POLITECNICO DI TORINO

Master of Science in ENGINEERING AND MANAGEMENT

Master of Science Thesis

Inventory Management Strategies: Multinational Corporation Case Study

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Turin, December 2021 Nataliia Barakina

Abstract

An efficient, adaptive and resilient supply chain is an integral capability required by organizations in the 21st century to build a competitive advantage and maintain high standards of service for partners and clients. Inventory management is set at the core of the supply chain, where all of its areas connect in tandem: it includes practices, processes and organizational structures utilized to control and oversee purchases from suppliers and customers, manage and replenish inventory holding levels, minimise costs and bottlenecks, monitor current and future stock requirements for order fulfilment.

Using a case study based on the strategic considerations involved in optimizing the inventory management of Whirlpool Corporation in Europe, this research aims to provide a theoretical framing of the key elements of centralised inventory strategies, as well as an applied investigation of the advantages and criticalities of this model. The case study is analyzed by presenting the current decentralised supply chain structure and processes and evaluating the potential effects of implementing a shift towards centralised inventory management. Both quantitative and qualitative analyses were conducted through stakeholder interviews and document analysis.

While a grounded, evidence-based approach through a literature review of cases of multinational corporations faced with similar strategic supply chain decisions appeared to provide clear indications for optimization through cost reductions within a centralised model, the findings of the document analysis identified significant issues in the implementation of a centralised strategy for Whirlpool due to low product commonalities across different European regions. Potential recommendations are made for a limited shift towards centralised inventory management, though the requirement for further cross-functional investigation is highlighted, to address in a comprehensive manner issue related to logistics costs and planning processes.

Title
Inventory Management Strategies: Multinational Corporation Case Study

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Keywords
Inventory replenishment; centralised supply chain planning; strategic sourcing; inventory planning; supply chain management.

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Nomenclature

Abbreviations

ATP - Available-To-Promise
E2E - End-to-End
EMEA - Europe, Middle East and Africa
FCF - Free Cash Flow
FPS - Finished Product Sourcing
HQ - Headquarters
KPI - Key Performance Indicator
LTR - Late-To-Request
MNC - Multinational Corporation
MTO - Make-To-Order
MTS - Make-To-Stock
NSO - National Sales Organisation
OTS - On-Time-Shipped
RACI - Responsibility Assignment Matrix (Responsible, Accountable, Consulted, Informed)
RDC - Regional Distribution Center
RDD - Requested Delivery Date
SC - Supply Chain
SCM - Supply Chain Management
SCP - Supply Chain Planner
SKU - Stock Keeping Unit
SRL - Square Root Law
SNP - Supply Network Planner

Chapter 1

Introduction

This chapter provides background information about the master thesis's topic and problem, as well as the study's aim and objectives. It additionally includes a list of the questions to be addressed as well as an explanation of the directions and delimitations. Furthermore, the thesis outline is presented.

Supply chain management has been increasingly prominent during the last few decades. This elevated focus is due to trends such as global sourcing, a focus on time and quality-based competitiveness, and their respective environmental consequences. Moreover, globalization has compelled businesses to create more effective ways to manage and coordinate the flow of products in order to fulfil customers' ever-increasing demands for cheaper costs, faster delivery, and defect-free items. (Wieland, 2021; Mentzer et al., 2001; Koberg et al., 2019)

The rise of globalisation and the resulting issues for corporate management have prompted practitioners' and academics' interest in global supply chain management (Gargeya and Meixell, 2005). Recent studies have focused on essential aspects/decisions that may be classified into three major groups: strategic supply chain alignment, global logistics network architecture, and coordination of global supply chain stakeholders. The first research stream includes studies on global manufacturing strategy (for example, plant siting and vertical integration) (MacCormak et al., 1994; Chopra and Meindl, 2013; Kotabe and Murray, 2004; Brown et al., 2007). Different supply chain architectures might exist depending on the extent of vertical integration (Hong and Holweg, 2002). In terms of the second line of research, configuring global logistics networks entails selecting the most appropriate international transport mode (primarily ocean container shipping,

railway or airfreight), designing infrastructures for freight consolidation and serving end markets (Min et al., 2009), and determining the number of echelons that comprise the logistics network (Kruger, 2002; Zeng and Rossetti, 2003; Imai et al., 2006; Creazza et al., 2010).

The total cost of all supply chain operations has traditionally been utilised as the key performance indicator (KPI) for supply chain optimization. However, in today's competitive market, it is not always ideal to cut expenses if this results in a lower level of customer service. Decision-makers should make a trade-off between these competing performance metrics. Strategic sourcing and inventory replenishment are two study fields with a considerable practical impact among the various supply chain-related challenges. One of them is that strategic sourcing, in particular supplier selection, is a strategic-level choice, whereas inventory replenishment constraints are considered at the operational level.
Strategic sourcing and inventory selection are interconnected, and uncertain aspects such as demand fluctuation and lead-time unpredictability have a considerable influence on the effectiveness and costs of supply chain systems. Inventory replenishment parameters are influenced by supplier locations and supply lead times. Diversified inventory policies, on the other hand, have an impact on the supply lead-time needs. In such an industrial setting, a multiobjective optimization approach is essential for finding best-compromise solutions that make joint decisions in a thorough manner. (Hongwei Ding et al., 2004)

1.1 Background and Literature Review

1.1.1 End-to-End Sourcing

End-to-end sourcing is when service providers handle inventory management, storage, and delivery. A logistics professional can maximise distribution and reduce delays from road congestion, vehicle breakdowns, and other factors by removing as many layers and procedures as feasible. Sourcing is the process of evaluating, identifying, and managing suppliers that can provide the resources that a company demands on a daily basis. Sourcing is accountable for conducting research, designing

and implementing strategy, setting quality and quantity indicators, and selecting suppliers that would fulfil these requirements. Sourcing maintains the firm's supply chain and ensures that the organisation always has access to the equipment it requires to meet its objectives.

1.1.2 Replenishment Strategy

The replenishment strategy in the supply chain is the process of ensuring that each warehousing point has the optimum amount of goods. This improves the system's efficiency, dependability, and fluidity. It is a method for increasing the number of units at upstream (reserve) storage facilities. Lost sales related to insufficient stock availability, as well as warehousing costs due to excessive stock, can be reduced through timely positioned fill orders. Even during the acquisition of a warehouse, planning is essential to forecast the final inventory count within the warehouse. Failure to determine an optimal inventory cycle and reorder level can result in capital expenditure inefficiency, underused resources, increased labour costs, faulty stock counts, and a rapid decline in service levels. (Hajji, 2011)

1.1.3 Centralised and decentralised supply chain models

For some years, it has been observed that a growing number of businesses are shifting away from a decentralised supply chain structure and toward a more centralised strategy. By lowering the number of operational nodes in the supply chain, the main objective is to reduce inventory holding costs and manpower while increasing customer service levels, such as delivery service rate, delivery accuracy, shorter lead times, and so on. Transportation is impacted as the corporation strives to maintain its market position while cutting the number of distribution points. The number of transportations may be reduced, but the distance to customers may be increased. Figure 1 depicts the centralisation concept in its entirety: a set of suppliers and a set of end customers. In the decentralised system shown to the left, each supplier has direct access to each end client. Suppliers can only reach end customers via a central distribution hub in a centralised setup.

