is advised to the user to analyse the chart “MAPE | Receita por Categoria”.

Excluding “Acessórios”, “Praia” is the category with lowest revenue and by consequence, the lowest impact in the global WAPE. The category “Beleza” has a higher revenue than “Praia” but it is below the average. It is more important to have better MAPE in “Beleza” than in “Praia”. It is also easier to predict the forecast of “Beleza” since “Praia” items are seasonal which increases the challenge.

What really stands out are “Corpo” and “Fragâncias” categories since they are the two categories with highest revenue. “Fragâncias” is below but close to the average in WAPE so it is the category where it should expend more effort to improve. It is also important to control and improve “Corpo” because any fluctuation in MAPE may impact the global WAPE result due to its weight in the total revenue.

On the **Future Demand Forecast (alias “Previsão de Venda”)** module (figure 25) it is presented the sell-out forecasted by cycle. The user is informed in the “Volume | YTG” data card of the volume forecasted in the YTG period. The actual sell-out forecast is of 2,6 million units.

The other data card (“Volume | Seleção”) presents the sell-out forecasted to the selection that is defined by the data segmentation “Categoria” and “Ano”. Besides the data card also the table and all the charts are adjusted according to the data segments.

As seen in the previous module, “Corpo” and “Fragâncias” were the categories with highest revenue and both have also the highest weight in the volume.

The cycle that has a higher forecast is 201815 because it corresponds to Christmas season and all the promotions are already impacted. The forecast in 2019 and 2020 are smaller since they only reflect the regular baseline sales. This is a point of alert because it will impact the purchasing forecast and, as consequence, the industry planning.

When the user selects the year “2019” the forecast sell-out is 2,7 million units for the whole year. Comparing with the 2,6 million units for the 2018 YTG appears to be unreliable but it is also a consequence of not having the impact of campaigns in the sell-out forecast.

Analysing the segments, the user may take an insight that the sell-out forecast is aligned with the actual sales since the three top segments weighting 38% of total forecast (“Loção Hidratante”, “Perfume EDT” and “Creme Mãos e Pés”) belong to categories “Corpo” and “Fragâncias”, the two categories with more weight in actual sales.

