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Pull mode forecasting in the agile supply chain

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Pull Mode Forecasting in the Agile Supply Chain

Presented by: Alireza Asgari

Date : from 01/04/20 to from 15/06/20

University advisor: Paul Reaidy

Research Dissertation

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Preface:

Grenoble IAE, University Grenoble Alpes, does not validate the opinions expressed in theses of masters in alternance candidates; these opinions are considered those of their author.

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Abstract

Purpose: This dissertation is to investigate forecasting processes deployed in industries applying the “Pull” Approach which are confronted with an uncertainty linked to the variability of demand. We focus on upstream and/or downstream and/or internal forecasts to be implemented in “Pull” mode to improve the capacity planning of the company's activities. Forecasting tools, data, supply chain practices were examined and classified according to different variables and dimensions. After a literature review, some hypotheses were developed followed by a theoretical model linking the Resource-based view to the forecasting in the agile supply chain.

Methodology: A literature review has been done for both understanding about the state-of-the-art in the fields and identifying research gaps for further research pathways. After the development of the hypotheses a theoretical research model was proposed.

Findings: The research problem before the initiation of the master thesis was how to associate the pull mode in the forecasting of the supply chain, and after the literature review, it became evident that research in this regard clearly lacks a theoretical background and empirical research. These gaps were identified, and to bridge the gap in the body of research, we developed hypotheses and designed a model.

Conclusion: After the contributions of the research, we see potential and promise in this research. By adding statistical tests to the current body of work, there could be a more definite indication about which relations among the constructs are positive or negative based on the answers of industries.

Keywords: Supply Chain Management, Forecasting, Agile, Big Data, Pull mode, Resource-Based View.

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1. Introduction

In this day and age, when a request has been made by a customer, companies, firms, organizations, and all parties will attempt to respond to the demand in either a direct or indirect manner. The inclusion of all parties, ranging from the customer to the raw material suppliers, comprise the supply chain (Mentzer ,2001; Chopra and Meindl, 2013). Throughout the years, the supply chain has been under the influence of both academia and professionals, coming up with new methods and techniques to improve the supply chain objective: increasing the surplus (the difference of revenue and cost).

With the increase of competition between organizations and supply chains, customer demand fluctuations, growing uncertainty, and complexity in the supply chain in modern times, (Christopher 2000; Yusuf et al., 2004; Tarafdar and Qrunfleh, 2017), the transition of organizations requirements to become more aligned with responsiveness to customer demands has been visible for many years now. The discussion to fully understand the agile methodology as a means to respond to this environment has been held in academia (Power et al., 2001). Through more than two decades of testing hypotheses and reporting the results, agility has proven itself to be a substantial factor in a companies' success and survival, especially in modern markets where customer demands are varied. (Miao and Xi 2008; Qrunfleh and Tarafdar, 2013)

The agile approach insists strongly on responding quickly to market demands (Rao and Kumar, 2019); therefore, by applying the pull method, the supply chain can be aware of the exact number of demands, reducing the chance of producing too many or too few products (Chopra and Meindl, 2013). Here it is observed that by associating the pull method, in the agile supply chain, with forecasting, the firm will produce what was requested and not repeat the pattern of what it produced in the past. This will clearly benefit the supply chain as a whole, reducing the inventory, reducing the risk of producing too much or too little, and becoming more responsive to the customer request.

The pull approach is used widely in the industry from the past until now. Chopra and Meindl, (2013) give the example of Dell computer manufacturing company where the pull processes are triggered by customer demand; therefore, the previously mentioned risks are lowered. Gunasekaran and Ngai, (2005) explain more in detail regarding the Build-to-Order supply chain, which gained popularity in Dell, BMW, and Compaq. However, this does not mean that

the inventory of companies must be empty, rather suggesting that the inventory must replenish before the customer order, in other words, the number of components and parts for the manufacturing must be predicted before the customer's order is submitted. This way, companies can reduce their difficulty in matching the supply to demand, emphasizing the importance of accurate forecasting in the supply chain's pull approach.

Nevertheless, it is important to note that the pull approach is not in any means segregated from the push approach, and both must be considered together. This is mainly because in the push phase, decisions are made regarding inventory and production capacity, which impose constraints on the pull phase (Chopra and Meindl, 2013).

One of the main processes which take place in the supply chain is decision making. Decision making is mainly based on forecasting and its results. The imperative role of forecasting is because of limited resources, rapid and varied customer requests and desires, and the reduction in lead times (Boone et al., 2018). The role of forecasting is challenging because the number of demands is not known beforehand. Different parts of the supply chain and organizations may have different forecasts of the future (Syntetos et al., 2016). The main problem of forecasting is uncertainty, and if more information is shared, especially towards the end-customer, the uncertainty associated with forecasting will be reduced (Ali et al., 2017). As a solution, there is a need for technology that can gather and store a large quantity of data. Syntetos et al., (2016) and Boone et al., (2018) argue that "Big Data" has significant benefits to forecasting in the supply chain.

"Big Data" has increased in popularity in recent years and can have significant implications on the design, forecasting, and agility of the supply chain (Wamba and Akter, 2019; Boone et al, 2019). "Big Data" has the potential to add more to the organizations' understanding of demand forecasting and improving supply chain performance, keeping in mind the quality of the data, which in the majority of cases is low, and the analysis as major challenges to implementing Big Data (Boone et al., 2019; Syntetos et al., 2016). Without the existence of proper analysis and methods to extract meaning out of data, Big Data is useless. The main goal of using Big Data is to improve decision making, increasing its accuracy, and reducing the risk associated (Gandomi and Heider, 2015). In order to enhance decision making, there is a need to fully understand the processes in Big Data. There are two main processes containing five stages (Labrinidis & Jagadish, 2012): Data Management and Analytics.

Therefore, by feeding all the available data into a system of forecasting, it is estimated to provide a more accurate with relatively lower uncertainty results.

A potential solution to include all these is “Predictive Analytics”; it is data-driven, meaning that it includes going through large quantities of data and extracting information, and knowledge integration from models (Shmeuli and Koppius, 2011), in order to be used in decision making. This is exactly what is required for enhancing the decision-making process through accurate forecasting results. Predictive Analytics runs an analysis on the data from both past and present in order to forecast. From this general definition, it is understandable that it can be used practically in all domains. The core objective of predictive analytics is to find patterns and realize relationships between data. This is done using two major techniques: regression techniques and machine learning techniques, which are both statistical methods (Gandomi and Heider, 2015).

The conceptual model we proposed below has been devised for better understanding of the concepts and processes:

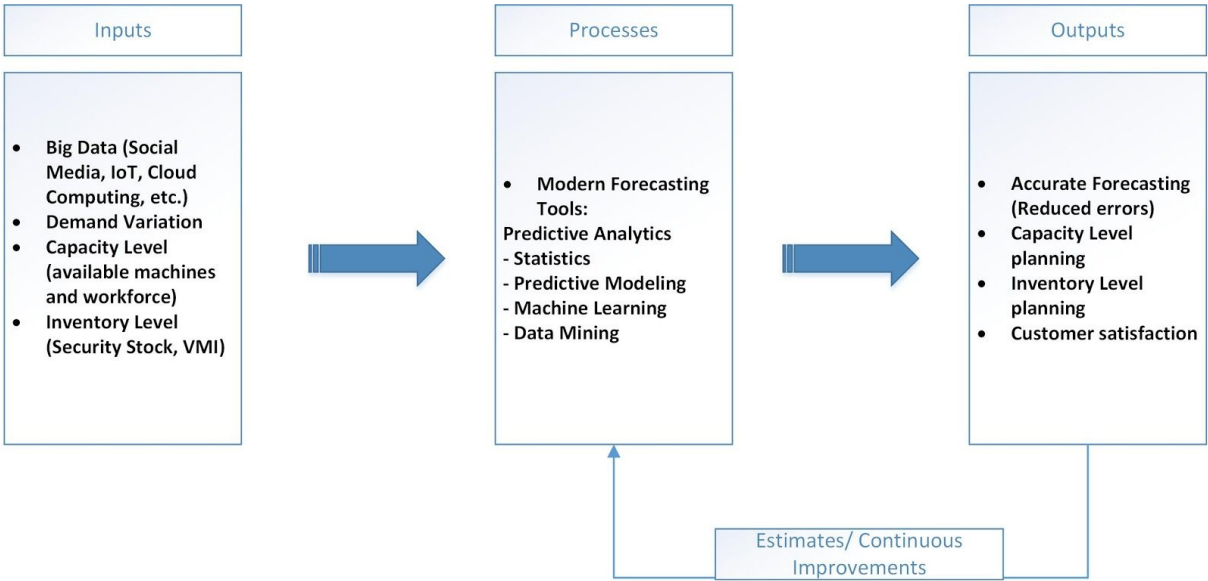


Figure 1 Modern Supply Chain Forecasting Conceptual Model

The modern forecasting model illustrated above consists of 3 main sections: Inputs, Processes, and Outputs, each section containing one or a number of factors. The model’s goal is to provide more accurate forecasting results primarily because of utilizing more modern forecasting tools as the data analysis processes, in addition to using Big Data and other sources of information (or data) to feed the forecasting tools. This model is the outcome

of the literature review and critically analyzing different aspects of different articles in order to reach this model.