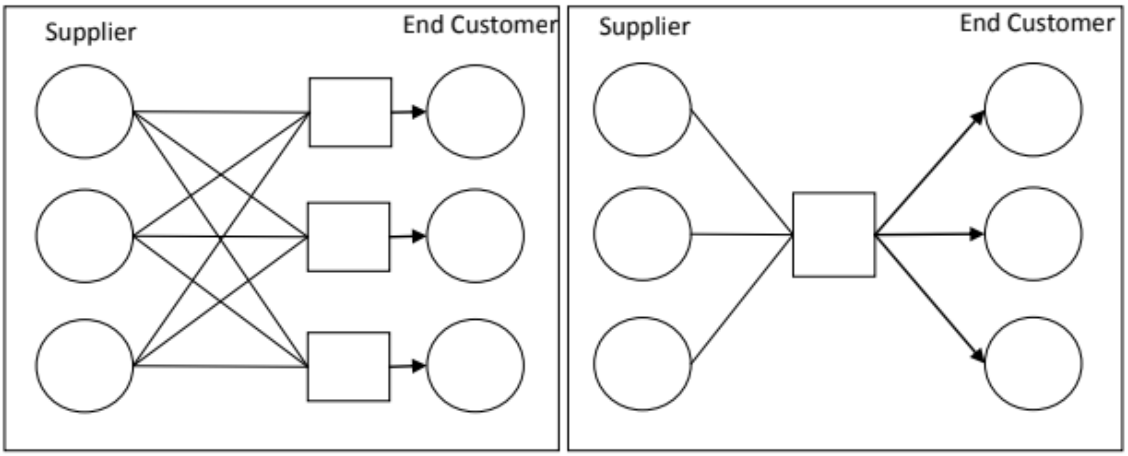

Figure 1. Conceptual representation of decentralised (left) and centralised (right) supply chain management model

According to Ekenstedt (2004), the driving forces behind distribution concentration include less warehouse space and associated costs, lower stock levels, the ability to ship components directly from suppliers to a single logistic centre, improved customer services, and a reduction in tied-up working capital.

Each node, such as factories and distributors, maintains its own inventory in a decentralised supply chain. Following the centralised method, the inventory is placed in fewer locations, each supporting a larger number of clients. Many firms have reported positive earnings after undertaking a centralisation model.

There are two types of benefits:

1. Cost advantages:

- Lower storage costs as a result of lower inventory;
- Decreased labour, inventory, and administrative expenses;
- Central planning and management of the physical flow.

2. Logistic added value:

- Shorter and more precise lead times;
- Increased delivery accuracy;
- Greater differentiating ability;
- More accurate and rapid customer information.

As a consequence of various case studies, we can observe that warehouse centralisation makes distribution itself a competitive advantage in the majority of

situations. Companies will also benefit from more flexible distribution as a result of improved management control.

Furthermore, Matthews (2003) addresses various, in some ways, unnoticed consequences of a centralised supply chain. He focuses on the impacts on the environment from transportation reduction as a result of a centralised warehousing structure. Amongst environmental impacts mentioned are:

- Reduced energy consumption;
- Reduced fatality rate;
- Fewer greenhouse gases are emitted as a result of more efficient transportation.

However, Matthews (2003) emphasizes that organisations must be large enough in terms of the number of clients, turnover, and so on to fully benefit from a centralised supply chain model. It is considered that the scope and size of Whirlpool Corporation in Europe fulfils this requirement for achieving optimal centralised model benefits (Figure 2).

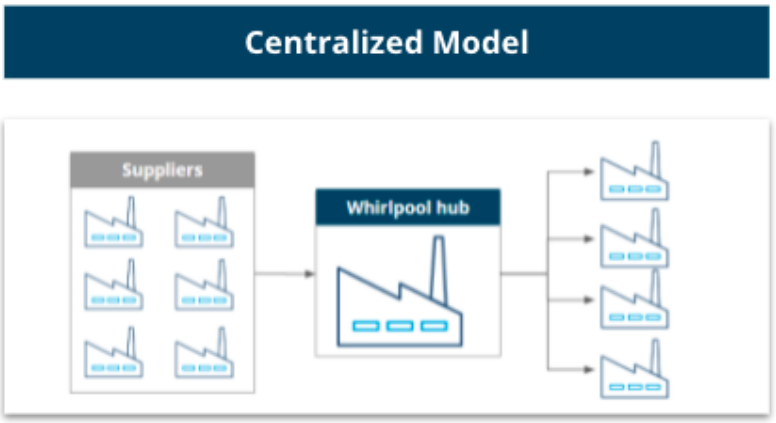

Figure 2. Graphic representation of a proposed Centralised Model at Whirlpool

1.1.4 Make-To-Stock model

The MTS manufacturing model entails retaining goods in stock for the prompt delivery in order to reduce customer delivery times. (Figure 3) This approach is appropriate for standardised items, high quantities, limited heterogeneity, and reliable forecasts. The competitive priority is low-cost production.

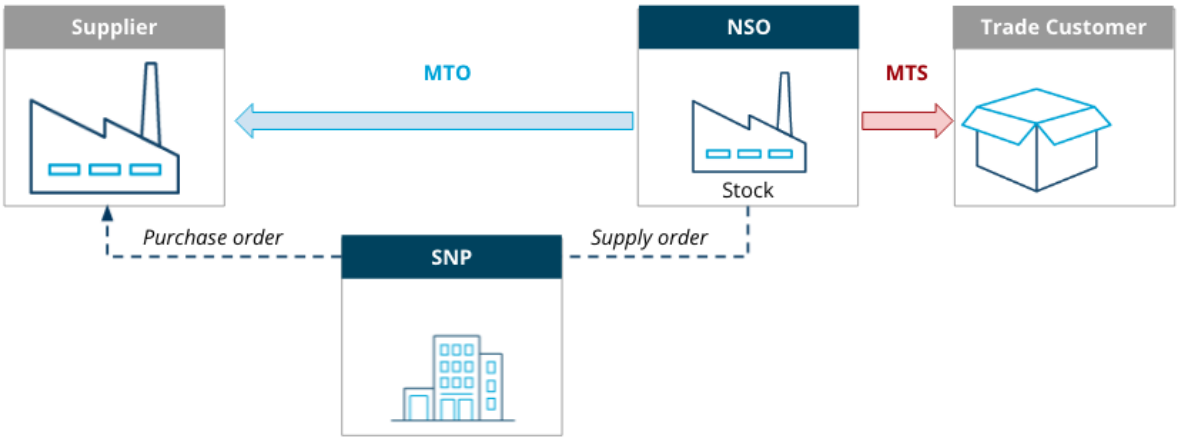

Figure 3. Graphic representation of current decentralised hybrid MTO/MTS Supply Chain inventory management model at Whirlpool Corporation in Europe (NSO = National Sales Organisation; SNP = Supply Network Planner)

1.1.5 Make-To-Order model

The MTO manufacturing method produces low-volume goods to client specifications. MTO frequently begins from the ground up and covers both product development and production. (Figure 3) MTO is often a more sophisticated manufacturing process than building a finished product from conventional parts and components. Companies that follow the MTO model are often vertically integrated throughout the organisation.

1.2 Introduction to Whirlpool Corporation

Whirlpool Corporation, the world's biggest producer and marketer of major household appliances manufactures in 13 countries and supplies its products in more than 170 other countries. In addition to its own key brands such as Whirlpool, the company markets as well under other 13 including KitchenAid, Inglis, Bauknecht, Ignis, and Indesit. The Upton Motor Machine Company, a producer of electric motor-driven washing machines founded in 1911 in St. Joseph, Michigan by Louis and Emory Upton, is the forerunner of Whirlpool Corporation.

During the 1950s and 1960s, Whirlpool Corporation developed into a broad range of major appliances, including central heating and even television. Today, the manufacture of its original laundry items remains the company's primary area of production, but it is closely followed by refrigerators and freezers, as well as by considerable sales of kitchen appliances.