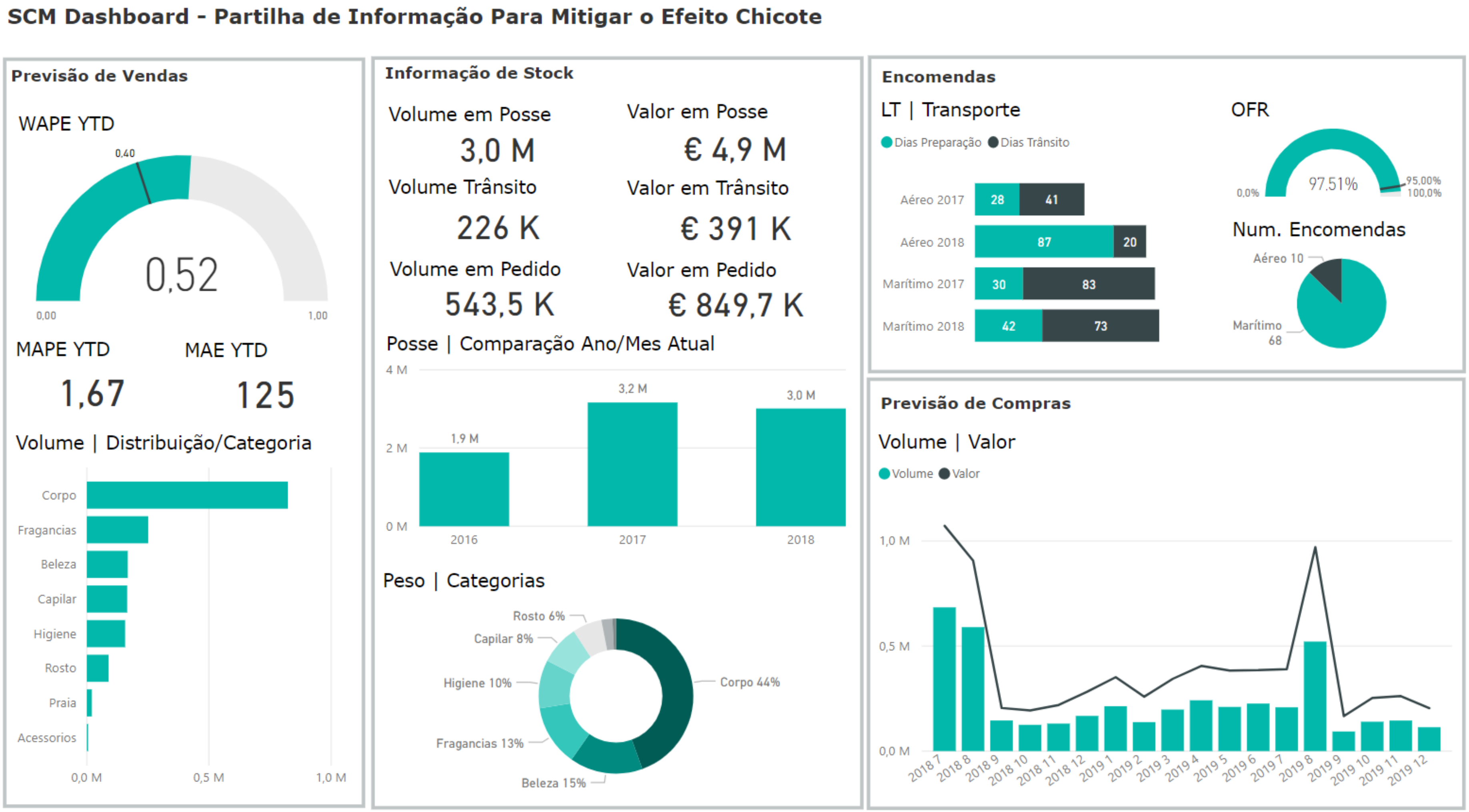


Figure 23 – SCM Dashboard: Summary Module, Information Sharing to Mitigate the BWE, alias "SCM Dashboard – Partilha de Informação para Mitigar o Efeito Chicote"

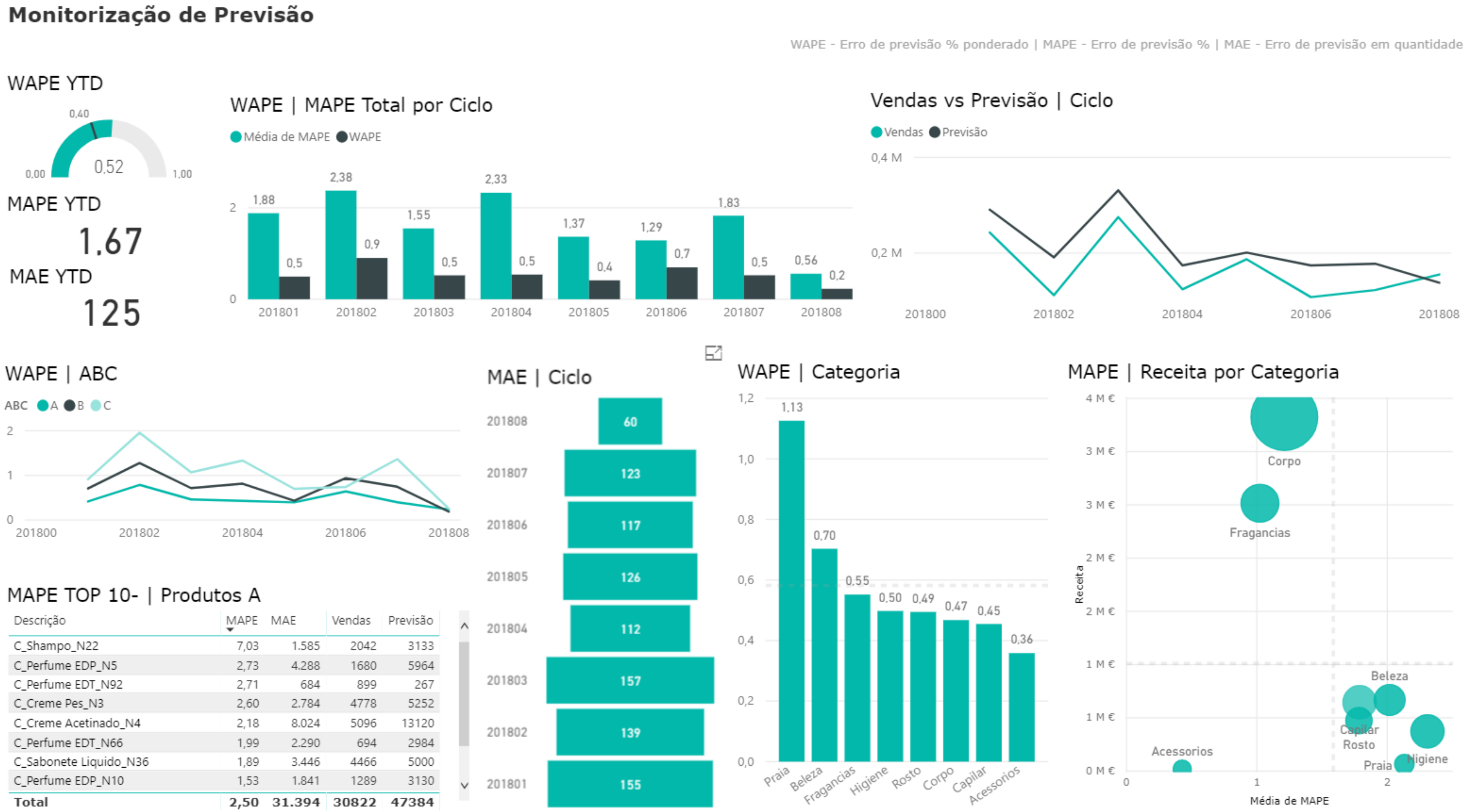


Figure 24 – SCM Dashboard: Demand Forecast Accuracy Assessment Module, alias “Monitorização de Previsão”