In the Inputs Section, Big Data was added due to many literature gaps found, which stated there are significant uses for Big Data in forecasting the supply chain (Syntetos et al., 2016; Wamba and Akter, 2019; Boone et al., 2019). Therefore, integrating Big Data as the source of information (or data) in this model was supported and suggested by the aforementioned authors.

In the processes section, the main focus was shed on more modern tools. Christopher, (2011) claims that nearly all recent and used supply chain models were designed in the period of stability, and due to the turbulent nature of the market nowadays, these models cannot respond as effectively as they could if they were designed for this particular environment. Consequently, there is a call for more modern tools to be associated with the model and the supply chain forecasting processes.

In the Outputs section, more accurate forecasting is enabled by using more modern tools to process the Big Data and other sources of information. If the forecasting is more accurate, it is clear that it would benefit the decision-making process in each step of the supply chain. Ordering the correct amount of raw materials, accurate production planning, and distributing right quantities, to the right location, at the right time (Simchi-Levi et al., 2008; Qrunfleh and Tarafdar, 2013)

Continuous improvement is a vital part of this model. Jabrouni et al., (2011) argues that a key element in competitiveness for systems is continuous improvement. The goal of this element is to make improvements in all or particular processes in the system over time, resulting in a better performing firm.

Associating pull mode (agility) and forecasting seems to be a suitable way to improve the type of forecasting done in shorter time intervals (Van Belle et al., 2020). The market and environment today calls for a more agile-oriented prediction system (Miao and Xi, 2008), and the market requires the firms to become more flexible and responsive, which is the main reason for moving from push to pull (Christopher, 2016).

Currently, in this dissertation, we aim to answer the following question:

- What is the impact of pull mode forecasting on the firm's performance?
- What are the factors contributing to pull mode forecasting?

To tackle these gaps and to provide an answer to the research questions, this dissertation draws on the Resource-based view (RBV), which states that sustainable competitive advantage is gained through valuable, rare, imitable, and substitutable resources (Barney, 1991). Since there has been a scarcity of theoretical foundations for this specific topic (Chae et al., 2014; Dubey et al., 2019), RBV has been suggested, and it has been observed and justified by this research to be a suitable fit (Hitt et al., 2015; Hazen et al., 2016). IT-enabled tools, Supply chain practices, and data have been considered to be sources of sustainable competitive advantage, and hence a theoretical model has been developed and a number of hypotheses formulated.

This master's thesis is organized as the following: the first section is the Methodology explaining the different steps taken in the thesis and what measures were taken in doing so. Then a literature review has been done in order to fully understand the state-of-the-art in this field and related topics and to put the master's dissertation in perspective; the literature review contains the review of work in Supply Chain Management, Supply Chain Approaches, Forecasting, Advanced Forecasting Tools, and Agile Supply Chains and Forecasting Systems as a conclusion. Following the thorough literature review, after the identification of gaps and research possibilities, the Research Problem section is presented, which aims at highlighting the gaps in the literature and ultimately develop more refined and specific research questions. The Theoretical Background section provides a theoretical foundation upon which the hypotheses are built, and at the end of this section, we proposed a theoretical model concluding all the work. Finally, putting everything together, a conclusion is drawn, stating the contribution, the limitations, and the future research prospects of this work.

2. Methodology

The methodology used in this dissertation consists of two parts, a literature review and preliminary analysis. We propose the following figure to illustrate the steps in this research work:

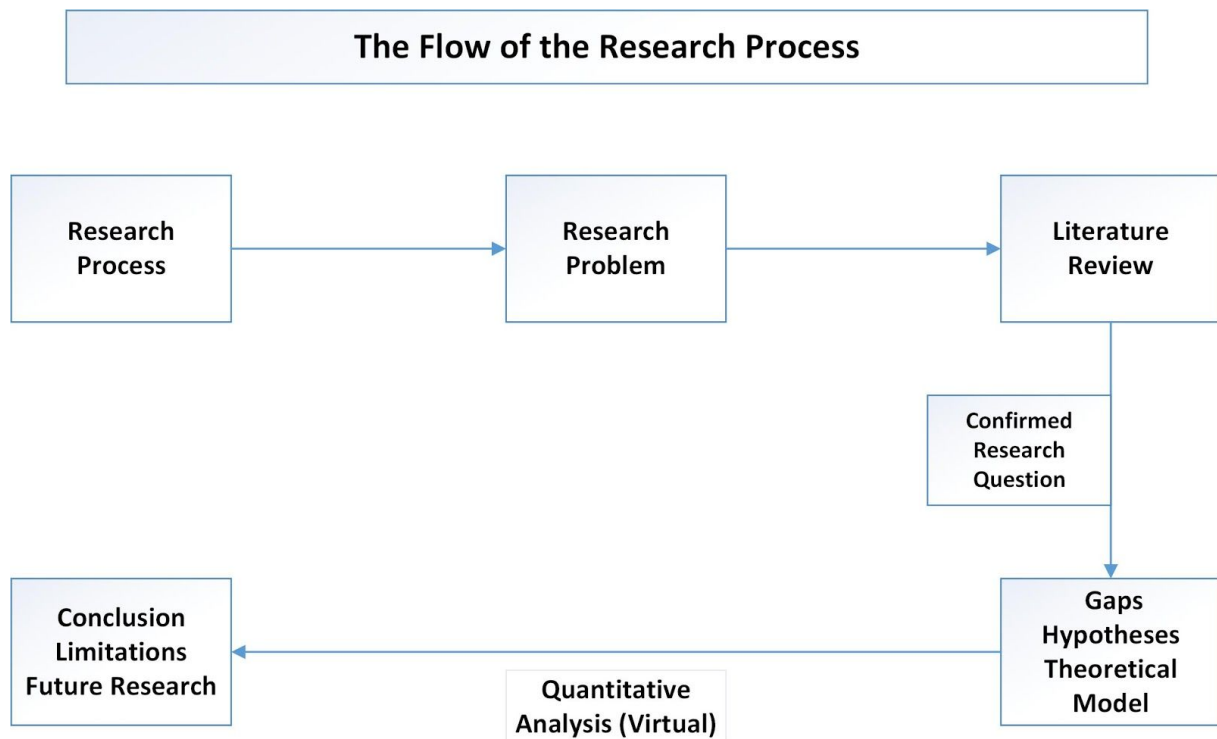


Figure 2: The Research Process (Methodology)

The process of this research was initiated by a general research problem in supply chain management, forecasting in the agile SCM to be exact. Generally, we wanted to increase our understanding of supply chain management, agility, forecasting, and different modes in it to ultimately investigate and find ways to better the current forecasting system. In order to understand the current transition supply chains had in the previous decades and, more importantly, the advances made in agility and forecasting, a literature review on these topics was carried out. According to Okoli and Schabram, (2010), a literature review is used to identify and evaluate the body of research up to now. Several categories were defined, and after the literature search and quality check, they were divided into the aforementioned categories, this eventually helped with the whole process of literature review being more systematic and organized.

After the literature review, the research problem became more refined and specific and as a result the solutions and answers we were looking for also became more clear. Numerous gaps were identified in the literature which led to several hypotheses and finally a theoretical research model. The hypotheses are all based on previous works of scholars and the research model describes the hypothetical relation between different items in the hypotheses. These relations can be tested using a complex statistical estimation model, which was not achievable during this short period of time due to the complexity and time-consuming trait of running these sorts of analyses, hence the virtual quantitative analysis.

Ultimately, a conclusion was drawn based on all the aforesaid processes, from the initial research problem to the theoretical model. The contributions of this research are twofold: a literature review not only on the topic of forecasting, but also in supply chain management, agility, and advanced tools that can be integrated into the supply chain. Most importantly, a theory was linked to the literature gathered and reviewed here. There are, and always has been, limitations to every research, these are also added as well as the further research pathways other researchers can take in order to facilitate their research into what we think is achievable and worthy. The following paragraphs will explain the two main parts of the methodology in more detail.

