St. Petersburg University
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PREDICTIVE INVENTORY OPTIMIZATION METHODS IN PROACTIVE WORKING CAPITAL MANAGEMENT

Master's Thesis by the 2nd year student
Concentration — Corporate Finance
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АННОТАЦИЯ

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Название ВКР	Предиктивные методы оптимизации складских запасов в проактивном управлении оборотным капиталом
Образовательная программа	Корпоративные Финансы
Направление подготовки	38.04.02 Менеджмент
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Научный руководитель	Старший преподаватель,Макарова Ольга Всеволодовна
Описание цели, задачи основных результатов	*Целью* данной магистерской диссертации является понимание того, как можно прогнозировать оптимизацию запасов путем сотрудничества в цепи поставок и, следовательно, стать проактивным в управлении оборотным капиталом. На основе методологии и полученных результатов можно сделать *ключевые выводы.* Во-первых, было доказано, что компания может сделать проактивным управление оборотным капиталом, если она сотрудничает с клиентами и включает их планы в процесс оптимизации запасов и управления ими. Во-вторых, было установлено, что компания может скорректировать свои запасы в соответствии с планами клиентов, если она внедряет прогнозируемую оптимизацию запасов. В-третьих, проактивное управление оборотным капиталом с помощью метода прогностической оптимизации инвентаризации будет означать снижение затрат и уменьшение денежных затрат, связанных с запасами. В конце было установлено, что предложенный метод прогностической оптимизации инвентаризации приносит больше пользы для компании.
Ключевые слова	Управление оборотным капиталом, предиктивная оптимизация запасов, сотрудничество в цепи поставок, проактивное управление оборотным капиталом

ABSTRACT

Master Student's Name	Ignova Keti
Master Thesis Title	Predictive inventory optimization methods in proactive working capital management
Educational Program	Corporate Finance
Main field of study	38.04.02 Management
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Academic Advisor's Name	Senior Lecturer, Makarova Olga Vsevolodovna
Description of the goal, tasks and main results	The *research goal* of this master thesis is to understand how to be predictive in inventory optimization through collaboration in the supply chain and hence becoming proactive in working capital management. Based on the methodology implemented and on the acquired results some *key findings* can be extracted. Firstly, it was proven that a company can make its working capital management proactive, if it collaborates with clients and includes their plans into its inventory optimization and management. Secondly, it was found that a company can adjust its inventory to the clients' plans if it implements a predictive inventory optimization. Thirdly, it was proven that the proactive working capital management through a predictive inventory optimization method would mean costs reduction and less money tied in inventory. Finally, it was found that the proposed predictive inventory optimization method brings more benefits for the company, instead of the past-looking one.
Keywords	Working capital management, predictive inventory optimization, collaboration in the supply chain, proactive working capital management

CONTENTS

INTRODUCTION

Working capital management as an area of corporate finance, attracts special attention of the academics and managers due to its high impact on operational performance. What most of the researchers have focused on, is its relation with profitability (Deloof 2003; Pandey 2008; Dharmendra 2015; Madhou, Moosa and Ramiah 2015; Rimsha et al. 2018; Nasser 2019). However, many researchers and authors of papers additionally state that inventory management and working capital management are closely connected (Sharma 2008; Singh 2008). According to these authors, inventory sometimes even takes forty percent of the current assets and the inventory management is a big issue across the industries (Huang et al. 2017). Hence, the management of inventory is truly important when it comes to better and proactive management of working capital.

The *research problem* lies in the fact that the studied literature clearly said that nowadays it is not enough for companies consider only internal factors for efficient working capital management. Instead, companies should focus on increasing collaboration in their supply chain (Holweg et al. 2005; Lam and Ip 2011; Ivakina and Zenkevich 2017). Companies, focusing on clients, apply predictive inventory optimization methods which stipulates them to be proactive in working capital management. Integrating their clients' plans in internal planning process, helps a company to act upon these plans, i.e. to be proactive. After conducting research on the differences between internal (company's individual) and back-looking methods of inventory management *and* methods that have a forward-looking perspective, and taking into account specific plans and needs of clients, certain benefits should be assessed..