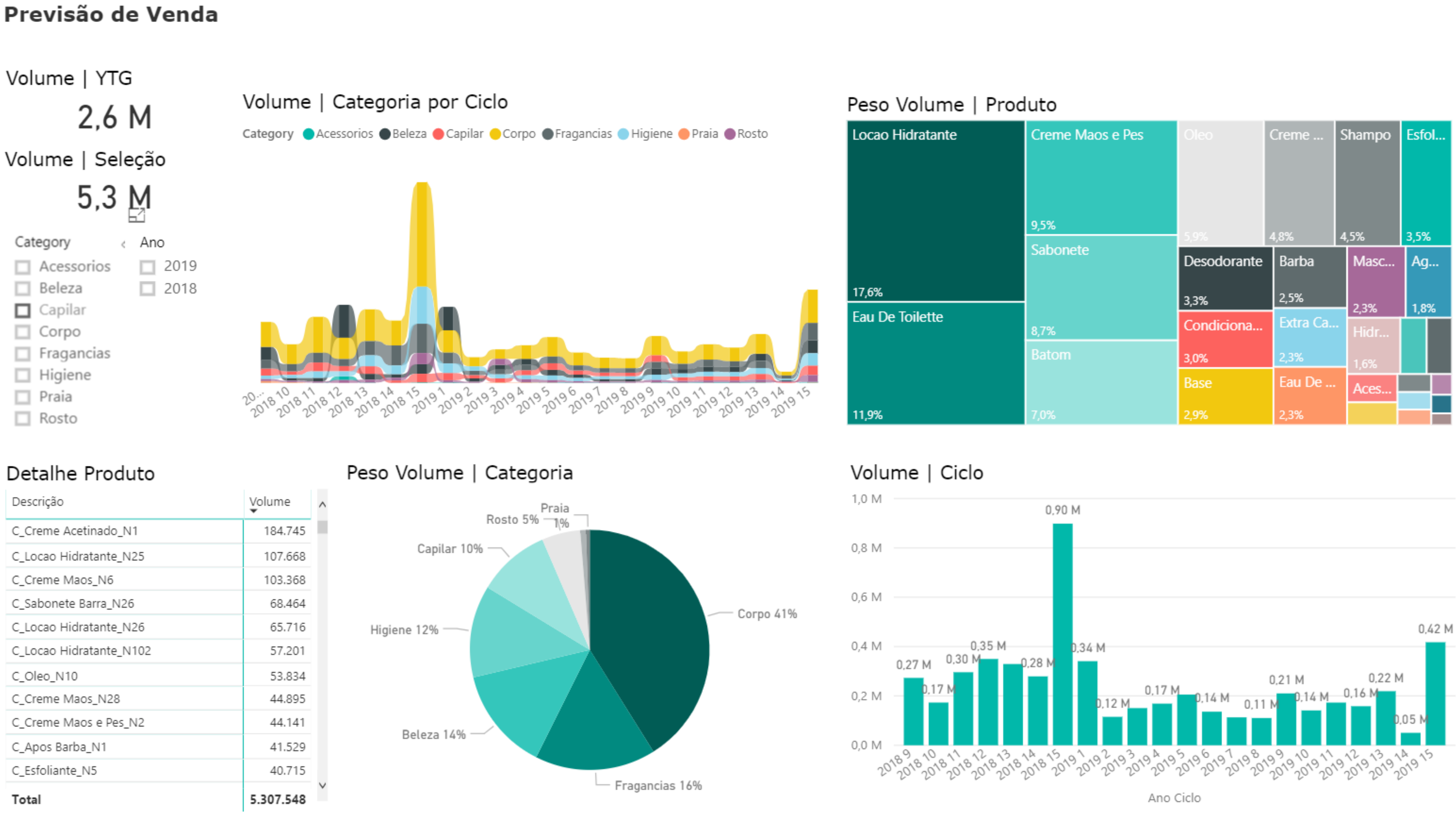


Figure 25 – SCM Dashboard: Future Demand Forecast Module, alias “Previsão de Venda”

The **Inventory Information (alias "Informação de Stock")** module (figure 26) gives the user a clear status of stock position. At this point, the Company X detains on-hand 3 million units (4,9 M€), divided respectively in volume through the distribution centre and its points of sales depots (e-commerce and physical stores) as 59,5%, 0,6% and 39,9%.

The company also detains 226K units that were already shipped and are in transit to the destination. This stock represents and investment of 391K€.

The supplier was requested to sell 543,5 thousand units (849,7K€) but the orders are in request, which means that may not be totally fulfilled.

During the first five months of 2018, the stock possession reached the highest volume when comparing with the same period of the two previous years.

It is possible to observe that in the sixth month, the 2018's volume remains stable when in the same period of the previous year it was registered a considerable increase in the stock. This shows that even with higher possession of stock, it is more stable than in previous years, suggesting an improvement in the stock management.

Regarding the stock possession, it is a plus to analyse the "Posse Volume | Evolução YTD" chart to have the knowledge where the stock is located. During the first three months of the year the stock level was slightly lower in the distribution centre than it is in the four to six months of 2018. During the last three months, the distribution centre and stores' stock is more stable, suggesting that the stock is more centralized and distributed to stores according to the sell-out needs.

Even though in the month six of 2017 the company possessed more stock in volume than in 2018, the stock possession in value is the same (4,9M€). It is possible to conclude that the average cost price by unit possessed is higher in 2018.