2.1. Literature Review

One critical part of research is the literature review process; to develop more advanced systems the edge of knowledge and our understanding must be found (Xiao and Watson, 2019). This thesis draws on the literature in supply chain management, forecasting in the supply chain, supply chain methodologies, agile methodology, pull method, Big Data, Predictive Analytics, and resource-based view. After the initial topic selection, these topics were made into different categories where new and fundamental articles were saved. The process of article selection has been thoroughly explained at the beginning of the literature review. The aim of the literature review was to, first, acquire knowledge on fundamental papers in the field as well as understanding what is new.

By using literature review, this dissertation was able to go through the state-of-the-art and identify gaps in the main topics of this research, for a more organized way of reviewing the literature, some processes of the systematic literature review were adapted: defining the purpose of the review, searching of the literature, practical screening, data extraction,

analysis of findings and finally the review was written (Okoli and Schabram, 2010). It is important to note that the literature review was not systematic; however, some steps were adapted primarily due to bringing validity, reliability, and repeatability (Xiao and Watson, 2019).

Prior to the process of the literature review, a research problem is formulated, and after the literature review, this research problem becomes a more refined research question which aims at improving the body of knowledge and contributes to research in addition to the industry. This literature review led to the identification of several gaps mentioned in the research problem section, and the design of two models (Figure 1 and Figure 2). While the first figure gives an overview of how forecasting can be improved by integrating the pull method and modern tools, the theoretical research model can be further tested using different statistical methods. Going through the literature, three dimensions (constructs) were realized to have the potential of providing a sustainable competitive advantage. When this was coupled with the idea of pull mode forecasting, the theoretical model was developed. The three dimensions of the RBV can contribute to the accuracy of the forecasting, leading to competitive advantage, which can ultimately contribute to the agility and performance of the firm.

This model can be validated through a series of statistical tests which can be run on the data collected and provided by previous research. Therefore, this aspect of the thesis is trying to further prove the validity of the model designed and try to understand if the relationships assumed are indeed, firstly, real, and secondly, there is a strong positive or negative influence. To test the validity, data is needed from the industry and different business units operating in the forecasting department of each firm. Due to the lack of time and the complexity of the tests, they have not been conducted.

2.2. Preliminary Analysis:

This dissertation used a questionnaire which was developed in a previous research project by the supervisor in order to gather information and data from different business units performing in the supply chain forecasting department of various companies. A total of 184 answers were collected. The questionnaire uses a scoring system from 1 (not agree at all) to 7 (totally agree) in order to fully understand the current situation in companies. Other scholars such as (Wamba and Akter, 2019) and (Chae et al., 2014) have used the PLS-SEM

model to do the analysis needed; however, due to the limitations faced, this will be suggested for further research.

In this master's thesis, only the questionnaire was provided. What we contributed was firstly to develop the questionnaire in terms of resources. Therefore, in the literature review, we tried to link and justify the items mentioned in the questionnaire. Appendix 1 was designed based on the analogy used in the works of other scholars such as (Wamba and Akter, 2019) which followed a similar approach to this thesis. Having said that, the second-order constructs were developed from the literature view, more specifically from the hypotheses in the theoretical framework.

Appendix 2 is the questionnaire developed by the supervisor in the previous research project. This questionnaire was used in order to understand the first-order constructs and the different items used in the pull mode forecasting. After the analysis, contributions such as updating the resources, building the second-order constructs, and the addition of items such as human capability and talent in the future questionnaire was added.

3. Literature Review:

3.1. The baseline

To respond to the broad research question formulated in the introduction part and to thoroughly understand the state-of-the-art in this particular field, a literature review has been conducted in order to make a solid foundation upon which this dissertation can be built. Therefore, this section discusses a review on the papers and ideas put forth by previous scholars in forecasting using predictive analytics in the agile supply chain and all the related theories and fields. It is also important to note that before the process of reviewing the literature published in academic journals, the topics were broadly searched on the internet to provide an insight and a broad vision of what the research was going to entail.

The main goal of this literature review was to identify the gaps and challenges in the forecasting section of the agile supply chain as well as finding a theoretical base to which the research can be linked. Due to the broadness of the field, many different subjects and papers must have been analyzed to fully grasp both the concepts and the gaps.

The process of learning about the recent literature has been facilitated, to some extent, by the plethora of search engines and digital resources on the internet. In order to conduct this research, Google Scholar, Science direct, and many more sources were utilized. There are, of course, challenges associated with this relatively easier process. For instance, by searching a common keyword (e.g. "Supply Chain Forecasting"), more than 475,000 results were found. These results were initially taken into consideration by factors such as their relevance, heading, time of publication, and the publishing journal.

To effectively find the related resources, after identifying the accurate keywords ("Agile", "Forecasting", "Big Data", "Predictive Analytics", "Resource-based view"), the abstract of aforementioned papers were read and the ones which were irrelevant to the topic were excluded. From the remaining, the ones more closely correlated with the topic were selected and divided into different groups, based on their main topic, and fully analyzed. This division helped with putting all related topics in correlated categories, which would benefit the literature review to become more coherent and cohesive. A mind map was drawn to visualize the different topics in order to facilitate the process of finding a link between different ideas and to quickly find the research gaps and potential research routes.

3.2. Supply Chain Management

Supply Chain is not in any means a new topic; it has been first coined by Forrester and Jay, (1958) in contemporary business literature as supply chain management. However, throughout the years it has been under the influence of both academia and professionals, coming up with new methods and techniques to improve the supply chain objective: increasing the surplus (the difference of revenue and cost) (Chopra and Meindl, 2013).

To this date, many definitions of the supply chain have been presented in articles and books all around the globe. In order to fully understand our purpose of this dissertation, we must define the supply chain through the definitions provided by scholars. The table below shows a number of most used definitions:

Author(s), Year	Definition
Mentzer et al. 2001	<i>“The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.”</i>
APICS Dictionary, page 134	<i>“The design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally.”</i>
Simchi-levi, 2003	<i>“A set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements.”</i>
David Fredrick Ross, 2010	<i>“Strategic channel management philosophy composed of the continuous regeneration of networks of businesses integrated together through information technologies and empowered to execute superlative, customer-winning value at the lowest cost through the digital, real-time synchronization of products and services, vital marketplace information, and logistics delivery capabilities with demand priorities.”</i>
Martin Christopher, 2016	<i>“The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole.”</i>

Table 1: Supply Chain definitions

Supply chains can be considered as complex systems (Sivadasan et al., 2006) and this complexity calls for a deeper understanding of supply chains and their objectives. By looking

at the definitions above, it is clear that improving the performance of the supply chain in the long-term is the objective (Mentzer et al., 2001), this will ultimately result in increasing the surplus through increasing customer satisfaction, efficiency, and responsiveness as discussed before. To do so, there is a need for a competitive infrastructure (APICS Dictionary, page 134), which can integrate all parties, for example, customers, suppliers, manufacturers, etc. (Simchi-levi, 2003; Chopra and Meindl, 2010); and all sources of information such as social media, Internet of Things, cloud computing, and etc (Syntetos et al., 2016; Boone et al., 2019). Through this integration of information and parties involved, there can be an access to real-time information plus the synchronization of supply chain sectors; therefore, the supply chain would be superior in bringing value and eventually becoming the value chain (Ross, 2010; Christopher, 2016).

Briefly, there is a need for a more modern, competitive infrastructure, designed for the volatile environment of today, which can integrate the whole supply chain to bring value to the customer and increase the surplus in the long run.

3.3. Agile Supply Chain

Before the selection of a tool to implement in the supply chain's complex system, there is a need to identify what is the firm's strategy and what are the suitable approaches, taking the time, market traits, and the firm's abilities into consideration.

Among the techniques developed, two are widely known by academics and professionals: lean and agile methodology. Initially, they were confused together when presented (Christopher, 2000). Although there are major differences regarding these two approaches, it cannot be stated that they are independent of one another. These two methods have been used and tested in companies and by scholars, either separately or hybridly (leagile), for years. Keeping in mind the strategy of the supply, either one or a combination of these methods was chosen in order to become more efficient or more responsive (Christopher, 2000; Qrunfleh and Tarafdar, 2013; Ciccullo et al., 2017; Tripp et al., 2018).

The lean approach can be an effective strategy when there are a set of characteristics involved, for instance, if the demands are stable, thus predictable and when a variety of products are not required. To put simply, leanness is eliminating inventory and accomplishing more with less (Christopher, 2000). Rao and Kumar, (2019) discuss that in the past profitability and optimization was the key aspect of manufacturing. Mass production was a

favorable idea since companies wanted to use the maximum out of the capacity of equipment and workforce. It is evident that with this approach the inventories increased in size due to the high number of finished and semi-finished products.