Whirlpool Corporation launched its worldwide expansion in 1958 with an investment in Multibras Eletrodomésticos, but the majority of its internationalisation occurred through joint ventures and acquisitions in the 1980s and early 1990s. North America currently accounts for around two-thirds of Whirlpool Corporation's $11 billion in sales, including a significant presence in Mexico. Whilst Whirlpool Corporation now has an executive team responsible for regional profits and losses, in the mid-1990s it established a worldwide Product Development and Procurement Organization to drive efficiency in product development and procurement across the areas.

In 2020, the firm recorded yearly revenues of around $19 billion, 78,000 employees, and 57 manufacturing and technology research centres. In accordance with the firm's mission and business vision, the American corporation has achieved success, resulting in a global presence in the sector (Company website):

> *"Be the best kitchen and laundry company, in constant pursuit of improving life at home" (Vision)*
>
> *"Earn the trust and create demand for our brands in a digital world" (Mission)*

Whirlpool Corporation operates in 4 global regions and has 4 Headquarters offices around the globe:

1. World Headquarters and North America (Benton Harbor, Michigan, U.S.A)
2. Europe, Middle East and Africa Headquarters (Pero (Milan), Italy)
3. Latin America Headquarters (São Paulo, Brazil)
4. Asia Headquarters (Hong Kong, China)

This thesis project is developed on behalf of Whirlpool Italy which is part of the Europe, Middle East and Africa region and located in EMEA HQ in Pero, Milan. Around 19,000 workers are employed in 11 industrial and technological development sites across five countries in Europe, the Middle East, and Africa. The region distributes Whirlpool, KitchenAid, Hotpoint, Bauknecht, and Indesit appliances.

1.3 Problem description

The management at Whirlpool Corporation is not new to implementing bold strategic decisions in relation to its supply chain management models to aptly adapt to evolving market scenarios and circumstances, as illustrated by a significant optimization of supply chain processes which took place company wide in the early 2000s (Todman, 2001). The recent shipment capacity bottleneck in China has revealed existing inefficiencies in the systems and processes utilized to deliver items from suppliers located in China. A significant amount of the issues encountered with suppliers and, consequently, with order fulfilment for trade customers, are attributable to strategic inventory management issues, rather than operational issues.

A review of the inventory framework, specifically for the European region holds significant potential for improvement, thus the purpose of several current internal research endeavours within the company is to establish systemic weaknesses and flaws in the existing model and address these through strategic focused or large-scale interventions.

As displayed in Figure 4 below, there has been a growing rate of Late-to-Request (LTR) order fulfilment delays, which in turn has downstream effects on:

- inadequate service level provided to Trade Customers
- rising logistics costs related to additional freight and warehousing, contributing significantly to overall Inventory management costs

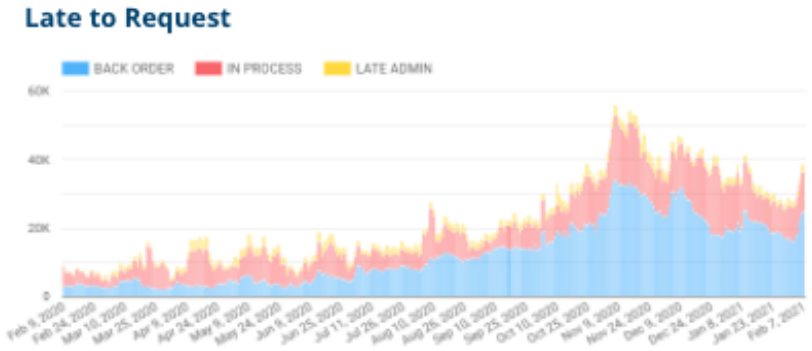

Figure 4. Late to Request (delayed orders) by causality

Through a clear framing and visualisation of the issues related to excessive inventory levels, we explore the prospective benefits and challenges of a centralised framework for the inventory management strategy, namely through the shifting of order planning, fulfilment and replenishment within one or more European hubs, rather than the current decentralised model which is described in more detail in the following sections.

1.4 Purpose

The goal of this thesis project is to spotlight current issues in the E2E sourcing management and in supply chain planning model at Whirlpool Corporation in Italy, as well as to propose practical solutions and a new replenishment strategy in line with Whirlpool's new inventory concept, in order to improve organisational work and strategic inventory control decisions in the direction of cost reduction and improvement of the supply chain process.

1.5 Research questions

Strategic replenishment is generally viewed as an important component of supply chain management in corporations, and dealing with this matter efficiently is critical for the development of successful firms. Whirlpool, on the other hand, appears to have experienced issues with its present sourcing approach, as evidenced by internal company statistics.

As a result, the following primary and secondary research questions have been developed:

1. What are the benefits and challenges of implementing a centralised model for inventory management?

2. Specifically, what is the entity of stock reduction obtained through risk pooling?

1.6 Directives and focus areas

This thesis project is conducted on behalf of Whirlpool Italia and, therefore, is established on directives from the company. The study focuses on the comparison between the current inventory management strategy with a proposed centralised model, including the changes in organizational work related to this topic in particular in relation to E2E sourcing for Whirlpool Italia. The study considers inventory and planning activities in the majority of the value chain related to this topic. Furthermore, the thesis is limited to a few of Whirlpool's suppliers situated in China and to the warehouses and sales units on the European market.

1.7 Target group

The stakeholders at Whirlpool Corporation, from whom the thesis was developed, are the primary target group of this thesis. Employees from the organization's supply chain department are among the stakeholders. These are not limited to the category examined in this thesis, but rather originate from a range of business units that stand to benefit from the study's conclusions. Furthermore, the findings of the project should be applicable and transferrable to other organizations with similar supply chain standards and requirements.

1.8 Thesis outline

Chapter 1: Introduction

This chapter provides background information about the master thesis's topic and problem, as well as the study's aim and objectives. It additionally includes a list of the questions to be addressed as well as an explanation of the directions and delimitations. Furthermore, the report's outline is presented.

Chapter 2: Methodology

The aim of this chapter is to identify and outline the core framework and principles of how the study is carried out in order to ensure the thesis's credibility. Its goal is to offer the reader an overview of how the problem was addressed as well as a brief analysis of the pros and cons of alternative techniques and methodical approaches.

Chapter 3: Case Study: Replenishment Strategy, Processes and Roles

This chapter depicts and gives an understanding of how Whirlpool Italy manages logistics, supply, and inventory planning in general, as well as describes the roles and duties of various professionals involved in these processes. The goal is to identify and describe the planning models and procedures implemented in the company.

Chapter 4: Analysis of Supply Chain Centralisation

This chapter describes the implications of centralisation in the logistics and supply chain planning activities and processes, that are currently carried out in a decentralised model by Whirlpool Corporation across Europe. Salient issues are raised related to the SC Bullwhip effect, Risk Pooling, Safety Stock reduction, Commonality range assessment, required transformations within the SC planning roles and structures.

Chapter 5: Conclusions

This chapter summarizes the results and observations made in the previous sections and discusses the generalizability of the finding. It also covers possible contributions to future inventory management and replenishment strategy for Whirlpool in Europe and recommendations for further in-depth investigations.

Chapter 2

Methodology

The aim of this chapter is to identify and outline the core framework and principles of how the study is carried out in order to ensure the thesis's credibility. Its goal is to offer the reader an overview of how the problem was addressed as well as a brief analysis of the pros and cons of alternative techniques and methodical approaches.

2.1 Research approach

The supply chain and its numerous inventory points may be defined as a system. Inventory at one point in the supply chain is influenced by inventory at other points, and decisions and adjustments made in one section of the chain might have an impact on other parts. Furthermore, one of the main concepts of supply chain management is that optimizing the entire supply chain brings greater advantages than optimizing each component separately. These perspectives, which emphasize on a system's links and relationships, have clear repercussions in leading this thesis toward a system approach.