When analysing the stock possession by categories in volume it was expected to have "Corpo" and "Fragâncias" as the two main categories since they were a trend in actual sales and sell-out forecast. "Fragâncias" is in third place and "Beleza" is the second most possessed category. This category may have problems of obsolescence in the future.

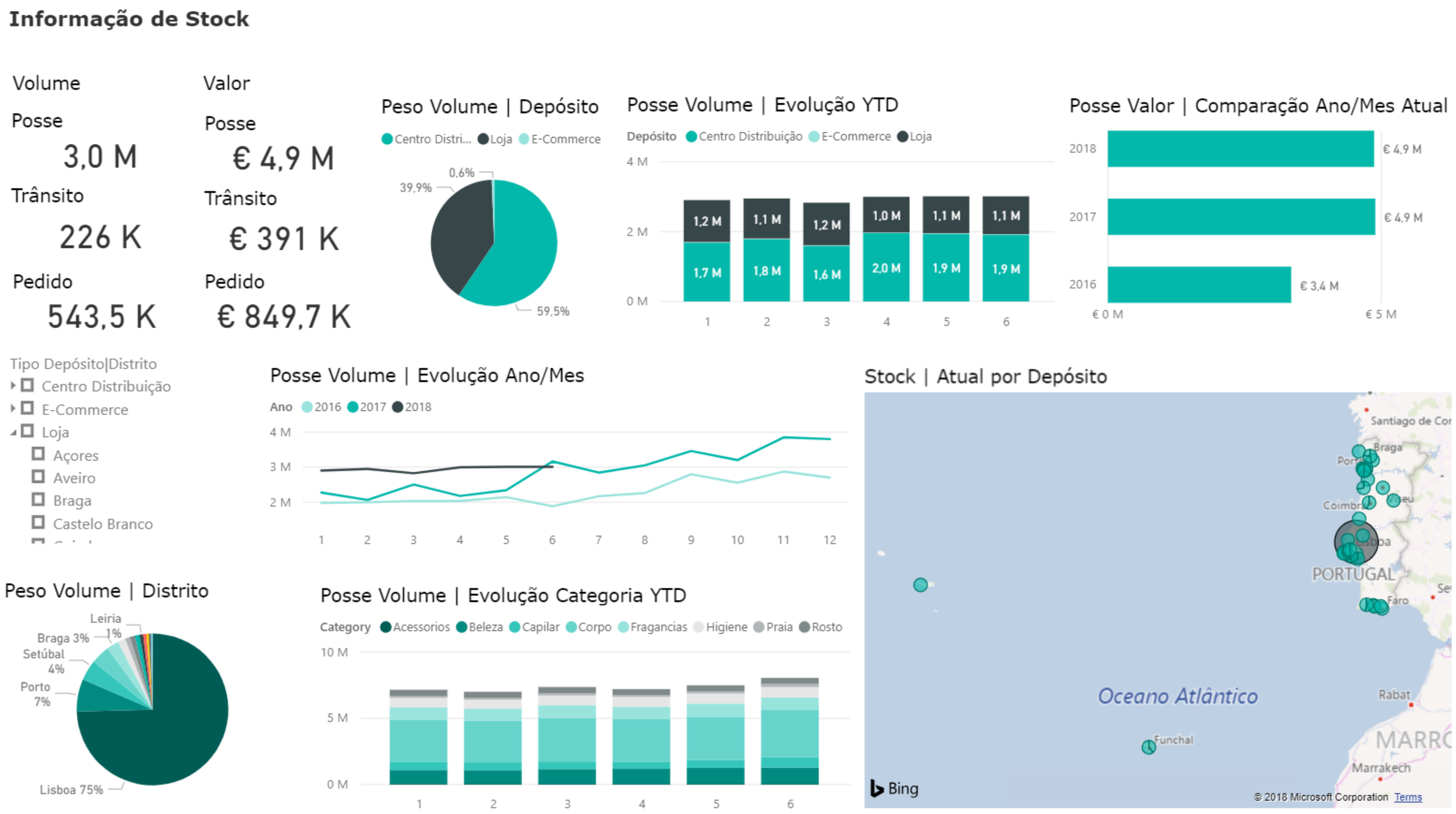


Figure 26 – SCM Dashboard: Inventory Information Module, alias “Informação de Stock”

The **Requested/Invoiced Orders (alias "Encomendas")** module (figure 27) presents the information about the orders that are already invoiced (delivered and in transit) and the ones in request from the beginning of 2017 until the fifth month of 2018.

By selecting the "A" (actual) and "YTD" at "Período" data segmentation, the user compares the order behaviour in the actual and previous year during the year to date.

In average, each order has 1.698 units and worth 2,80K€. By selecting the "Transporte" data segment it is possible to analyse the differences between aerial and maritime. In average the maritime transport has more units in the shipment than the aerial.

The regular transport is maritime which is used in 86% of the times. On the other hand, the aerial is used in 14% of the orders.

In 2018 the company made 19 orders, when in the previous year made 38. It is making less orders in this year but is also buying less, as it is possible to observe in the chart "Valor | Encomendas por Mês".

The average lead-time is of 113 days and it does not diverge much from 2017 to 2018 (4 days).