However, in the markets today, that is not the case. Demands are highly volatile and companies must offer a diverse variety of products. This is mainly because firms intend to increase customer satisfaction in order to survive and remain competitive. With the increase of competition between organizations and customer demand fluctuations in modern times, the transition of organizations' requirements to become more aligned with responsiveness to customer demands has been visible for many years now (Power et al., 2001; Qrunfleh and Tarafdar, 2013). The discussion to fully understand the agile methodology has been held in academia.

By looking at the history of agile methodology, we can observe that the increase of interest in it began in the 90s. Cristopher, (2000) mentions major companies in the world are taking agility into consideration and these companies will have the approach to survive in the uncertain environment of the new era. This is further solidified by looking at Power, (2001) which states the shift of companies' strategy to agile, and their success in doing so in the 90s. A more recent article Cecere, (2012) claimed that 89% of companies are well aware of the importance of Agile Supply Chain; nevertheless, a considerably lower percentage of them knew how to use this approach to their advantage. It is understood that even after many observations in agile methodology, professionals and organizations still lack a complete understanding of supply chain agility and the correct shift towards it.

Qrunfleh and Tarafdar, (2013) concludes from the results of the analysis that it is evident that agile strategies in the supply chain contribute significantly to the responsiveness of the supply chain. The firms which devise such strategies will continue to satisfy customer demands and will gain a competitive advantage in order to survive. Having the previous result in mind, the analysis also indicates that responsiveness has a major positive effect on the firm's performance. From this, it is concluded that having an agile methodology can improve a firm's performance. However, no connection between leanness and responsiveness was spotted; therefore, eliminating waste and doing more with less has little to no influence on firms' performance when it comes to volatile markets. The results of the analysis made by Rao and Kumar, (2019) indicate the significant reduction in both lead time and inventory after applying the agile methodology, which is yet to be implemented fully in

companies all around the world. According to the authors, the adoption of technology and the increase in collaboration are two main approaches which can bring advantage to smaller firms.

Christopher, (2016) and Chopra and Meindl, (2013) discuss the concepts of pull and push in the supply chain. Essentially, push approach refers to ordering raw material, assembling or producing based on the historical data the company has, and on the other hand, the pull approach is triggered when a customer submits an order, which then the company will be fully set in motion to respond to this demand. Engineer-to-order and built-to-order are examples of the pull mode, they are engineered (designed and analyzed) and created when the customer orders. Put simply, in terms of accuracy, the pull method enables the firm to know exactly what, and how many products the customers need, eradicating the uncertainty of demand. After applying the pull methodology, the supply chain can be aware of the exact number of demands, reducing the chance of producing too many or too few products. Here it is observed that the agile supply chain is basically trying to produce what was requested, and not repeating the pattern of what it produced in the past (Rao and Kumar, 2019). Nevertheless, it is important to note that the pull approach is not in any means segregated from the push approach, and both must be considered together. This is mainly because in the push phase decisions are made regarding inventory and production capacity which impose constraints on the pull phase (Chopra and Meindl, 2013).

To conclude, for the volatile and constantly changing environment of today's markets, reduction of uncertainty in customer demand, and the importance of responsiveness in customer satisfaction and survival, adopting a methodology with a stronger focus on agile, and pull method, has been recommended by recent literature as well as previous works of scholars. In addition, It has also been implemented and investigated by professionals, practitioners, and firms.

3.4. Forecasting

Forecasting is the fundamental of all planning in the supply chain (Chopra and Meindl, 2013). There has been a wide interest in the topic of forecasting and the uncertainty linked to it by both researchers and practitioners for a considerable number of years. This has led to topics such as collaborative forecasting or planning (Fildes and Kingsman, 2011). Aiming to make a profit, gaining a competitive advantage, and increasing customer satisfaction continuously without having an accurate and clear image of the future, in terms of quantity, is not possible.

One of the main processes which take place in the supply chain is decision making. Decision making is mainly based on forecasting and its results. The imperative role of forecasting is because of limited resources, rapid and varied customer requests and desires, and the reduction in lead times (Boone et al., 2019). There are challenges associated with forecasting as well, one of the main ones is accurately forecasting the demand (Jaipuria and Mahapatra, 2014), which is of the utmost importance when it comes to having competitive advantages and fulfilling the purpose of the supply chain.

The importance of forecasting is when it is considered with the different approaches of the supply chain. Chopra and Meindl, (2013) claim that if push processes are considered, the planner must forecast and plan the amount of production for each period of time, logistics, the activities, etc. However, in the pull approach, considering the conceptual model designed, the demand variation, production, or inventory's capacity level must be planned and forecasted, and not just the quantity of products. The focus of this dissertation is on the pull approach since it has become more relevant in the volatile and ever-changing market (Gunasekaran and Ngai, 2005).

Syntetos et al., (2016) mentions that forecasting is more than just predicting the number of products to be sold. Coordinating the supply chain and sharing the information between the different parties are also part of this function. The role of forecasting is challenging because the number of demands is not known beforehand. Different parts of the supply chain and organizations may have different forecasts of the future, which is directly linked to their decision-making processes, for instance, some rely on short term predictions, inventory, and others a few times a year, such as sales planning. The complexity of forecasting has increased over the years for a variety of reasons, namely the increase in competition, market volatility, and life cycles of products. Yet, the role of forecasting not only remains crucial to the supply chain but becomes critically important if firms tend to stay relevant (Boone et al., 2019).

Ali et al., (2017) also claims that the main problem of forecasting is uncertainty, and if more information is shared, especially towards the end-customer, the uncertainty associated with forecasting will be reduced. This allows executives to efficiently plan as well as respond properly to changes in the market. However, it is not very applicable in all circumstances. This article mentions that due to compatibility of information systems, information quality, and

trust and confidentiality reasons information is not shared thus analyses forecasting in such scenarios.

Therefore, the importance of collaboration and information sharing can be seen. Syntetos et al., (2016) goes further to explain this importance by stating that Some applications for supply chain forecasting such as Vendor Managed Inventory (VMI) and Collaborative Planning, Forecasting, and Replenishment (CPFR) are the results of the collaboration. Therefore, we can understand although supply chains are highly competitive, by having the right partners and high visibility, competitive advantage can be gained in forecasting.

However, Ali et al., (2017) discusses that If the information is not shared by the retailers, mainly due to trust issues, the organization can base their forecasting upon two solutions: they can either predict future requests by the amount that the retailer orders or infer customer requests mathematically.

The output of the forecasting process, the input data which we feed to the forecasting system and their compatibility has not been well explored by forecasting literature. Another point in regards to the literature gap that this article makes is the ongoing problem with forecasting due to the software and data (Syntetos et al., 2016). This can be linked to the low data quality problem, for instance, as reported by DeHoratius and Raman, (2008) from the 370000 records of inventory 65% were not accurate, thus making forecasting problematic and increasing the margin of error. This problem can be fixed by retailers who are in direct contact with correct records of sales and stock.

The imperativeness of forecasting and decision making is evident when looking at the supply chain and its objective. Thus, it is clear that there is a need for advanced tools in order to facilitate these crucial processes by increasing data quality and quantity, reducing the risk and uncertainty, and increasing the accuracy of demand forecasting.

3.5. Advanced Tools in Forecasting

The amount of data has surged in recent years due to technological advancements in computing, databases, and the generation of data from different sources in the previous twenty years, in addition, this process is highly unlikely to stop growing (Addo-Tenkorang and Helo, 2016), on the contrary, the amount of data generated will most likely be doubled every two years (Hofmann and Rutschmann, 2018).

The term Big Data was coined due to the soaring amount of data; therefore, it is referred to sets of data which are considerable in volume, which is evident from the name, generated in real-time or near real-time, which includes high velocity, and finally poses a variety of formats, either structured or unstructured, which brings it considerable variety. Putting these three Vs (volume, velocity, and variety) together, the characteristics of Big Data become clear (Gandomi and Haider 2015; Boone et al., 2019). According to Gandomi and Haider, (2015) later on three more Vs were added to the characteristics of Big Data: veracity, variability, and value which were introduced by majors companies such as IBM, SAS, and Oracle respectively. To put simply, Big Data can be defined as extremely considerable quantities of data, either structured or unstructured, which are generated through different sources (social media, cloud computing, Internet of things (IoT), and Point of Scale systems) (Boone et al., 2019), and analyses which extract meaningful insights from aforesaid data to facilitate and help with the process of decision making (Sheng et al., 2017).

By looking at the work of (Wamba and Akter, 2019) it is evident that “Big Data” has increased in popularity in recent years and can have significant implications on the design, forecasting, and agility of the supply chain. The interest of Big Data has also increased among people, especially since the year 2011, according to Google Trends (Sheng et al., 2017).