Due to the purpose of this thesis, the procedure could effectively be broken into phases to make the structure of the work simpler. This meant that the study could not be generalized to a single type. Instead, because each phase had a different objective, the study's character changed from one phase to the next. The study's first goal was to investigate and explain the current situation (as described in *Chapter 3*). Following that, the objective was to make suggestions for improvements and provide directions and guidelines for how to work and optimize the current processes and strategies through centralisation *(Chapter 4)*. This leads to a potential definition of the research approach utilized in this thesis as being both exploratory and explanatory, as well as following a normative approach in providing decision-makers with desired outcomes. (Baburoglu, 1992)

2.2 Research process

This thesis was conducted according to an inductive research process. The study used empirical data and conditions as its starting point, where it began with understanding the current planning strategy at Whirlpool Italy and how the company operates within its inventory management framework. After acquiring a basic understanding, analyses were carried out to identify issues and improvement areas in their strategy and approach. Following that, a new inventory management strategy was proposed, followed by a generalization to the final theory.

2.3 Research methods: case study action research

The subject of how to improve Whirlpool's inventory management might be viewed as a problem, therefore to solve it and reach an applicable solution the study needed to be conducted in collaboration with Whirlpool. However, the study's aim was to not only solve Whirlpool's problem but also to generalize the solution and approach in order to contribute to theory. As a result, action research appears to be an appropriate research methodology definition to apply to this study.

Because action research can be considered as a real-time case, the methodology used in case study research can also be applied to it as well. Because of the nature of the thesis, a single case study with a single unit of analysis was the most effective way of explaining it. When a case is representative of a typical everyday or frequent event, single case studies are applicable. (Yin, 2009). Since this thesis was written on behalf of Whirlpool and because the focus of the investigation was limited to inventory processes, the thesis was written as a single holistic case study. Additionally, because the thesis concentrated on a thorough analysis of an inventory system, numerous case studies would have been challenging to accomplish due to limitations related to time constraints, resources and access to data.

Finally, in consideration of the fact that inventory management was the subject of the case study, it was used as the unit of analysis.

2.4 Data collection methods: interviews, document analysis

In order to collect our data for the analysis, various data collection methods were used in this study, for triangulation, validation and hypothesis testing purposes. For both quantitative and qualitative approaches, data was collected by conducting interviews and by retrieving data from company documents and archival records.
For quantitative data, different internal databases at Whirlpool were reviewed and reliable data was collected, while qualitative data was gathered through semi-structured and unstructured interviews with employees at Whirlpool in Italy and FPS planning teams in Poland. The data gathered through interviews was collected directly from the sources and was therefore considered as the primary data. Information from interview transcript data was collected to identify and evaluate current processes and challenges/criticalities experienced by the different teams within the firm from a procedural perspective, specifically with regards to the sales, SNP/inventory planning, suppliers.

The secondary data analysed in this thesis was the data gathered through documents, archival records and literature during the course of the project. Once again the data was analyzed to identify advantages, shortcomings and potential areas of improvement of the current inventory replenishment strategy, in particular with regards to costs and delivery time efficiency.

2.5 Method of analysis

During the course of the project, both quantitative and qualitative analyses were conducted, as stated in the previous section. The data acquired from databases was quantitative in nature, and it was mostly analyzed using figures and tables. By comparing and contrasting diverse sources, the processing and analysis of qualitative data acquired from interviews and documents were examined. This meant that a strategy's development was based on both quantitative and qualitative analysis.

2.6 Validity

The exploratory and explanatory sections of this thesis served as the foundation for the proposals, and it was critical to ensure internal validity throughout this phase. This was accomplished through the use of multiple sources of data and information from various parts of the organization, as well as regular feedback sessions with project supervisors appointed within the company.

Furthermore, allowing key informants within the organization to access drafts of the report helped to confirm and validate the findings. Because extensive theory about the subject was lacking and replication of the study in other case studies was not included in the scope, external validity is not obtained to the same extent. However, the plausibility of the findings may benefit from further examination with university staff and company stakeholders to determine the extent of generalizability of the findings.

Chapter 3

Case Study: Inventory Strategy, Roles and Processes

This chapter depicts and gives an understanding of how Whirlpool Italy manages logistics, supply, and inventory planning in general, as well as describes the roles and duties of various professionals involved in these processes. The goal is to identify and describe the planning models and procedures implemented in the company.

3.1 Sales and capacity planning

The challenge of balancing demand and supply is both crucial and challenging. Having too little in-stock results in missed sales and maybe a negative reputation, while having too many results in high storage expenses and capital tie-up. Forecasting future sales and related planning activities are the activities that influence this equilibrium.

3.1.1 Forecasting

Sales projections for all items are based on sales history over the previous years and are aggregated from the bottom up to better account for seasonal tendencies. Each article's and selling unit's weekly sales history is aggregated to the local market level (e.g. Italian market). To construct the regional weekly forecast, market information such as promotional activities and product range modifications are incorporated at the regional, retail unit, or selling unit level (client). The projected share is determined by the sales history of each retail and selling unit in relation to the aggregated sales history on each level.

The defined regional forecast, which includes all market information, is then subdivided based on the predicted share for each retail and SKU to arrive at a final forecast of item per selling unit every week. The projection on a selling unit level can be changed in the short term and, if necessary, further broken down to a daily level.

3.2.2 Demand planning

The demand estimation for every single product model is implemented based on the broken down projections for each product. The planning frequency for the demand calculation is weekly for a three-month planning horizon and monthly for a 6-month planning horizon. The demand of the Italian market is calculated by adding the requests of all Sales team representatives that are responsible for demand satisfaction of all Trade Customers of Whirlpool Italy. To develop order proposals, both the Supply Chain and Sales team must consider existing stock, scheduled orders, products in transit, and safety stock. Finally, the accumulated demand, as well as the need for selling units refilled by direct deliveries from suppliers, are aggregated to order proposals to each supplier.

3.2.3 Order and capacity planning

After determining the overall Italian market demand, numerous input elements for planning are considered. These include capacity checks for suppliers, transportation, and RDC and warehouse planning.
Possible imbalances between these parameters and the total Whirlpool Italy need adjustments in order placement, which are subsequently assigned to client level according to specific regulations.
Orders for suppliers are then aggregated and issued as block orders for a specified period of time. This means they are typically issued as monthly and, in some circumstances, weekly orders, depending on the supplier's capacity and flexibility. Orders are filled within the replenishment lead time.
Supplier capacity has a significant influence on order proposals since it determines the maximum quantity that Whirlpool may order.
The suppliers determine the capacities in advance and are generally offered as weekly, monthly, or in certain circumstances yearly amounts for the bigger suppliers, allowing Whirlpool to define the weekly capacity plan themselves. The capabilities are determined by manufacturing, storage, and transportation constraints, as well as the fact that providers strive for a more or less steady output throughout the year. Whirlpool requires suppliers to have the capacity to manufacture 10-15% more than the expected amount to allow for some flexibility.

If the demand exceeds a supplier's available capacity in a given week, order changes must be made and the surplus amount must be produced sooner. This quantity, in general, cannot be held by the provider and must instead be transferred across marketplaces. In the rare scenario where pre-production is not possible, for example, if the supplier has manufacturing capacity limits over a longer period of time, the orders must be cancelled or renegotiated to be supplied on time but at a higher cost.

In specific cases, Whirlpool has made buying obligations with suppliers. These create an agreed-upon quantity in volume, number of goods, or, more typically, money between Whirlpool and the supplier to be purchased in a specific time period. Commitments benefit both sides by ensuring certain order amounts from Whirlpool to suppliers, providing a favourable price for Whirlpool. They often comprise supplier warranties to guarantee that quality objectives are reached as well as other KPIs (Key Performance Indicators) such as delivery performance and service level are satisfied.

Whirlpool has a common interest that a negative price development is included in the commitment, which means that both parties should concentrate on making logistics and production operations more effective in order to cut expenses and hence the price.