It is notorious to conclude by analysing the "Preparação/Trânsito por Transporte" chart that the aerial transport is increasing drastically the lead-time in the overall. In 2017 the supplier was taking 27 days to prepare the order and ship it when in 2018 it is taking 87. This suggests that the supplier is losing agility.

On the other hand, the transit days are shrinking from 41 to 20. Since the supplier is taking more days to prepare the orders and the transit itself is the same (same flight hours), the handling to check in the items in the distribution centre is being more efficient.

The maritime lead-time increased in three days which is residual. Nevertheless, the preparation days of the supplier increased from 36 to 42, confirming the insight that the supplier is decreasing the service level. Even though the service level is decreasing caused by the increase of preparation's days, the Order Fill Rate (OFR) is of 97,46%.

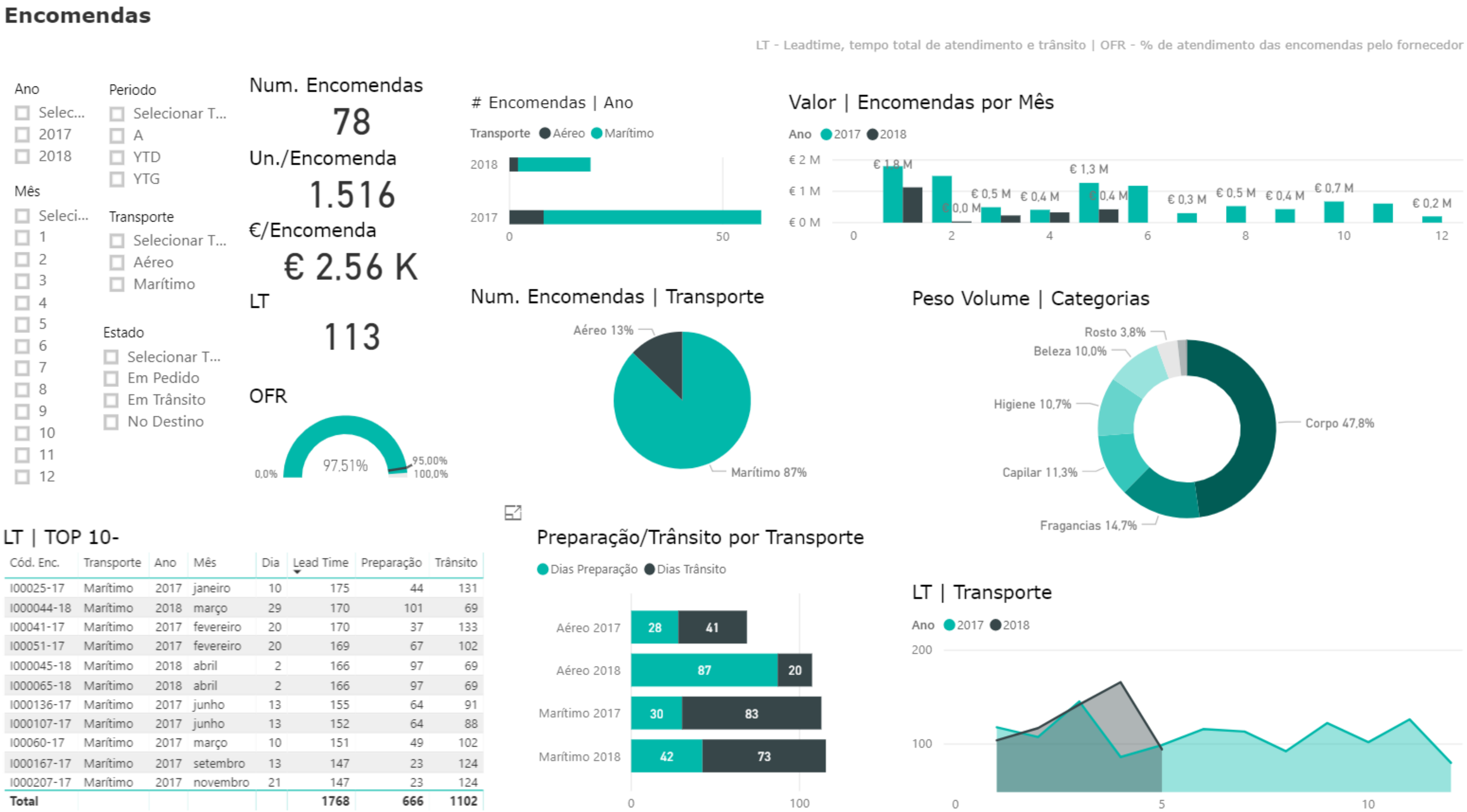
This may suggest that the Service Level Agreement (SLA) may not being respected. If the supplier – for instance in case of shortage – prefers to increase the lead-time in order to guarantee the OFR when what is more important to the Company X is to decrease the lead-time, there is a conflict of interests. In this situation it is advisable to understand which KPI's the supplier is being measured for.

Naturally if the problem is structural and operational it is necessary to guarantee that the supplier works towards its solution and performance improvement.

The **Purchasing Forecast (alias "Previsão de Compra")** module (figure 28) presents the information about the future orders that are sent to the supplier each month. The Company X does not have any commitment to acquire the specific quantity that forecasts but sharing it with the supplier allows the supplier to better plan the industry and the order fulfilment process.