Although “Big Data” introduces a number of prospects for the future of forecasting, it is not without challenges. For instance, the size of databases and the amount of data collected can be overwhelming, also “Big Data” integration into the conventional systems currently in use can be hindered and slowed by the acceptance rate of companies (Boone et al., 2019). Having all these points in mind, due to the real-time nature of big data and the increase in computational power, big data has major implications for the supply chain. Syntetos et al., (2016) also stresses that Big Data has significant benefits to forecasting in the supply chain. Supply Chain Forecasting is a field exposed to rapid evolution and change that provides a variety of opportunities for scholars and professionals to make contributions and attempt at solving the issues at hand. In addition to Big Data, an unsolved problem is the integration of social media in the supply chain forecasting process which a lot of researchers and professionals intend to use in forecasting. The challenges of these two ideas is not merely a forecasting subject, it also falls into the category of data management. A potential solution to include all these is “Predictive Analytics”, which is advised for further exploration (Syntetos et al., 2016).

Predictive Analytics is data-driven, meaning that it includes going through large quantities of data and extracting information, and knowledge integration from models, in order to be used in decision making (Shmueli and Koppius, 2011). The authors also suggest a definition for Predictive Analytics as a combination of statistical techniques and methods to create empirical predictions as well as quality assessment of those predictions in reality. Abbott, (2014) defines Predictive Analytics as recognizing patterns of data using statistical methods, machine learning, artificial intelligence, and data mining. All in all, Predictive Analytics is a process including many techniques to better predict the future and help with the process of decision making, this can highly benefit the supply chain.

Investigation and research in Big Data, Predictive Analytics, and Supply Chain Analytics have all been suggested by numerous scholars. Dubey et al., (2019) suggests exploring the benefits of Big Data Predictive Analytics, Boone et al., (2019) explains the major benefits of implementing Big Data in the systems. Gandomi and Haider, (2015) stresses the potential of real-time analytics in many different fields, which is then further suggested by Syntetos et al., (2016) which claims Big Data Analytics has great use in forecasting. To conclude, a major sub research question can be derived from this literature:

- How to associate pull mode forecasting with emerging technologies such as Big Data and Predictive Analytics?

Nowadays companies' future planning is moving from long-term planning and prediction to this new environment where nothing is made, sourced, or moved until a request has been made (pull) (Christopher, 2016). This shows the necessity of having forecasting associated with agility in the current environment (Miao and Xi, 2008). There are instances of improvements made in the prediction of companies simply by forecasting in a shorter time (Van Belle et al., 2020), which is essentially agility applied in forecasting. Some successful methodologies such as Just In Time (JIT) and systems such as Kanban are considered to be agile due to bringing flexibility to the companies (Christopher, 2016).

More useful insights are being produced at higher speed due to the utilization of more modern agile analytical means (Wamba and Akter, 2019). The forecasting system has to become associated with agility in order to make improvements in the supply chain (Dubey et al., 2019). This means that by using more advanced forecasting tools, firm's agility as well as supply chain's performance can improve.

To bring it all to a conclusion, all the literature reviewed in this thesis illustrated some gaps and potential ways to make contributions to the body of existing work. In the following section, we will propose the gaps identified, and finally, try to refine them to reach solid research questions to tackle.

4. Research Problem

Merriam-Webster’s online dictionary, (2020) defines a problem as “a question raised for inquiry, consideration, or solution”. According to Ellis and Levy, (2008) a problem, scientifically, is a controversy, unsolved or general issue, or a concern which is stated in research. The aim of stating the research problem is to fully and clearly comprehend what are the questions, or issues, we aim to answer, or solve, from the identified gaps in the literature.

In this dissertation, a variety of topics were selected and observed sequentially. By reviewing the vast literature on supply chain management and supply chain agility, the state-of-the-art was fully investigated and new pathways were discovered into current and future ways to improve the processes and the main objectives of the supply chain. Since the focus of this thesis is on the forecasting aspect of agile supply chain management, the majority of the gaps identified were regarding the most pressing problems in research as well as the industry in forecasting.

The table below is the collection of the main gaps we found in the literature:

Authors, Year	Main Topic	Research Gap
Chae et al., 2014	Supply Chain Analytics	SCA is still in initial stages and lacks theory and empirical studies/ SCA is growing in importance and deserves more investigation.
Gandomi and Haider, 2015	Beyond the Hype of Big Data	Real-time Analytics can be a major research field.
Hazen et al., 2016	Big Data Predictive Analytics Theories	Resource-based theory can serve as a potential theory for BDPA research/ explore BDPA as a resource.
Syntetos et a., 2016	Supply Chain Forecasting	Big data has major applications for forecasting/ Predictive Analytics is worth exploring in the future.

Barbosa et al., 2017	Big Data Analytics	Little is known about Big Data Analytics approaches in the supply chain.
Yu et al., 2017	Data-driven supply chain	Practitioner outlets and consultancy reports mention using Big Data is beneficial; however, there is a lack of empirical research.
Wamba and Akter, 2019	Supply Chain Analytics Capabilities	Investigation for holistic IT infrastructure to capture and share real-time data and support Big Data/ Investing in Big Data.
Boone et al., 2019	Forecasting using big data	The golden age of forecasting is coming, focus on challenges and new technologies, Big Data has major implications for the supply chain.
Dubey et al., 2019	Big Data Predictive Analytics	Only a few studies utilize a theory-focused approach to explain the benefits of BDPA.
Dubey et al., 2019	Big Data Analytics Capability in Agile Supply chain	Investigate other theories for a better, clearer understanding.

Table 2: Research Gaps

We have fully analyzed all of the articles mentioned in the table above in the literature review part of the thesis. The gaps identified in this thesis are twofold, firstly, there is a clear lack in a theoretical foundation and theories in Supply Chain Forecasting and Big Data Analytics. Secondly, a lack of empirical research on the usage of Big Data in the forecasting of the supply chain.

Supply Chain Analytics (SCA) is still in the initial phase and has yet a lot of room to improve, it lacks empirical research and theories to which it can be linked for further solidification since SCA is constantly increasing in importance (Chae et al., 2014). Hazen et al., (2016) introduced a number of theories to which Big Data in Supply chain could be linked, one of them was Resource-based view. According to Yu et al., (2017) numerous practitioners have suggested the use of Big Data in the supply chain; however, it still lacks solid empirical research. And finally, Dubey et al., (2019) claims only a few studies utilize a theory-based approach into the benefits of using Big Data in reality. It is visible that a lot of researchers stress the need for a theoretical foundation for future research to be built upon. This has been provided by this dissertation by linking the Resource-based view to the forecasting in the agile supply chain as well as providing a theoretical model which can be tested to provide

further proof of the influence of all the aforementioned resources (IT-enabled Tools, Data, Supply Chain Practices) in accuracy of forecasting.

One of the major benefits of Big Data Analytics is its real-time characteristic, which can be considered a major field of research (Gandomi and Haider, 2015). This was further proved by Syntetos et al., (2016) when the importance of Big Data in forecasting was suggested and stated that predictive analytics will grow in importance. Barbosa et al., (2017) states that still there is little known in the field of Big Data Analytics and its benefits in supply chain approaches (agile, lean, or a hybrid). Ultimately Wamba and Akter, (2019) and Boone et al., (2019) both agree that Big Data has major implications for the future and it must be investigated, yet it is not without challenges. The models developed (Figure 1 and Figure 2) try to provide a visualization of Big Data in the supply chain forecasting and an understanding of the relationships in the forecasting process respectively.

To conclude, it must be considered that the current system, in which companies are operating, must be analyzed through the utilization of a survey to fully understand what is the percentage of usage of these modern forecasting tools and what are their biggest and most pressing problems. Without properly examining the current systems, simply suggesting the use of Big Data and the ways of Big Data implementation would be inadequate and obsolete. Therefore, the following research questions:

- What is the impact of pull mode forecasting on the firm's performance?
- What are the factors contributing to pull mode forecasting and how strong is their influence?

And a sub-research question:

- How to associate pull mode forecasting with emerging technologies such as Big Data and Predictive Analytics?

5. Theoretical Framework and Hypothesis Development

5.1. Resource-based View

Chae et al., (2014) and Dubey et al., (2019) both stress that there is a need for theory and empirical research in Supply Chain Analytics and Big Data Predictive Analytics research due to it being fairly novel. Therefore, by going through many theories suggested by Hazen et al., (2016), it became evident that the Resource-based view (RBV) is the best fit for the theoretical background for this dissertation in order to develop a number of hypotheses. In addition, Hitt et al., (2015) suggests that RBV has become a theoretical foundation to critically respond to more novel research questions in the field.