3.2 Planning roles

The responsibilities of various personnel participating in planning activities will be discussed in order to acquire a better understanding of the decisions impacting the planning processes, as well as why and by whom these decisions are made. In addition, several critical position descriptions will be listed alongside. This will assist the reader to understand the planning operations, duties, and strategies.
Figure 5 further below depicts the current supply chain planning model including communications and workflow in a chronological perspective between different planning roles within Whirlpool Corporation in Italy.

3.2.2 Demand planner

Demand Planners are accountable for the forecasting of the Whirlpool range broken down to SKU per client.
Demand planner takes into consideration need and safety stock calculation, as well as planning for capacities and constraints for warehousing, transport, suppliers and categories. The calculations and planning are made on store, RDC and supplier levels where the output of those processes are stock exceptions and order proposals. The latter comes in the form of demand forecast, which is the plan communicated to Supply Network Planners, containing the information of when the client wants what quantities produced or delivered.
The sales team also makes their own internal forecasts without the participation of demand planners. Like the demand forecasts, these are based on sales history but include the stores' own analyses and perspectives. These mainly consist of an estimate of weekly sales and a sales index of how this estimation is distributed over the weekdays and serve as input parameters for the forecast.

3.2.3 Supply Network Planner

Supply Network Planners are the intermedium between the NSO team and the suppliers. The purpose of supply network planning is to support and update on a daily basis all EMEA market teams with inventory balancing. Supply Network Planners are accountable for defining the replenishment solutions and planning the stock structures between the multiple locations (across the EMEA region). They are also responsible for the collection and aggregation of internal orders from all markets in EMEA, followed by the facilitation of communication between the Demand Planners and the suppliers (Figure 5).

3.2.4 Supply Chain Planner

To support the SNP, Supply Chain Planner takes ownership of the data capture, analysis, and formulation of production plans to meet or exceed customer expectations, additionally, utilise all supply chain resources to continually improve

the Trade Customer experience across all supply chain streams. Moreover, SCP is responsible for scheduling the E2E process for Production and Packing functions in line with demand forecasts. Liaise with suppliers to agree on output and performance rates to ensure an accurate demand planning model for future business growth.

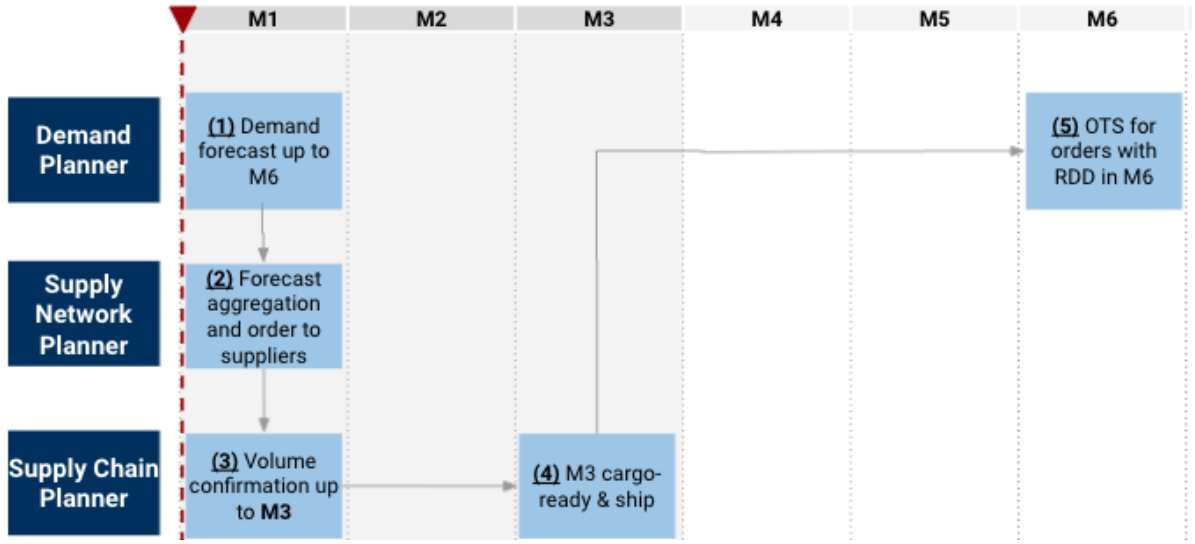

Figure 5. Current SC planning model

A detailed description of the inventory supply planning model with the specifications of the communications occurring in the planning process between the aforementioned roles (Figure 5) is provided:

1) On a monthly basis, Demand Planner is providing the demand forecast from the Italian market projecting the delivery of goods week-by-week in 6 months;
2) After receiving the forecast demand data, Supply Network Planner aggregates the information with forecasts collected from other markets in the EMEA region and sends the order to supplier / suppliers, at the same time providing the feedback to the Demand Planner in case of eventual updates regarding the future production or delivery;
3) Based on the requests from the SNP, the Supply Chain Planner has to verify with the supplier if the requested amounts can be produced in the next 3 months and afterwards delivered in time to Italy (from Month 4 to Month 6).

The most common issues that could affect the production volumes requested are:

- Lack of the parts for the production,
- Limited production capacity,
- High demand from other markets,
- Lack of containers or vessel space for the delivery.

Following the verification of possible production with the Supplier, SCP has to update the SNP whether the requested amount is possible to produce and deliver in time.

4) If none of the issues occurred, confirmed production has to be executed 3 months later and in most cases shipped immediately.
5) On-Time-Shipped orders with requested delivery date on Month 6 (in relation to the moment of order placement). Shipment of the production from China to Italy by the vessel takes around 3 months, therefore, the expected time of arrival counts as 3 months later from the date of departure. In case of significant delays, an alternative type of transportation should be applied for the delivery (train or aeroplane).

Chapter 4

Analysis of Supply Chain Centralisation

This chapter describes the implications of centralisation in the logistics and supply chain planning activities and processes, that are currently carried out in a decentralised model by Whirlpool Corporation across Europe. Salient issues are raised related to the SC Bullwhip effect, Risk Pooling, Safety Stock reduction, Commonality range assessment, required transformations within the SC planning roles and structures.

4.1 Logistics and SC Planning Centralisation

There is a high correlation between the degree of global supply chain planning centralisation and the extent of internationalisation. Particularly, it is possible to assume that the higher the level of internationalisation of production and procurement processes, the more complex the logistics context becomes, and thus the greater the necessity may be for raising the amount of centralisation of global supply chain planning decisions. (Creazza et al., 2010)

It is possible to state that a high level of internationalisation may necessitate the centralisation of supply chain planning. This is particularly beneficial for companies that have already centralised their entire business process. However, few companies exist that are characterized by a high degree of supply chain planning centralisation and a low degree of company centralisation, according to empirical evidence. (Creazza et al., 2010)
Companies with a high degree of supply chain planning centralisation claim that the logistics process was only centralised after the enterprise had been centralised. This is because logistics cannot be centralised on its own: only with a strong commitment from the organization, and usually after an overall centralisation (in terms of centralisation of other processes such as procurement, R&D, and accounting), can logistics be centralised. This activity is usually made possible by earlier processes and IT system integration and standardization.

The 'double marginal effect' and the 'bullwhip effect' are two main implications of decentralised decision-making in a supply chain (Zhang and Chen 2013). The double marginal impact arises from the fact that the overall logistics cost is more important in a decentralised decision than it is in a centralised decision. The bullwhip effect refers to demand unpredictability being amplified by supply chain stakeholders at each stage (Lee, Padmanabhan, and Whang 2004).
Several researchers have attempted to apply various supply chain partner cooperation strategies in order to increase the efficiency of decentralised decision supply chains.