This *research gap* was identified during the review of literature. It became evident that, most of the researchers undervalue the importance of being predictive in inventory optimization and proactive in working capital management through collaboration in the supply chain. Additionally, the literature review shows that there are not many attempts to combine working capital management and inventory management decisions. Most of the working capital management studies were devoted to explanation of its relation with profitability or productivity. Having in mind the importance and relevance that inventory has in the working capital, the sphere leaves a gap that ought to be fulfilled by studying deeper the theory and practice. The mentioned collaboration is needed in terms of understanding the plans that companies' clients have and incorporating them into company's own plans and operations. In terms of collaboration, companies should focus to most important, key partners Barrat (2004).

According to the literature studied, the following *research questions* were posed, with the purpose of fulfilling the discovered research gap:

- How can a company make its management of working capital proactive, through the better understanding and management of inventory?
- How can a company adjust its inventory towards the plans of their clients?
- What benefits proactive working capital management can bring to a company?
- How does the predictive inventory optimization method differ from the past-looking one?

Having identified the research problem, gap and questions, the *research objectives* are to be included, as guidance for the direction of movement of the study. One objective is to find out whether the company that employs predictive approach and collaborates with clients for including their plans in the supplier's inventory management can be considered proactive. Also, an objective is to discover whether clients' plans could be a basis, on which the company adjusts its inventory. Moreover, it is an objective to find out whether all these efforts would bring benefits for the company. Finally, one objective is to be able to distinguish the two methods by showing the gaps or discrepancies that arose.

As a result, the *research goal* is to develop a framework of predictive approach for inventory optimization through forward-looking collaboration in supply chain and hence becoming proactive in working capital management. This framework will address companies to consider understanding the plans that companies' clients have and implementing them into company's own inventory optimization and management, being a key element of the efficient working capital management in inventory-intensive companies.

An accent should be put on the importance of proper control, optimization and being predictive in inventory management in terms of making working capital proactive.

To reach the goal the author solves the following tasks:

- Study traditional methods in inventory management as a component of working capital and analyze their advantages and disadvantages,
- Explore the past- and forward- looking approaches and problem of predictivity in inventory optimization

- Compose an approach and a model that is oriented to improve the efficiency of inventory management by employing a forward-looking, proactive tools that oriented to higher predictivity,
- Test the model for a company that is inventory-intensive and have stable relationships with its clients

The research is composed of the 3 chapters. In the first chapter we study the theoretical grounds of working capital and company's financial performance and discover the influence of inventory management on its effectiveness from position of proactivity as a preferred approach. In the second chapter the forward-looking inventory optimization model is described. In the 3rd chapter this model is adopted and results from combination of past- and forward- looking methods is presented.

CHAPTER 1 LITERATURE REVIEW

1.1 Theoretical grounds regarding working capital management

The main objective of a firm – its value optimization – cannot be completed successfully if the firm does not manage and succeed in its short-term operations. Also, the firm's long-term objectives and goals are difficult to consider if the firm does not have the appropriate financial health and management within its short-term management. Therefore, when trying to research and investigate a company from this aspect, the working capital, as a collection of short-term assets and liabilities, needs to be explored.

The previously stated ideas are supported in Sharma's (2009, 24-43) work. In fact, in this book, Sharma (2009, 24-43) describes working capital as "one of the fundamental measures of a company's financial strength". According to the author, working capital should be understood as the capital, which is needed for the company to finance its daily activities. Moreover, when talking about working capital, two concepts can be distinguished. The first one is gross and the second one is net working capital. Gross working capital is related to the investment into current assets (inventory and accounts receivable). When talking about net working capital the difference between current assets and current liabilities is explained. Therefore, following the logic of Sharma (2009, 24-43), if current assets represent assets that will be converted into cash within one-year period, and if current liabilities represent obligations which will require cash within one-year period, it can be concluded that the difference of these two categories would represent the net working capital.