For firms to survive and make a profit with their slim profit margins, there is a need for acquiring competitive advantage and sustaining it for a period of time (David and David, 2016). Resource-based view claims there are four main indicators to generate sustainable competitive advantage from resources. These resources must be or have the capability of being valuable, rare, imitable, and substitutable (Barney, 1991; Wu et al., 2005). Put simply, because of particular resources or capabilities that companies possess or develop, they are able to compete and gain an advantage over their competitors. Not all resources that companies possess fall into this category, they must have the characteristics mentioned above, which means they must be rare and valuable to obtain competitive advantage and hard to duplicate and non-substitutable in order to gain a sustainable competitive advantage for a period of time.

Resources include everything controlled by organizations in order to utilize to bring value or profit. These resources do not always bring efficiency or effectiveness to the company; however, the main goal of the firm is to make such use out of these resources to implement strategies which increase the firm's efficiency and effectiveness. A sustained competitive advantage is a company applying a strategy to create more value when other companies are incapable of doing so, either duplicating the advantages or bringing value from an identical way, hence the four indicators of resources (Barney, 1991). In terms of Information Technology and Information Systems, Barney, (1991) indicates that these systems must be considered as resources. On one hand, machines solely can not become sources of sustained competitive advantage because they are not rare by themselves, they can be sold and bought in the market. On the other hand, some information processing systems are the

heart and soul of decision making in each supply chain. They are very specifically designed and altered that only fit that particular company and it is not duplicable.

5.2. Hypothesis Development

Wu et al., (2006) uses RBV to justify the effectiveness of IT as a resource in the supply chain. Although there are discussions on IT not being a resource mainly because of accessibility by all firms, the authors of this article argue that if IT is integrated into the supply chain system, the creation of higher capabilities is, thus, possible, making it challenging for other organizations to imitate or duplicate the resource. Supply Chain Capability refers to the identification, utilization, and assimilation of internal and external information or resources of an organization to improve supply chain processes. Based on the results of these authors' testings, IT-based resources become valuable aspects of the company due to these supply chain capabilities. By exchanging information and coordination with different parties in the supply chain the firm can obtain information advantage for a period of time. Responsiveness also improves through the use of IT, meaning the firm will be quicker and more effectively in the volatile market of today. To conclude, Wu et al., (2006) put forth a solid argument that supply chain capabilities and IT-based resources go hand in hand and can bring sustainable advantage to the firm. Hitt et al., (2015) further solidifies the impact of IT-based resources as valuable resources for improving collaboration and coordination in the supply chain.

When looking at the topic of resources more fundamentally, IT-enabled resources need input in order to perform. This input is data, which has been considered a major resource in organizations (Marchand et al., 2000). The majority of data analyzed and used in the supply chain stems from the partners, this data is further utilized for planning, decision making, and performance management. According to Chae et al., (2014) a possible future pathway can be the data sharing IT resources of the partners, this further proves the vitality of data in the supply chain.

Supply Chain Analytics (SCA), Big Data Analytics (BDA), or Big Data Predictive Analytics (BDPA) are all practices and methods, or a combination of methods, used in the supply chain, all of which have been recognized as resources and linked to RBV (Barbosa et al., 2017). They may be considered as buzzwords; however, they have a longer history, starting from the maturity of data-mining or data warehousing. Most importantly, data can not solely be considered as insight into the processes of the supply chain, it must be coupled with analytics, practices, tool and manager insights in order to become fully operational, then it is

possible to claim that data is a resource capable of providing a competitive advantage, yet the reason for this value creation is obscure to some extent (Sharma et al., 2017). In addition, there is an accumulating notion among managers and practitioners that data has the potential of value creation (Tan et al., 2015; Yu et al., 2017). To conclude, it is evident that data, if analyzed and coupled with other tools and methods, is capable of bringing competitive advantage, hence can be considered a resource.

When both IT-enabled tools, and data as a supplement to IT-tools, are coupled together, we can view them as the company's IT infrastructure. By viewing both of them as resources, they can be contributing positively to the company's forecasting accuracy.

Hypothesis H1a: IT Infrastructure has a positive effect on forecasting accuracy.

Chae et al., (2014) seeks to understand supply chain analytics' role by defining three resources which comprise SCA: data management resources, IT-enabled planning resources, and performance management resources, by drawing from the RBV. According to the authors, SCA has the characteristics to provide a sustainable competitive advantage, therefore SCA along with supply chain practices can be seen as resources. Analytics, if considered solely, is not a specific method or technology, rather a combination of IT-based resources for many purposes such as supply chain planning, data-driven decision making, and optimization; therefore, sustainable competitive advantage is gained through consistently recombining the assets (Hitt et al., 2015). These IT-based resources comprise many different components, for instance, enterprise resources planning (ERP), Radio-Frequency identification, different forecasting tools and methods, and any practice or tool which helps with the improvement of processes of the supply chain (Chae et al., 2014). Briefly, it is understandable that supply chain practices, more specifically their combination, can be considered as resources which contribute to bringing sustainable competitive advantage to the firm. Dynamic Capabilities Theory (DCT) can be considered an extension of RBV, which was not premised on its logic. It can bring useful insights regarding a clearer understanding of resources and their contribution in volatile markets in maintaining a competitive advantage (Teece et al., 1997; Hitt et al., 2015; Barbosa et al., 2017). Wang et al., (2017) stresses that there is a gap between supply chain practices and theory.

Garmaki et al., (2016) suggests different elements in supply chain practices, for instance, planning or coordination are two elements which the authors point out in their work. Other collaborative elements such as collaborative Planning Forecasting and Replenishment

(CPFR), Vendor Managed Inventory (VMI) have been introduced as supply chain practices which can lead to higher forecasting accuracy (Syntetos et al., 2016).

Hypothesis H1b: Supply Chain Practices have a positive effect on forecasting accuracy.

There are more general hypotheses that are derived from the literature review when everything is put together. Firstly, the effect of forecasting accuracy on both supply chain agility and firm's performance must be analyzed.

Short-term forecasting is associated with agility, if the forecasting process is done in shorter time intervals, the firm is agile because they are able to take recent changes in the market into consideration; therefore, Ameliorating the short-term forecasting can result in making improvements in supply chain agility (Van Belle et al., 2020). This led to the idea of the possibility of a positive relationship between forecasting accuracy and supply chain agility. It seems that scholars have also developed hypotheses regarding the association of supply chain analytics and agility. Dubey et al., (2019) and Wamba and Akter, (2019) have both integrated Big Data Analytics and Supply Chain Analytics in their model and analyzed its effect on Supply Chain Agility.

Hypothesis H2: Forecasting Accuracy has a positive effect on supply chain agility.

Miao and Xi, (2008) assert that an agile approach to forecasting is a suitable way to bring satisfaction to operation levels' requirements when working in uncertainty. Van Belle et al., (2020) stresses that forecasting accuracy is capable of influencing a firm's profit in a positive manner. Wamba and Akter, (2019) also stress that modern analytical tools and methods are beneficial in terms of producing insights much quicker. To further analyze their results, we proposed this hypothesis:

Hypothesis H3a: Forecasting Accuracy has a positive effect on firm's performance.

And finally, the relationship between agility and firm's performance has been investigated before (Wamba and Akter, 2019) and has shown positive results. In addition, Dubey et al., (2019) also claims there is a positive influence from agility to firm's performance in their study, more specifically, Supply Chain Agility along with other capabilities have a positive

effect on the organization’s performance. This will also be hypothesized to provide further evidence to whether or not agility will influence firm’s performance.

H3b: Supply Chain Agility has a positive effect on firm’s performance.

To bring everything to a conclusion a theoretical model has been developed drawing from all the literature review and drawn from the theoretical foundation upon which this research was developed. The following diagram is the theoretical research model we developed and proposed through the careful analysis of the literature review and other scholars’ findings.