The user has eighteen months of purchasing forecast resulting in 4,3 million units and 7,3 M€. On the 2018's YTG the months seven and eight are the ones with the highest volume of purchases, representing the Christmas season replenishment. In 2019 only the eight month presents this peak.

This is the repercussion of only having the regular baseline sales in the sell-out forecast of 2019 which impacts directly the industry planning. The supplier does not have a clear view of the volume and the raw materials' forecast won't be enough to meet the needs of production. This will result in highest cost of production due to low economies of scale in sourcing and by consequence a lowest margin.



Cód. Enc.	Transporte	Ano	Mês	Dia	Lead Time	Preparação	Trânsito
I00025-17	Marítimo	2017	janeiro	10	175	44	131
I000044-18	Marítimo	2018	março	29	170	101	69
I00041-17	Marítimo	2017	fevereiro	20	170	37	133
I00051-17	Marítimo	2017	fevereiro	20	169	67	102
I000045-18	Marítimo	2018	abril	2	166	97	69
I000065-18	Marítimo	2018	abril	2	166	97	69
I000136-17	Marítimo	2017	junho	13	155	64	91
I000107-17	Marítimo	2017	junho	13	152	64	88
I00060-17	Marítimo	2017	março	10	151	49	102
I000167-17	Marítimo	2017	setembro	13	147	23	124
I000207-17	Marítimo	2017	novembro	21	147	23	124
Total					1768	666	1102

Figure 27 – SCM Dashboard: Requested/Invoiced Orders Module, alias “Encomendas”

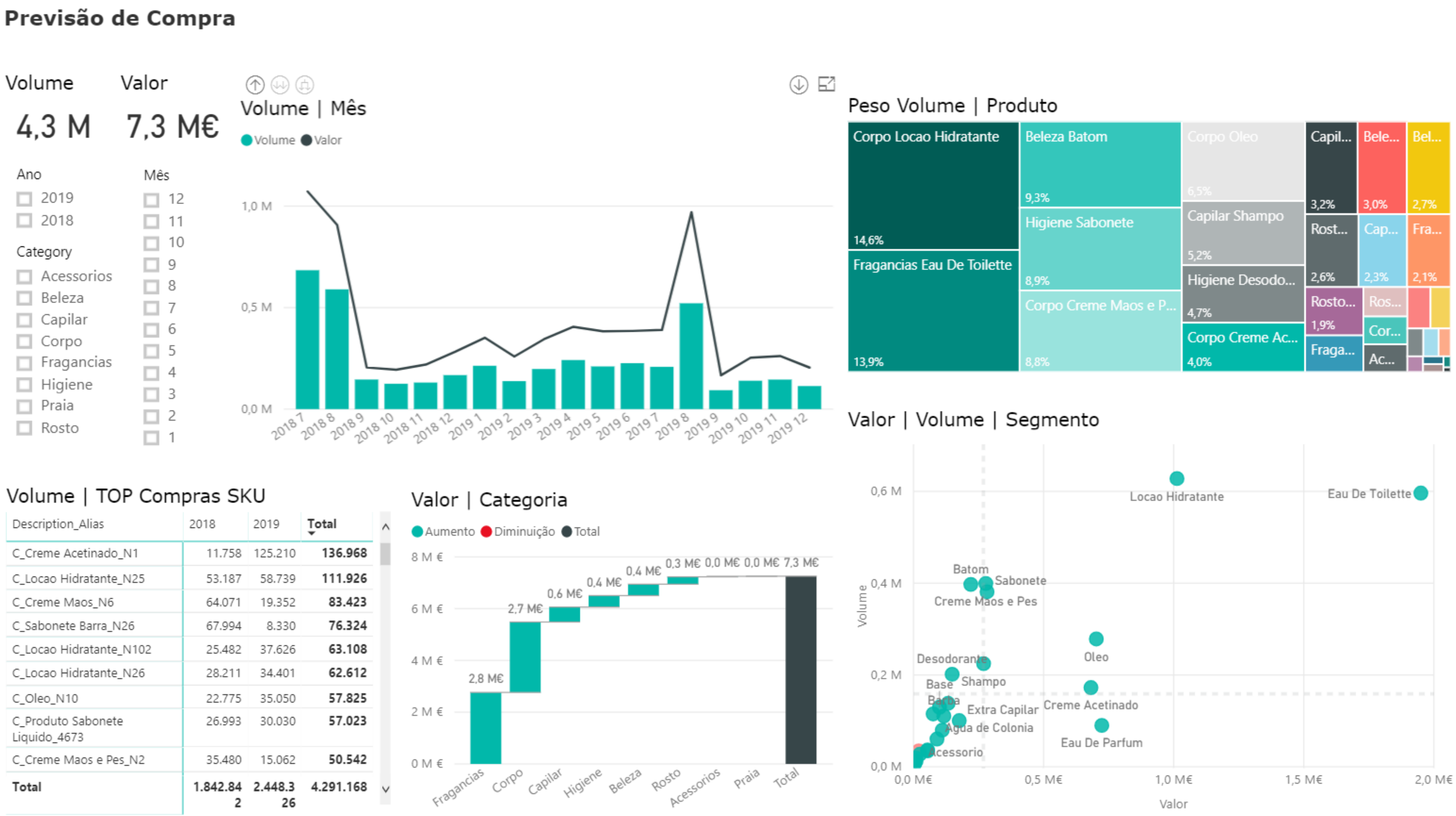


Figure 28 – SCM Dashboard: Purchasing Forecast Module, alias "Previsão de Compra"

5. RESULTS AND DISCUSSION

In this chapter will be presented the resulting SCM dashboard as output of this project and the evaluation of the dashboard results.