In fact, managing working capital efficiently is definitely paying-off when it comes to the cash flow (Damodaran2014, 160-227). According to Damodaran (2014, 160-227), for a company to have an efficient working capital management, it means that this company has to manage to reduce its net working capital needs whilst achieving this without having its earnings and revenues affected. Having all of this in mind, it can be understood why there is a lot of research done in exploring the relationship between working capital management and performance of the company. The fact itself that working capital management is directly influencing companies' profitability is a good reason why working capital management stands as an important part of the corporate financial management (Nihiu and Dermaku 2017). Therefore, the successful working capital management is one of the preconditions for the successful maintenance and profitability in any firm.

If the nature of the financial categories in question is considered i.e. the current assets and current liabilities, a conclusion can be made that they are very important for every firm's day-to-day activities. For example, as Nihiu and Dermaku (2017) state in their research paper, US and European companies hold more cash than necessary in working capital and this is a result of the high and unnecessary levels of inventory, receivables and/or debt. Moreover, the authors state that these problems are followed by the fact that strategic initiatives are implemented in an inadequate way. Having all of the previously stated ideas in mind, an understanding could be established about the need and the benefits from proper management of working capital, as well as the importance it has in corporate finance and in companies' overall functioning.

1.1.1 Working capital management and company's performance

First, in order to be able to find out the benefits that the proactive working capital management brings, there is a need to understand why it is so important to know this and how important working capital is to the company as a whole. In the recent years, many corporate finance research papers were devoted to the explanation of the relationship between working capital management and company's performance or profitability. They are truly important to be taken into consideration within the literature review of this master thesis, as they are emphasizing the essence of working capital management and are showing why this category of corporate finance should be studied in more detail. The fact that many studies prove that working capital management has an impact of company's profitability is what makes working capital management an important and always interesting research issue.

One of the most widely cited authors among them is Deloof (2003), who investigates this relationship on the sample of large Belgian non-financial firms and his study shows some quite important results as well. For measuring profitability, the author uses Gross Operating Income, whereas for measuring working capital management he uses the Cash Conversion Cycle. His findings suggest that the profitability of a company can be increased if managers successfully reduce the number of days accounts receivable and days inventories are held. This statement is one of the reasons why this particular research paper is important to this master thesis. From this paper, it can be understood that a very important part of the working capital management is the inventory management, measured by the number of days inventories are held.

However, Cash Conversion Cycle was not the only measure of working capital that was put against the measures of profitability. In the paper of Dharmendra (2015), the relationship between working capital attributes like current ratio, liquidity ratio, debtor's turnover ratio and

inventory turnover ratio on one hand, and profitability on the other hand, is being tested on the example of selected automobile companies in India. According to the study these authors conducted, it can be concluded that profitability is positively associated with debtor's turnover ratio and inventory turnover ratio. This means that the higher these ratios' values are, the higher the profitability**.** Thus, the more quickly a company converts its credit sales into cash, the more profitable will this company be. Moreover, and what represents the important part from this paper for the purposes of this master thesis, is the conclusion that the more times the company "turns" its inventory and sells it – the more profitable will this company be. Additionally, in general, it can be once again concluded that indeed the management of working capital influences the profitability.

Furthermore, profitability-related importance on working capital management is given in the paper of Madhou, Moosa and Ramiah (2015). Working capital, among other factors, is represented as a determinant of the profitability of the company. The research in this paper is done on the interactions between corporate profitability and working capital management (from the cash, accounts receivable, inventory and accounts payable perspective), as well as other incremental relationships. As the authors (Madhou, Moosa and Ramiah 2015, 2) say, "one key area of interest in corporate profitability research is identifying the determinants of profitability, one of which is believed to be working capital management as postulated by working capital managers and corporate treasurers". They definitely suggest and try to prove the similar idea as other authors in their own researches before – the healthy working capital management has an influence on the corporate profitability, and its overall value. Finally, these researchers show the interactions of working capital, corporate profitability as well as economic condition and firm characteristics. The findings of their research are in line with other authors' results about how the determinants of working capital management influence profitability.