The Bullwhip effect causes massive inefficiencies, such as excessive inventories, poor customer service, and revenue loss. (Duan and Liao 2013; Lee, Padmanabhan, and Whang 1997). Some recent studies have investigated the issue in more detail, establishing and comparing centralised and decentralised systems. (Salcedo et al. 2013; Fu et al. 2014; Hassanzadeh, Jafarian, and Amiri 2014). It appears that the centralised system performs better in mitigating the Bullwhip effects across the Supply Chain when applying Model Predictive Control (MPC) in inventory management as a tactical decision policy. (Fu et al, 2014; Dong et al, 2011)

4.2 Risk Pooling and Stock Reduction in Centralised SC

Matching supply with uncertain demand is the key challenge in supply chain management (SCM). By aggregating the underlying demand uncertainty, risk pooling is an efficient and viable technique for solving this challenge. The primary goal of this research is to examine the effects of risk pooling in various supply chain contexts. (Cai, et al. 2009)

Risk pooling is a strategy for aggregating demand across regions or time in order to reduce variability, which is evaluated by the standard deviation or coefficient of variation. Because demand levels differ from market to market, excessive demand in one tends to be balanced out by low demand in another. As a result of the lower

unpredictability, the safety stock and average inventory can be reduced, lowering the estimated system cost.

Risk pooling in SCM is typically accomplished by employing a centralised system with the aggregated inventory at a distribution centre rather than a dispersed system with a separate inventory.

The centralised distribution centre's variability, as measured by the standard deviation or coefficient of variation, is significantly smaller than the aggregate variabilities of the decentralised system's various warehouses.

Briefly, risk pooling entails restructuring the supply chain to limit the effects of uncertainty and reduce predicted system costs while maintaining a high level of service. The mathematical underpinning of risk pooling is simple: Given a set of random variables $X_1, X_2, \cdots, X_n$, then

$$\sigma(X_1 + \cdots + X_n) \leq \sigma(X_1) + \cdots + \sigma(X_n).$$

- $X_0 = X_1 + X_2 + \cdots + X_n$: the aggregated demands in the centralised system with probability distribution $f_0(x_0)$, where $f_0(x_0) = 0$ for all $x < 0$;
- s_i: the stocked level at the ith location ($i = 1,2,\cdots,n$)
- $s_0 = s_1 + s_2 + \cdots + s_n$: the aggregated stocked level in the centralised system;

4.2.1 Calculating Risk Pooling in a Decentralised vs. Centralised System

A decentralised system's goal is to retain the optimally supplied level s_i while lowering the expected total cost $HD(s_i)$ throughout the system, which is accomplished by minimizing the sum of the individual location costs H_i:

$$\min HD(s_i) = EX_i [H_i(s_i, X_i)], \text{ s.t. } s_i \in S,$$

$$\text{where } i = 1, 2, \cdots, n \text{ and } S \{s*_i , HD (s*_i)\}$$

The reduction in variability generated by offsetting low demand in one place with high demand in another frequently results in a reduction in the required safety stock

in a centralised stock and inventory planning system. As a result, average inventory is reduced, however, the extent of the reduction varies depending on the degree of correlation among demand streams.

The goal of a centralised system is to ensure the optimum stocked level s0 and expected total costs HC(s0) inside the system by minimizing the aggregated total costs H0:

$$\min HC(s0) = EX0\,[H0(s0, X0)]$$

s.t. $s0 \in S$, where S is a generic feasible set. The optimal solution of the equation above is $\{s*0, HC(s*0)\}$

4.2.2 Stock reduction in Centralised Model: strategic gains in case study

The square root law (SRL) of inventory quantifies the reduction of safety stock, defined as inventory held to avoid stock-outs when changing the number of warehouse locations. Future inventory is equal to the existing inventory multiplied by the square root of the future facility-to-current-facility ratio, according to the formula. In recent empirical research systematic analysis has demonstrated a 27,84% median margin of error when the estimated SRL values are compared with the outcomes of real-world implementations of warehouse reductions (Oeser, 2019). The SRL equation is as follows:

$$X2 = (X1) * \sqrt{(n2/n1)}$$

Wherein:

$$n1 = \#\ of\ existing\ facilities$$

$$n2 = \#\ of\ future\ facilities$$

$$X1 = existing\ inventory$$

$$X2 = future\ inventory$$

Calculating the SRL effects within the Whirlpool case study (ie. with the consolidation of the current stock in warehouses distributed nationally into a centralised European Hub), the estimated potential reduction of the stock of 9% as presented in figure 6 below. This estimated stock cost reduction is calculated on the basis of quarterly inventory data obtained for the year 2018.

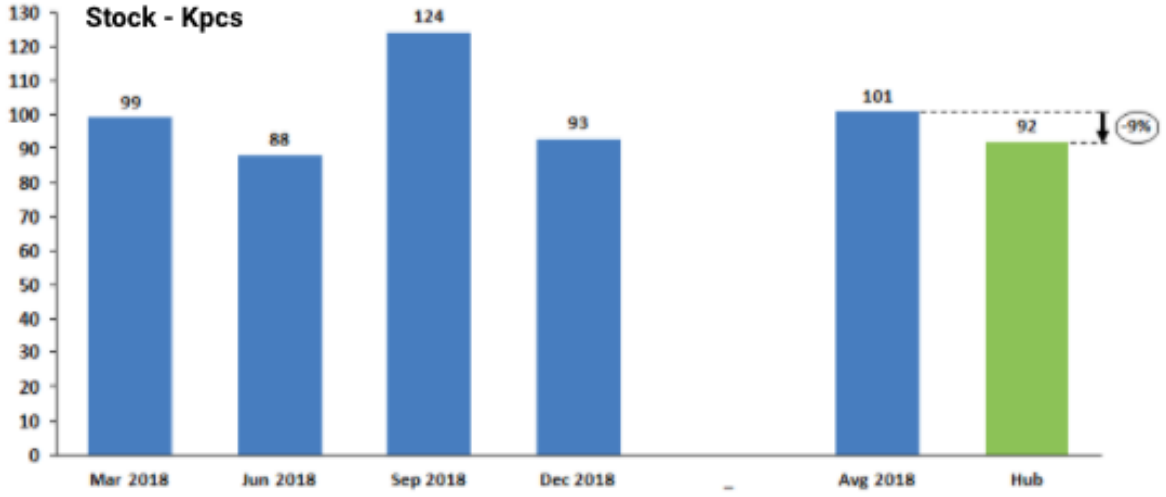

Figure 6. Potential safety stock reduction by virtue of centralisation when applying the SRL function to the 2018 inventory data

The magnitude of the correlation between demand streams in the EMEA market for Whirlpool products appears to be low (ie. there is high variability in terms of product demand across different areas) (see figure 7 below), hence there are increased benefits from the implementation of a centralised model in terms of reduction of required safety stock, as opposed to the safety stock distributed among individual locations in the current decentralised model.

Analysis of the Finished Product Sourcing (FPS) in relation to the origin and destination also informs us that a centralised inventory model would foster significant simplification to the internal planning and communication processes towards suppliers, by providing a homogenous solution and reducing the points of contact, leading to greater E2E accountability, specifically for the suppliers and SNP.