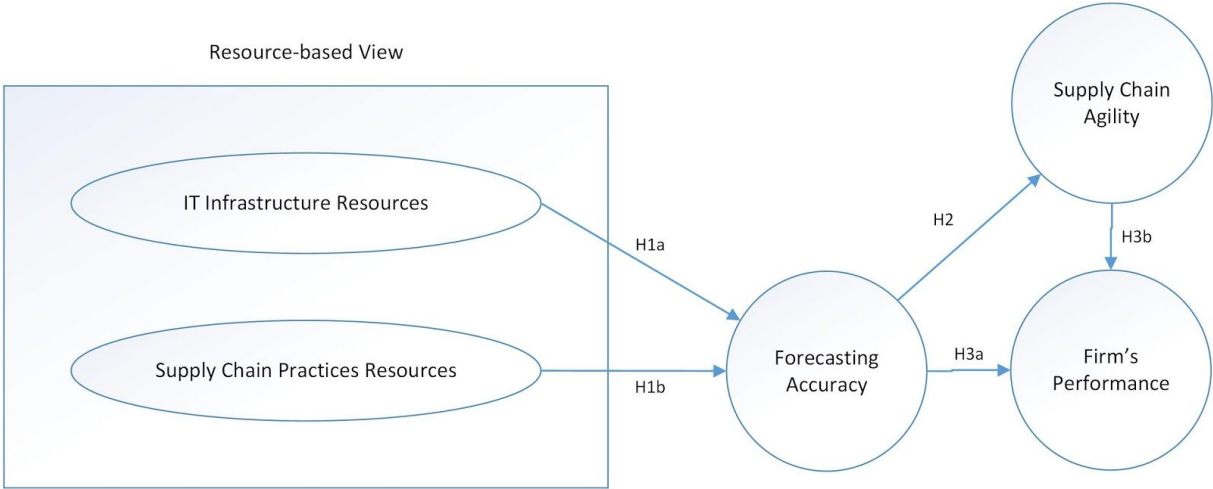


Figure 3: Theoretical (Research) Model

The theoretical research model we have proposed above is the combination of all the hypotheses developed from the literature review. The RBV consists of two main resources (IT Infrastructure and Supply Chain Practices) are thought to have an influence on the company’s forecasting accuracy. The Forecasting Accuracy is thought to influence two other constructs of the model: Supply Chain Agility and Firm’s Performance. Finally, Supply Chain Agility is also believed to have an effect on the Firm’s Performance. The Model essentially is proposing the question of whether these constructs have any influence on one another and if the influence is negative or positive. However, this test was not conducted due to the lack of time.

6. Conclusion

Forecasting is and always has been a crucial process of every supply chain. The unpredictable, ever-changing nature of the environment calls for better approaches, methods, and systems with which it can cope. The uncertainty and volatility are highly unlikely to alter in the future, on the contrary, it is highly probable that this trend will continue (Chrisopher, 2011).

6.1. Contributions

The aim of this master thesis has been to find answers and solutions to the initial research problem which dealt with the association of pull mode in the agile supply chain to contribute to the existing body of research. In terms of contributions, the literature of different topics surrounding the main aim of the thesis was reviewed and that resulted in a state-of-the-art review as well as a history of how supply chain, agile methodology, forecasting, and Big Data were shaped throughout the years. Additionally, a number of relevant research gaps (e.g lack of theoretical framework, lack of empirical research, investigation in Big Data) were identified which led to the formulation of five different hypotheses with the help of the theoretical framework of the thesis, Resource-based view (RBV). After, based on the hypotheses a theoretical research model was developed to make a link between the theoretical framework (RBV), the literature, and the gaps. Furthermore, another contribution is updating a questionnaire (appendix 2) provided by the supervisor. Specifically, the items in the questionnaire did not contain any references; therefore, the literature review provided resources to further justify the existence of the items which led to the development of the tables in appendix 1. An additional contribution is the second-order construct, in the tables in appendix 1, which puts a cap on the whole questionnaire and links it to the hypotheses and the theoretical model derived from the literature review.

6.2. Limitations

There are limits in research, and our research is not an exclusion from that fact. This master thesis was limited mainly by time. Time plays a crucial role in the development of ideas and finding suitable links between the research questions, theories, and possible solutions. This limitation hindered the process of running statistical analysis on the data and further test the hypotheses and the theoretical model. The other limitation was due to the Covid-19 pandemic which caused a lot of worries and hindrances in the research process and regular meeting with the supervisor. Although the internet compensates greatly for this limitation, the

pandemic was not without effect on the research. Lack of time also limited the search and better understanding of other theories such as Dynamic Capabilities (Teece et al., 1997) and possibly newer more relevant theories.

6.3. Future Research

There are pathways we wish to shed light on for future research. The topic of forecasting in the supply chain is subject to a lot of change and challenges in the future (Syntetos et al., 2016). This brings the possibility of integrating new technologies and different methods in order to make improvements in forecasting. One perspective pathway researchers can work on is integrating the challenges that hinder the resources from generating sustainable competitive advantage (Barney, 1991), for instance, the quality of data or the software with which the companies are forecasting (Syntetos et al., 2016). Another possibility is to gather data from a more international environment to better understand the forecasting system used in the world and in different countries.

In this research, we suggested using PLS-SEM tests primarily due to analogy and it being used by other scholars, this can bring more thorough and useful insight into the data. Also, the theoretical model can be improved. For example, challenges can be added as another dimension (construct) to completely understand their influence on other dimensions or the relationship between the resources can be developed and analyzed to see if they influence one another, or adding capabilities such as talent and skill to the resources (Wamba and Akter, 2019).

7. Resources

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8. Appendices

Appendix 1

8.1. Survey Measures:

The goal of having the different constructs (dimensions) of the theoretical model is to completely understand the first constructs, or the building blocks, of the questionnaire. This will ultimately be helpful in the IBM SPSS analysis of the data or if PLS-SEM is used.

1. IT-enabled Tools as Resources:

2nd Order Construct	1st Order Construct	Item Labels	Items	Source(s)
IT infrastructure resources	Excel Files	IT101	The extent to which we deploy Excel tools in our firm.	(Syntetos et al., 2016)
	Database Management System (DBMS)	IT102	The extent to which we deploy DBMS in our firm.	
	Enterprise Resource Planning (ERP)	IT103	The extent to which we deploy ERP in our firm.	
	Material Requirements Planning (MRP / MRP2)	IT104	The extent to which we deploy MRP/MRP2 in our firm.	
	Distribution Resource Planning (DRP)	IT105	The extent to which we deploy DPR in our firm.	(Syntetos et al., 2016)
	Big data	IT106	The extent to which we deploy Big Data in our firm.	(Syntetos et al., 2016; Boone et al., 2019)
	Radio-frequency identification (RFID)	IT107	The extent to which we deploy RFID tools in our firm.	(Addo-Tenkonang and Helo, 2016)
	Historical Data	IT108	The extent to which you use sales histories calculated internally for developing forecasts.	(Syntetos et al., 2016)
		IT109	The extent to which you use sales histories given by distribution centers for	

			developing forecasts.	
		IT110	The extent to which you use sales histories given by customers for developing forecasts.	
	Promotions	IT111	The extent to which you use promotions implemented by your marketing department for developing forecasts.	
		IT112	The extent to which you use promotions implemented by your customer for developing forecasts.	
	Point of sale data (POS)	IT113	The extent to which you use POS for developing forecasts.	(Boone et al., 2019)
	Product life cycle data	IT114	The extent to which you use Product life cycle data for developing forecasts.	(Van Belle et al., 2020)

Note: ITI, Information Technology Infrastructure

2. Supply Chain Practices as Resources:

2nd Order Construct	1st Order Construct	Item Labels	Items	Source(s)
Supply Chain Practices Resources	The information systems used are well mastered by the various departments.	SCP01	The extent to which you use these mastered information systems in various departments.	(Wamba and Akter, 2019)
	The systems used allow a computer link between the planning, the DRP and the forecast software	SCP02	The extent to which you use this computer link between planning, DRP and forecast software.	
	The systems used make it possible to measure the performance of forecasts	SCP03	The extent to which you use to measure the performance of the forecasts.	
	You operate in Shared Supply Management (GPA or VMI) with your main partners (suppliers or customers).	SCP04	The extent to which you use the shared supply management (GPA or VMI) with main partners.	(Syntetos et al., 2016)

	You have implemented collaborative solutions (CPFR) to develop your forecasts jointly with your main partners.	SCP05	The extent to which you use collaborative solutions to develop your forecasts jointly.	(Syntetos et al., 2016)
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Note: SCP, Supply Chain Practices

3. Forecasting Accuracy:

2nd Order Construct	1st Order Construct	Item Labels	Items	Source(s)
Forecasting Accuracy	Forecast of production	FAC01	The extent to which the forecast of production was close to reality.	(Syntetos et al., 2016)
	Forecast of demand supply	FAC02	The extent to which the Forecast of demand supply was close to reality.	(Grunfleh and Tarafdar, 2013)
	Forecast of logistic demand	FAC03	The extent to which the Forecast of logistic demand was close to reality.	(Syntetos et al., 2016)
	Forecast of sales demand	FAC04	The extent to which the Forecast of sales demand was close to reality.	
	Forecast of finance demand	FAC05	The extent to which the Forecast of finance demand was close to reality.	
	Forecast of marketing demand	FAC06	The extent to which the Forecast of marketing demand was close to reality.	