Singh and Pandey (2008) also study the fact that working capital management is of great importance because of its direct impact on profitability and liquidity. In this paper, the authors study the working capital components and their impact on profitability in the specific case of a company. Working capital directly represents the liquidity of the company, which surely is the "blood" of the organization and these authors prove this fact as well. According to the authors, a significant determinant of the company's well-being is the efficiency in managing working capital. The relevance that this paper brings is connected to the previous statement that no matter how important profit is, in order to achieve it firstly companies need to "survive" in the short-term. The

management of working capital needs to be very proactive if they want to obtain all the benefits it has to offer.

This relationship has been also analyzed by Rimsha et al. (2018), Nasser (2019) and by many more. These authors, as well as many others who have investigated this relationship, have found a statistically significant positive relationship between working capital management and profitability. This means that the more and the better working capital is managed, the more profitable will the company be.

Additionally, the above-mentioned relationship is once again supported by the study of Sen and Oruc (2009) as well. They support the facts that the shorter the cash conversion cycle as well as net working capital levels, inventory period, accounts receivables period – the higher will the return on total assets be. In other words, according to these authors' findings, it can be stated that financial managers can influence the performance and profitability of their companies through the improvement of the efficiency in their management of working capital.

The main drawback that all of the above-mentioned studies have in common is that they are just analyzing this relationship, without going deeper into understanding what can happen if companies learn how to better manage some of the components of working capital. They do not pay a lot of attention to what benefits can a company have if it is predictive and attentive with clients, thereafter being proactive in its management of working capital. Hopefully, this master thesis will fill in at least part of the research gap that exists in this area.

1.1.2 Working capital management through the cash conversion cycle

Many of the studies mentioned previously used the cash conversion cycle as a measure for working capital management. Even though current ratio and quick ratio are also used, they are considered to represent a static picture of the working capital. Moreover, if the focus is on the examination of firm's efficiency in managing working capital, then the concentration should be focused on the cash conversion cycle (Shin and Soenen 1998).

As it can be seen in the paper of Nihiu and Dermaku (2017), working capital consists of inventory, receivables, cash and cash equivalents and current liabilities as its main components that build it. All of them combined i.e. their summary represents the Cash Conversion Cycle (or Working Capital Cycle, as these authors state it).

The studying of cash conversion cycle dates from very long ago, as it can be seen from the following paper. In their paper Richards and Laughlin (1980) state that financial managers intuitively acknowledge that all working capital investments do not have the same lifespan and

cannot as quickly transform into liquidity flows – hence, the approach using cash conversion cycle to working capital management diminishes the danger of using such an intuitive approach. These authors developed the idea of cash conversion cycle and define it as a "period of time required to convert a dollar of cash disbursements back into a dollar of cash inflow from a firm's regular course of operations" (Richards and Laughlin1980, 34). In other words, and according to the authors, cash conversion cycle is the "net time interval" between the cash expenditures on resources purchase and the recovery of cash receipts from product sales. Furthermore, the authors state that the increase in potential liquidity problems for companies is a result of an extended operating cycle, which comes from the declining of receivables and inventory. Moreover, the companies' liquidity management problems are moderate because of longer payment period, which comes from declining payables turnover.

Richards and Laughlin (1980) say that four basic activities determine the liquidity of a company. These include purchasing/production, sales, collection and payment. The cash conversion cycle is a dynamic measure that gathers these flows and integrates them through the turnover calculations of account receivables, account payables and inventory. A company manages its cash conversion cycle successfully when it effectively manages the individual components of current assets (Stojanovic 2014).