The ‘Evaluation’ phase of the methodology evaluates if the project meets the expected output, or if it requires more iterations to improve the current model.

5.1. EVALUATION OF THE RESULTS

The conceptual model of the SCM dashboard was conceived, designed and developed according to a literature research to reach the best solution for the proposed problem.

Through the implemented data model, raw data is converted into reliable information that is related, properly aggregated and released to the users through the dashboard in a web browser, allowing a direct and easy access to data.

The interactivity offered by the dashboard is beneficial to the use and exploitation of data.

This dashboard is customized with information presented to satisfy the specific objective to produce clear insights about the SC in a simple way to relate it with the BWE. It achieved the objective of assist and support the users in the task of understanding data.

It is insured that users have full comprehension of the information presented. The measures and metrics available in the dashboard are known by all the target users. Nevertheless, additional explanations are provided in the dashboard to avoid misunderstandings.

Although most of the information presented are measures, the combination with metrics is crucial to complement the communication to the user. Therefore, strategic metrics are also presented to monitor the performance of the target achievements.

It is considered that the dashboard presents measures and metrics which reach the purpose of assess the performance of the SC. It also promotes the generation of knowledge about the SC and give the information needed to manage it.

The information display methods are relevant, concise and intuitive. The presentation is made according to the type of data and the purpose of the analysis. The display methods provide the comprehension of large amount of data and allow the perception of not anticipated data. Also, enhances the large and small-scale features of data and support the hypothesis formation in the analysis process.

This tool presents high-level summaries, which allows the user to adapt its analysis by data segmentation, drill-down and drill-through in a simple and intuitive way.

Following the DSR methodology it is considered that the artifact implementation suits the requirements for the problem resolution and as consequence other developments won’t be performed.

5.2. PROJECT APPLICATION

This project was developed to Company X and Group Y but is applicable to any company with the same characteristics than Company X.

The priority is to replicate this project in other branches of the Group Y due to the similarity of the processes, data features and data sources.

Besides the Group Y's branches, other companies are eligible to implement this project. Following, it is presented the requirements to replicate the project entirely to other companies:

Table 13 – Requirements to project application in other companies

Characteristic	*Requirement*	*Observation*
Number of Suppliers	One	If a company has more than one supplier may implement the project, but it won't discriminate data from different suppliers. It will treat all the supplier's data as one.
Type of goods sold	Products	A company that sells services is not eligible
Period of demand forecast	Cycle	The cycle may assume the period the user demand. The maximum number of cycles allowed are 30. If the company forecasts in cycles of small periods it may be not enough to the supplier consultation.
Order Up-To Model	Monthly	Purchasing is made once by month. The monthly purchase can be made through multiple orders. The purchasing forecast is made by month.
Order Status	Requested	Orders requested but not invoiced. Invoice is made before of shipment.
	Invoiced	Orders in transit that did not arrived at the destination.
	At the destination	Orders integrated in the on-hand inventory.
Number of Inventory depots	Not defined	The inventory depots are aggregated according to distribution centre and type of sales' channel
Product Master	Two levels	Product category and product segment.
ABC	Defined to actual sales	Only applicable to demand forecast accuracy assessment

6. CONCLUSION

The dashboard conceptual model is an IT artifact developed under the DSR methodology as a solution to mitigate the Company X's BWE over the SC. After verifying that the artifact suits the requirements for the problem solution, we can conclude that the dashboard is potentially one of the best solutions for organizing and present SC information and performance indicators.

This dashboard communicates the demand forecast, inventory information and order information. These were the topics pointed in the literature review as critical to be shared over the SC links, which have a positive impact in the BWE mitigation.

By compiling information of different SC areas, the developed dashboard has the potential to decrease information distortion, to inform managers and SC's users, to improve their knowledge and make them more aware of SC as a whole, its activities and processes' performance. As result, the users are informed with clarity, the process of decision making is easier, more conscious and supported with facts.

This dashboard is considered an SCM tool. Its contribution in the monitoring of the key BWE's offenders (demand forecast) and impacted factors (inventory, orders, lead-time) is critical to the SC welfare.

By measuring the demand forecast accuracy, the process gets better managed and the improving is expected. This leads to more accurate information to plan sourcing, manufacturing and operational activities by the supplier. Better planning brings savings and cost reduction, reducing the product cost and generating more margin to the Group.

By displaying the inventory information, the user has clear knowledge of the inventory status and investment evolution over the SC. Also allows the company to monitor the unique supplier and require service level standards.

The indicators play an important role in this dashboard, as such, its choice was based in the literature review. It is considered that the indicators bring relevant insights to the analysis and to the decision making-process. The measures and metrics available in the dashboard are known by the users, being easy to make the dashboard available without complex training.