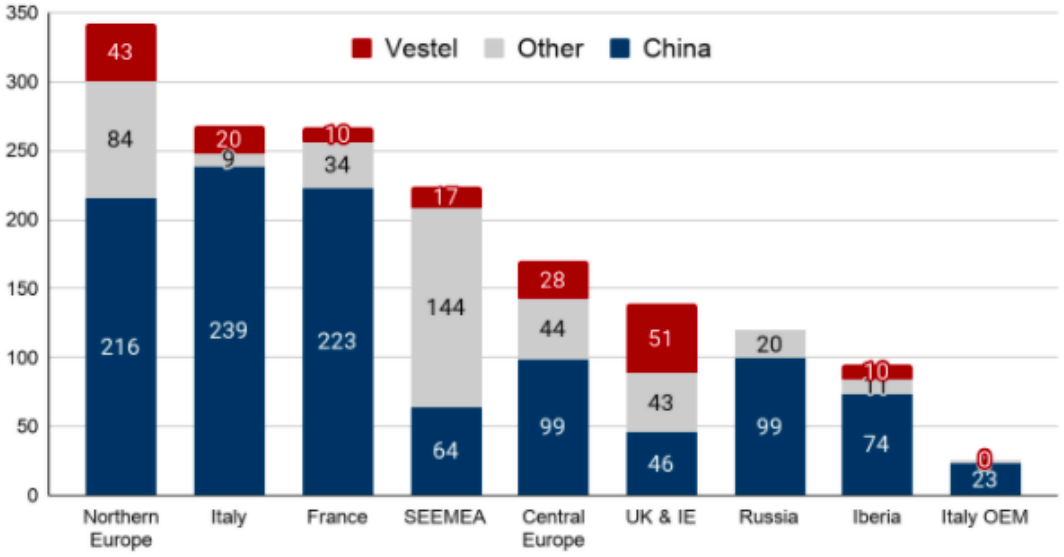

Figure 7. Finished Product Sourcing (FPS) by area of origin and destination (K units)

4.3 Issues with product commonality ranges in Centralised model: case study implications

Despite the significant cost reductions related to a decreased requirement for safety stock described above within a centralised inventory model, focusing the analysis on the commonalities of SKUs across different EMEA markets/regions, which are represented by the clustered orders from suppliers located in China and in Other locations in figure 8 below, informs us that the potential efficiency gains of a centralised inventory model would potentially be limited by the large percentages of products (represented as Stock Keeping Units, SKUs) that require area-specific orders.

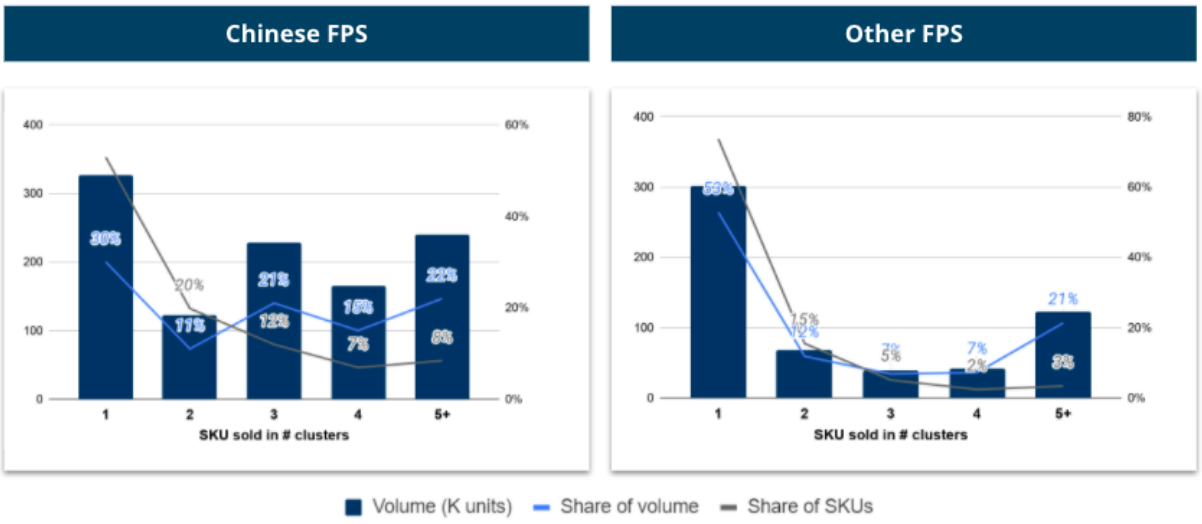

Figure 8. Degree of product commonality from China and other suppliers: data displayed by clustered SKU volume (K units), volume (%), share (%) SKUs

To validate this hypothesis, a closer analysis of the commonality ranges across one specific product (referred to generically below as "household appliance") was conducted. With the following results:

Household Appliance Product Communalities	**Total SKU #**	**Avg Monthly Orders**	**SKU # with communality**	**Avg monthly Orders - SKU communality**
Supplier 1	59	13.445	13	3.829
Supplier 2	86	24.638	26	11.289
Supplier 3	33	9.328	13	3.427
Supplier 4	54	21.268	21	8.952
Total	232	68.679	73	27.496

Table 1. Comparison for single product type of total orders vs. potentially clustered orders (SKUs and monthly orders of products with commonality)

Within this product category, due to the necessity to apply various area-specific range exclusions (i.e. area-exclusive ranges due to compatibility issues, customs

implications, Build-to-Order products), only approx. 40% of total sales (approx. 30% SKUs) are eligible to be managed by a central European hub.

This result has clearly significant implications for the implementation of an EMEA-wide centralised system within this organizational context. A centralised system within which only a minor percentage of stock can be pooled has a reduced efficacy in relation to the risk pooling benefits that were discussed above.

4.4 Additional considerations and findings from qualitative research

In order to validate the theoretical assumptions and quantitative analysis of the potential benefits of centralised inventory management, described in the sections above (4.1-4.3), a series of semi-structured interviews was conducted with members of the following teams operating in different European regions:

- Sales
- Demand Planner
- SNP

The interviews consisted of open-ended questions regarding the current criticalities present in the system from the perspective of each team member within their specific role. The findings were instrumental in creating a Responsibility Assignment Matrix, also known as a RACI (Responsible, Accountable, Consulted, Informed) matrix.

From the RACI analysis, it was apparent that the shift to a centralised model would have particularly significant implications in the operations and role of the Supply Network Planner (SNP) team. Namely, new responsibilities would involve:

- Managing central FPS demand forecast
- Assess demand variability
- Manage central FPS orders to suppliers
- Being accountable for inventory and Free Cash Flow targets
- Allocating available supply by market

All the above entail a shift in accountability for stock availability to the central SNP team, including the potential for conflict resolution in case of low availability. This

shift away from individual inventory accountability for each location is a major element among the considerations to be made at a management level regarding the SC centralisation strategies to pursue.

4.5 Reconciling quantitative and qualitative research findings

The following table 2 summarises the structure of Quantitative and Qualitative Criterias that were considered and evaluated in the comparative analysis between Decentralised MTS and Centralised MTS models. Additional details regarding the cost items considered in the Total Cost section in branch chart format in figure 9.