4. Supply Chain Agility:

2nd Order Construct	1st Order Construct	Item Labels	Items	Source(s)
Supply Chain Agility	Predict customer demand	SCA01	The extent to which you were able to Predict customer demand in pull mode.	(Grunfleh and Tarafdar, 2013)
	Establish the Capacity	SCA02	The extent to which you were able to Establish the Capacity (output, labor, equipment) in pull mode.	(Syntetos et al., 2016)
	Establish the Stock	SCA03	The extent to which you were able to Establish the Stock (safety stock, intermediate stock : raw materials,	(Rao and Kumar, 2019)

			semi-finished) in pull mode.	
	Establish a balance between customer demand, capacity, and stock	SCA04	The extent to which you were able to Establish a balance between customer demand, capacity, and stock in pull mode.	(Qrunfleh and Tarafdar, 2013; Syntetos et al., 2016; Rao and Kumar, 2019)

Note: SCA, Supply Chain Agility

5. Firm's Performance:

2nd Order Construct	1st Order Construct	Item Labels	Items	Source(s)
Firm's Performance	satisfaction of players	FPR01	The Extent to which you experienced Better satisfaction of players (customers, suppliers, internal)	(Chae et al., 2014)
	visibility of the market	FPR02	The Extent to which you experienced better visibility of the market (anticipation)	
	lead time Improvement	FPR03	The Extent to which you experienced An improvement in lead time.	(Christopher, 2016)
	Planning Improvement	FPR04	The Extent to which you experienced Improved planning.	(Chae et al., 2014)
	Changes in Market Demand	FPR05	The Extent to which you experienced quick response to changes in market demand	(Qrunfleh and Tarafdar, 2013)
	Resources Optimization	FPR06	The Extent to which you experienced Better optimization of resources (machines, human).	(Chopra and Meindl, 2013)
	Manufacturing Costs	FPR07	The Extent to which you experienced Reduced manufacturing costs.	
	Inventory Costs	FPR08	The Extent to which you experienced Reduced inventory costs.	

Note: FPR, Firm's Performance

8.2. Appendix 2

The questionnaire:

The purpose of this study is to better understand the role of forecasts in the supply chain in "production on demand" or "Pull" mode . This survey covers your forecasting processes and the tools deployed within your supply chain . Likewise, we wish to study the impact of this association between forecasting and production on demand on the performance of your company and the SCM.

In the questionnaire, when will used the term " forecast ", you will hear ' forecast of demand "

The confidentiality and anonymity of the information will be respected. The results obtained will only be used for scientific and educational purposes. *It goes without saying that you are not required to indicate what you consider to be too confidential .*

The questionnaire, which is administered to you, is primarily concerned with your perceptions and impressions ; as such, there is therefore neither "right" nor "wrong" answer . You are invited to respond freely without any *preconceptions* or specific intentions, depending on your opinion. To answer the questions, simply check R the answer that seems best suited to your opinion and the situation of your Business Unit.

If a question does not apply to your organization or if you do not know what a question is about, it is best not to answer the question , rather than choosing a random answer.

A . Environment and Strategy	not agree at all 1	No agreement 2	Somewh at disagree 3	neutra l 4	Somewhat agree 5	Okay 6	Totall y agree 7
1. Characteristics of the environment in which you operate :							
1.1 Stable							
1.2 Competitive							

2. Characteristics of the demand:							
2.1 Stable							
2.2 Season							
2.3 Variable							
2.4 Random							
3. In your BU, the products are rather :							
3.1 Standard							
3.2 Tailor-made							
3.3 standard proportion / tailor ? (Example: 40% / 60%)							
4. How can you qualify the strategy applied in your BU ?							
4.1 Reactive							
4.2 Efficient							
4.3 Both : Responsive and Efficient							
5. What is the Strategic operating mode :							
5.1 Pull (Pull, production on demand)							
5.2 In push flow							
5.3 In Pull and Push							
5.4 Other (s) (specify)							

B . “ Pull ” and Forecast : Association between production on demand and forecast

6. The processes in pull mode, in your BU, concern :							
6.1 The design (Engineer To Order)							
6.2 Production (Make To Order)							
6.3 Assembly (Assemble To Order)							
6.4 Distribution (Distribute To Order)							
6.5 Others (specify)							
7. The combination of forecasts in pull mode allows : (why ?)							
7.1 predict customer demand							
7.2 Establish the s level x capacity (output , labor, equipments)							
7.3 Establish the s level x stock (safety stock, intermediate stock : raw materials, semi-finished)							
7.4 Establish an e balancing between customer demand , inventory levels and production capacity							
7.5 Other (s) (specify)							
8. IS / IT tools and forecasting process deployed :							
8.1 Excel files							
8.2 Database management system (DBMS)							

8.3 Enterprise Resource Planning (ERP)							
8.4 Material Requirements Planning (MRP / MRP2)							
8.5 Multi-period management tool							
8.6 Distribution Resource Planning (DRP)							
8.7 Advanced Planning System (APS)							
8.8 Demand Driven Material Requirements Planning (DDMRP)							
8.9 Big data							
8.10 RFID							
8.11 Other (s) (specify)							
9 The data for developing forecasts :							
9.1 Sales histories, calculated internally							
9.2 Sales histories given by the distribution center							
9.3 Sales histories given by customers							
9.4 Promotions implemented by your marketing department							
9.5 Promotions implemented by your customers							
9.6 Point of sale data (POS)							
9.7 Product life cycle data							

9.8 Market information provided by the sales force							
9.9 Sales targets set by the finance department							
9.10 Market information provided by external consultants							
9.11 Strategic information : increased production, lower costs							
9.12 Data calendar and weather							
9.13 Other (specify)							
10. Collaborative forecasts and practices :							
10.1 The information systems used are well mastered by the various departments.							
10.2 The systems used allow a computer link between the planning, the DRP and the forecast software							
10.3 The systems used make it possible to measure the performance of forecasts							
10.4 You operate in Shared Supply Management (GPA or VMI) with your main partners (suppliers or customers).							
10.5 You have implemented collaborative solutions (CPFR) to develop your forecasts jointly with your main partners.							

11. Horizons of demand forecasts made in your BU :							
11.1 At 1 week							
11.2 At 1 month							
11.3 At 3 months							
11.4 At 6 months							
11.5 At 1 year							
11.6 Other (s) (specify)							
12. Accuracy of demand forecast by service :							
12.1 Our forecast of <u>Production</u> demand is close to reality							
12.2 Our forecast demand <u>supply</u> are realistic							
12.3 Our <u>logistics</u> demand forecasts are close to reality							
12.4 Our <u>sales</u> demand forecasts are close to reality							
12.5 Our forecast of demand in <u>Finance</u> is close to reality							
12.6 Our forecasts of <u>Marketing</u> demand are close to reality							
13. Barriers / Obstacles?							
13.1 Obsolete tools							
13.2 Incomplete data							
13.3 Skills of the forecaster							

13.4 Coordination between partners (suppliers, customers, internal)							
13.5 Other (s) (specify)							
14. What are the means used to make the forecasts more reliable?							
14.1 Regular calculation of forecast reliability (Forecast Accuracy) by measuring deviations							
14.2 Calculation of the impact of marketing plans on demand : promotions, discounts, new products, withdrawals, etc.							
14.3 Use of Category Management to influence demand							
14.4 Implementation of projects dedicated to improving forecasts							
14.5 Implementation of collaborative solutions with the main customers to make data reporting more reliable							
14.6 Reduction of the number of references to simplify the system							
14.7 Establishment of a bonus system to reward the reliability of forecasts							
14.8 Other (s) (specify)							
15. How often are the forecasts revised?							
15.1 A 1 time / week							

15.2 A 2 X / week							
15.3 A 1 times / month							
15.4 A 1 times / 3 months							
15.5 A 1 time / 6 months							
15.6 A 1 time / 1 year							
15.7 Other(s) (specify)							
16. Earnings :							
16.1 Better satisfaction of players (customers, suppliers, internal)							
16.2 Better visibility of the market (anticipation)							
16.3 An improvement in lead time							
16.4 Improved planning							
16.5 A quick response to changes in market demand							
16.6 Better optimization of resources (machines, human)							
16.7 Reduced manufacturing costs							
16.8 Reduced inventory costs							
16.9 Other(s) (specify)							

C . Information to better know your company and your BU

1. Name of your company:

2. Name of your business unit:

3. What is the sector of activity of your business unit :

- o A - Commerce (mass distribution, specialized distribution, mail order and internet)
- o B - Mobility (manufacturers: automobile, aeronautics, rail, naval)
- o C - Health Beauty (cosmetics, pharmacy, hospital, medical equipment)
- o D - Food industry (liquid, fresh, frozen, dry)
- o E - Transport (transporter, PSL)
- o F - Energy (Production and distribution of electricity, gas and water)
- o G - Electronics and IT (computer, chip, processor)
- o H - Building (structural work, finishing work, electricity, home automation)
- o I - Mechanics (mechanics, metallurgy)
- o J - Chemistry (chemistry, plastic)
- o K - Other sector: specify :....

4. Date of creation of your business unit:

5. Number of employees in your business unit:

6. (Approximate) date of creation of your company's supply chain service :

.....

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