Beyond that, the data visualization enhances the potential analysis of the generated data, being a step-forward development that improves the company's perception of its SC, encouraging the user to be alert and critic, promoting the call to action to improve the processes.

This evolution is a major step not only in information reliability but also for the analysts that are currently responsible to generate this information. This change will have a positive impact in the work satisfaction by allowing the analysts to focus on analytical tasks and continuous improvement projects. The democratization of the SC information will allow other users to have access to the information.

Even though this project is targeting Company X, it shall be implemented in other Group Y's branches, providing an adapted and standard solution to each branch. The information democratization to Group Y leads to better planning of sourcing and operation, driving to cost reduction.

This project can also be replicated to other companies with similar characteristics, being provided the requirements to fit the implementation.

The following assessment (figure 29) presents the level of achievement of the:

- Initial goals proposed for this project;
- Degree of solution to the problems identified in the “Study Relevance and Importance” section;
- Best practices of a dashboard creation identified in the literature review.

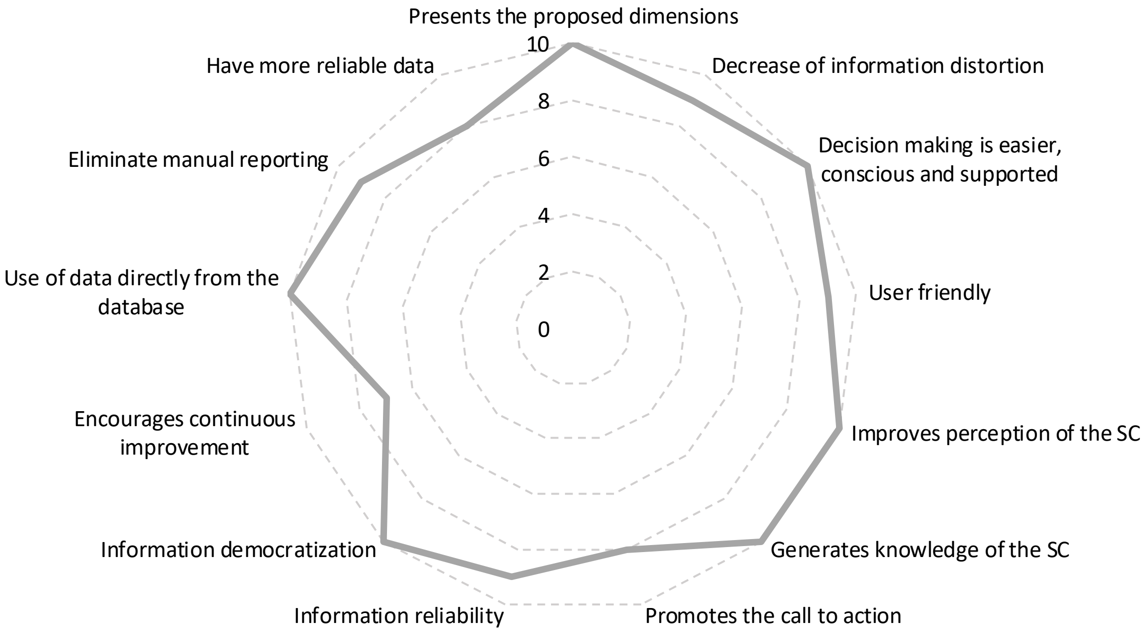


Figure 29 – Evaluation of the projects’ achievements

In the analysis of the final results, it is concluded that the artifact accomplish the goals proposed for this project with success. The artifact is a step forward in the SCM of this company and group. SC managers and users have the opportunity to follow the performance and improve processes with the main goal of impact the decrease of the BWE.

7. LIMITATIONS AND RECCOMENDATIONS FOR FUTURE WORKS

Following are presented the limitations occurred during the development of this project:

- Due to compliance issues and data protection it was not possible to access directly to the company's database;
- The lack of system integration between the Company X and Group Y did not allowed to consider more relevant data to the SC dashboard;
- The process of gathering data was challenging since not all the data required is available at the database. It was necessary to approach different departments to collect relevant data;
- The data collected from the departments had different formats and features. It was required additional data treatment to achieve the quality desired to consider it in the project;
- The business characteristics and processes implemented make it impossible to analyse all data with the same temporal periods (month or cycle). For this reason, it is not possible to apply the same data segments or compare data with different temporal periods;

After the development of this project a few recommendations for future works are presented:

- Present real-time data by connecting the dashboard to the company's database;
- Connect the Company X and Group Y databases to create synergies, improve data quality and make it available and properly updated;
- Considering that not all the data is available at the database, the departments that own the data should be responsible to provide it in proper format to the dashboard. This will arise the departments' sense of responsibility about the data displayed to the organization and lead to an improvement of the data's reliability;
- Targets to metrics and measures should be defined to provide a performance context and guide the user during the analysis. Only "WAPE" and "OFR" present targets since are the metrics with official goals;
- Measure the impact in the BWE of this dashboard's information sharing through the evolution of the measures and metrics;
- Consult the dashboard's users to guarantee that the dashboard is a simple tool and meets the business requirements;
- Apply a survey to measure the satisfaction about the dashboard in a defined period basis to understand the users' engagement.

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