Quantitative Criteria	**Total Cost**	- Logistic Cost
		- Warehousing Variable Cost for CDC
		- Warehousing Fixed Yearly Cost
		- Inventory Holding Financial Cost
	Minimum Stock Level	- Value of the part of the inventory specific to the logistic set up analyzed. (i.e. Supply Chain cannot work with a lower inventory level)
	Low Frequency Supply	- Percentage of supply with a not satisfactory replenishment frequency from Far East to Europe
Qualitative Criteria	**FPS Strategy**	- Finished products sourcing strategy in terms of number of suppliers and platform moves across supplier
	Inventory	- Risk of creating obsolescence in stock - Safety stock
	Complexity	- Change of management: organisational changes, skill set creation, contract etc.
		- Planning complexity in operations to achieve optimal results

Table 2. Decision Criteria structure applied in the Quantitative and Qualitative Analyses

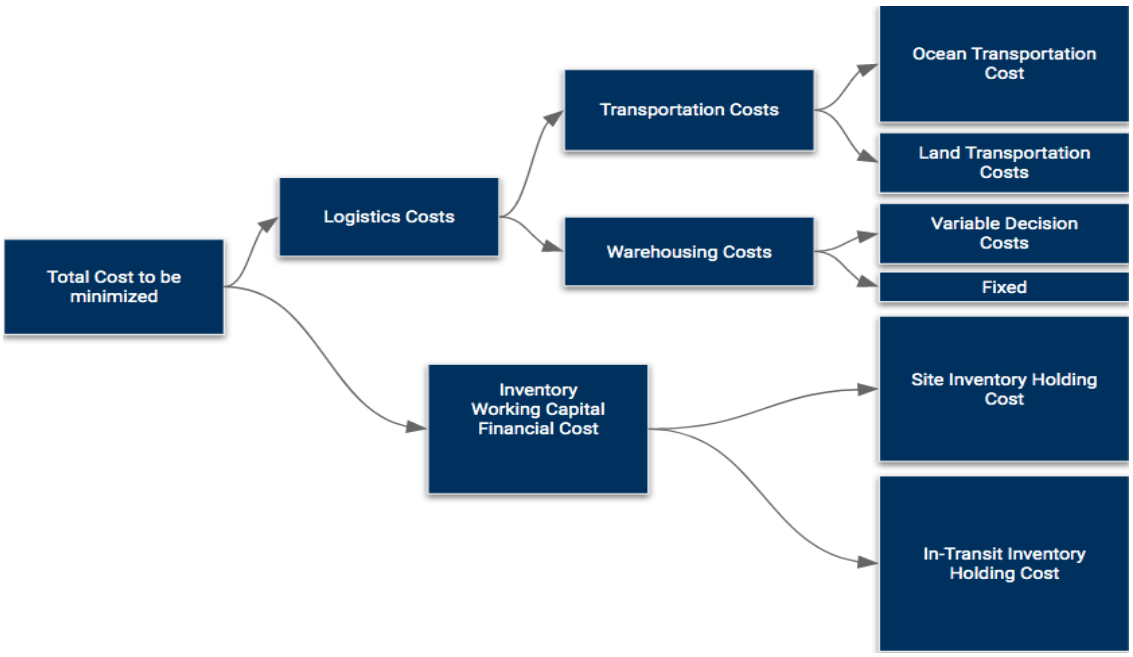

Figure 9. Branch chart illustrating breakdown of Total Cost to be minimized

Based on the qualitative analysis of the cross-departmental interview data referenced in section 4.4, the table below lists some of the main potential advantages and criticalities for each model:

Qualitative Criteria SCM model comparison	Advantages	Criticalities
Decentralised MTS (current model)	- Market accountability of Trade customer - Demand management	- Inventory and FCF targets and accountability - System infrastructure is difficult to establish
Centralised MTS (proposed)	FPS Strategy: - Overall intake reduction - Rationalization of suppliers Inventory:	- Structurally exclusive SKUs (e.g. different area-specific plugs) **(see section 4.3 above**) - Applicability for

	- Possibility to run last minute decisions on stock allocation - Stock pooling and buffers **(see section 4.2.2 above)** Complexity: - E2E accountability - Improved hub shipment efficiency - Easier communication system set-up (less points of contact)	European suppliers

Table 3. Analysis of Advantages and Criticalities based on qualitative criteria for logistics and SC planning within current Decentralised MTS model and proposed Centralised MTS model

Based on the comparative analysis of the company data collected and analysed during the project, the following percentage cost variations for decentralised vs. centralised models were obtained.

Quantitative Criteria SCM model comparison	Total Cost	Minimum Stock Level	Low Frequency Supply
Estimated Percentage variation shifting from Decentralised MTS to Centralised MTS	**+ 20.1%**	**- 3.7%**	**- 4%**

Table 4. Analysis of Advantages and Criticalities based on quantitative criteria for logistics and SC planning within current Decentralised MTS model and proposed Centralised MTS model

The increase in Total Costs (as illustrated in table 4 above) is mainly attributable to higher logistic costs within a centralised MTS model, and are partially mitigated by the Minimum Stock Level and Low Frequency Supply, as well as by the qualitative improvements identified above (table 3). In order to perform an informed strategic decision on the degree of centralization of the inventory management, further analysis is required to determine whether the increase in Total Cost due to the higher logistic costs can be fully balanced by the summation of the other direct and indirect factors listed above.

Chapter 5

Conclusions

This chapter summarizes the results and observations made in the previous sections and discusses the generalizability of the finding. It also covers possible contributions to future inventory management and replenishment strategy for Whirlpool in Europe and recommendations for further in-depth investigations.

Given that the prospected reduction in inventory costs within a centralised SC model is one of several factors that must be considered by the firm management to determine the most beneficial replenishment strategy, it is recommended that additional cost/benefits and process advantages/criticalities analysis are conducted to validate the current proposal for a greater degree of centralisation of the inventory management. As defined in the previous chapter through the qualitative (cross-departmental semi-structured interviews with key stakeholders) and quantitative analyses (review of company documentation), the advantages and criticalities for a centralised model can be summarized in the categories of Stock / Cost / Service / Processes, as follows:

	Advantages	Criticalities
Stock	Potential stock reduction 9% decrease = significant increase in free cash flow (lower inventory carrying cost)	
Cost	Cost avoidance: reduction of National Sales Office teams	Increased logistic costs due to increased distance between central hub and vendors
Service	Potential of increased flexibility in adjusting BTO orders	Orders lead time to Trade Partners to be adjusted (+4 days) No stock downstream for the common product range
Processes		Higher complexity to manage in planning phase

Table 5. Advantages and Criticalities analysis for Centralised model based on findings for Stock, Cost, Service and Processes

Furthermore, taking into account the significant issues raised by the findings related to low product commonalities across different regions (section 4.3), it may be necessary to consider and further investigate a mid-way, pragmatic strategic solution for the inventory management centralisation that is not comprehensive for all European markets.

For instance, Cai et al (2009) provided a theoretical demonstration of the fact that the more locations are pooled in a centralised supply chain planning and inventory model, does not necessarily increase the marginal benefit of risk pooling. Conversely, if it is assumed that geographically closer locations share greater SKU commonality than more distant locations, it may be advisable to limit the implementation of centralised processes of the inventory planning to those locations only, thus obtaining the cost reduction benefits over the broadest range of products as possible. In fact, as the product commonality issues are largely due to different product specifications across different European areas, it can be assumed that the locations for which inventory pooling is feasible will also be geographically closer, hence the increased transportation costs of the centralised stock would be marginally reduced with two or more central hubs in comparison to those that would result from a single European hub for all products and regions.

Figure 10. Map of the potential distribution of centralised European hubs and decentralised markets

A model for the proposed scenario is represented in figure 10 above. The map indicates the proposed location for two centralised hubs for Northern Europe and Southern Europe, namely in Poland and Italy, where large warehouse units and SNP teams are already in place, to leverage the highest degree of product commonality across these macro-regions. Moreover, the map also highlights markets that due to very low levels of product commonalities (e.g. due to custom electronic requirements) may continue to be better served by a decentralised model (UK, Russia, Turkey).

These observations and proposals are intended as a tentative and theoretical proposal, based on limited data access, which would require additional feasibility studies and investigation from cross-functional teams within Whirlpool Corporation to ultimately identify the ideal configuration and location of a European centralised inventory hub(s). Besides the necessary further validation of the findings, it is also necessary to note that this investigation may serve to reaffirm the fact that a theoretically-driven one-size-fits-all solution for a supply chain management strategy is neither applicable nor advisable, as even solutions that from a theoretical standpoint appear to be solidly grounded in evidence-based research and empirical data, upon closer scrutiny of the peculiarities of each market, organization or product may prove not to lead to prospective efficiency and cost reduction improvements, as in this case once accounting took place of the degree of product commonalities across different Whirlpool locations.

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