In general, the longer cash conversion cycle will mean a larger commitment to cash or non-cash investments into current assets and will mean that the ability to finance these investments with current liabilities is less extensive (Richards and Laughlin 1980). The shorter cash conversion cycle means better liquidity and better position of the company's working capital management (Stojanovic 2014). This author has come to an understanding that by decreasing the inventory's and account receivables' conversion periods and by increasing the payables deferral period, a company can achieve having shorter cash conversion cycle. This was proved with the companies that were under author's analysis. Those companies with negative cash conversion cycle were the ones that were very successful in inventory and receivables management. This was enough in order to decrease their operating cycle significantly (they even made their cash conversion cycle negative), even though they had to pay their bills in shorter periods (because of having small amount of days payables outstanding).

1.1.3 Working capital and inventory management

For many companies, one of the most important parts of working capital management is the inventory. According to Sharma (2008), inventory requires higher and more critical investigation

because it often takes up to forty percent of the current assets of a company. The proper management of companies' inventory is one of the very first and principle aspects that companies need to achieve. Companies that have the major part of their working capital being in inventories must excel in the short-term actions, like inventory management, and then focus on long-term activities. Every company has to be successful in the short-term, before even thinking of keeping the long-term sustainability. Working capital, and analogically in cases like this – the inventory, is the "blood" that the company needs to stay alive, have ongoing work and have good financial health.

According to Singh (2008), a synonym for managing working capital is the management of inventory. The main reason behind this is that one of the biggest parts of current assets is the inventory that takes a lot of investment. Therefore, the statement that has already been made in this master thesis is supported by the research conducted in the papers of the previously mentioned authors. Even more, this author states that inventory is something that definitely and especially needs to be analyzed if the intention is to understand working capital management. Inventory is the working capital category that represents large percent of the current assets taken into consideration when analyzing the working capital management.

1.1.4 Proactive working capital management

Today's business environment has become much more competitive and faster moving than before (The Economist Intelligence Unit 2006). Therefore, following this dynamic atmosphere and uncertainty, a conclusion can be made about the existing need for being proactive. It is not enough to look at companies' past trends and make conclusions about inventory and working capital management based only on that (Barrat 2004).

Companies need to learn how to be predictive in the inventory management and acquire information from clients that will help them with their inventory planning. This means that companies need to learn how to be proactive and act on the information that is acquired, in order to make the supply chain synchronized. It is expected that this master thesis would improve the methodology of managing working capital and would bring benefits for the company in terms of avoiding the creation of unnecessary costs due to issues in inventory management. In the dynamic business environment, it is not enough for a company to look only after itself, not taking into account the plans their clients might have. Moreover, for companies that are B2B oriented, it is very important to be attentive to every client. It is very often the case (as it is the case in the company used as an example in this master thesis), that these types of companies have several key clients with whom they collaborate (Barrat 2004). Therefore, there is a need of knowing their plans for the

future, in order to be able to maintain them by keeping them always satisfied. Additionally, this synchronization of supply chains is supposed and expected to produce the optimal inventory level where the costs are minimized.

1.2 Theoretical grounds regarding inventory management

If the intention is to understand how to manage inventory better, then definitely there is a need to set the theoretical grounds on inventory and its management. This should be explored, especially if the intention is to manage and control it not only according to companies' historical data and according to their own information. Instead, including what information their partners or clients can provide as well, in order to adjust company's inventory according to their plans. Additionally, this kind of information is relevant when it comes to inventory optimization, as well.

Nihiu and Dermaku (2017) define inventory as the goods or materials that are going to be converted in cash by being sold in the short term. Accordingly, inventory management is an aspect that significantly influences the financial management of a firm, especially in the short-term. If a company invests a lot in inventory, it will have a lot of cash that is unavailable because in order for it to turn over, the company needs to sell this inventory.

According to Brealey, Myers and Allen (2011), when talking about inventory and its management, two types of costs that inventories produce can be distinguished. In the beginning, every order that a company places brings handling and delivery costs (i.e. order costs). After that, the inventory brings the carrying costs. These, represent all the costs related to storage of the inventory items, opportunity costs of the capital invested into that inventory. Knowing this, the authors say that that good inventory management means a trade-off between the order and the carrying costs.

Following the logic of the previously mentioned authors, it can further be added that a company is put in front of the decision whether to make larger orders and less frequently, hence reducing the order costs. This trade-off is often a case in inventory management. When a company has quite high carrying costs and the ordering costs are lower, it is expected that the company will reduce the amount of items kept in the warehouse. This company will manage inventory in such a way that it will place orders more often, having the inventory in and out of the warehouse quickly in order to avoid the high carrying costs. If a company does this and makes larger orders, it will eventually increase the quantity that is held into the warehouse, the carrying costs will rise. This is why it is very important to understand how to balance these things and get the most benefit out of any situation.

As much as companies tend to holding higher inventory levels, they have higher costs to bear. Even though it is always good to be able to respond on the needs and demands of clients, holding huge amounts of inventory is not the right way to do this. As previously stated, one of the objectives of this master thesis is to find out how a company can adjust its inventory management practice according to the plans of its clients. Thus, as Singh (2008) states, it is all about keeping the inventories at a correct level.

However, the importance of managing inventory properly usually comes from the fact that companies usually have either too much or too little inventory, and this is definitely producing some costs. Sharma (2008, 32-33) explains that as the costs of having too much inventory consist of: "opportunity cost of capital, storage costs, theft, damage and pilferage costs, obsolescence risk, insurance costs". On the other hand, the costs of having too little inventory are essentially the costs rising from stock out: "lost sales due to unavailability of material, delayed delivery to customers, loss of goodwill". This statement is supported by Singh (2008), who represents the idea that companies should have an inventory level, which will not be inadequate or excessive because these kinds of situations lead to lowering profitability and sales operations. What these papers, and many of the papers related with inventory management, lack, is the possibility of establishing a forward-looking, predictive, inventory management model. A model that will take into consideration the plans of companies' clients and can take into account this information during the planning, control and management of their own inventory.

Because of the importance and financial significance of these costs, it has become the scrutiny of inventory management to find ways for getting rid of as much inefficiencies as possible. Reducing the cost of different activities in the supply chain, whilst not affecting the service level through this improvement of the efficiency of the supply chain has become one of the main objectives in inventory management (Civelek 2016). Having in mind the significance of the costs related with inventory management, according to Civelek (2016) different techniques have been implemented by the decision makers in order to improve the conventional working capital management. Hence, as the author states, they are working in favor of finding ways to reduce the lead-time and variability in demand, strengthening the relationships they have with their vendors and suppliers, improving the accuracy of their predictions, as well as combining different sources of risk in the supply chains. This statement establishes and supports the importance of this master thesis' research, as it would be extremely beneficial for decision makers to have it as a base for their further management of inventory or, i.e. working capital.

1.2.1 Inventory management and financial performance

While inventory management is significant from many points of view, it is important for this master thesis to cover inventory management with regard to the financial performance. There is always the question of whether proper inventory management can lead to better financial performance of companies.

With the research done in the paper of Karadag (2018), the author, among other hypotheses, tests the following one: "Small and medium sized companies which have higher conduct of inventory management practices have better financial performance". The results of the conducted analysis in this paper support the hypothesis and show that there is positive association between the inventory management practices and companies' financial performance. Additionally, this paper takes into account the competitiveness as an important factor. In fact, SMEs - when related to their competitors, need to be more effective and more efficient in using their financial management and therefore working capital in general and even more specifically, inventory. The better management of these categories will lead to better financial performance, hence - improved competitiveness, as the results themselves show.

In the research conducted by Madishetti and Kibona (2013), they prove once again that the inventory turnover period has an inverse relationship with the profitability of the chosen companies. This means that the shorter the period inventories are held, the higher will be the profitability. The authors distribute the message that the managers should use the adequate inventory management tools (for classification, analysis and management).

What is more important and what these articles do not cover is that not only financial performance is relevant when talking about inventory management. Seeing things from the perspective of this master thesis, an emphasis should be made on proving how much benefit, does the predictive inventory management (and therefore working capital management) bring in terms of cost reductions. Being proactive in the management of working capital can provide companies with additional benefits from eliminating inefficiencies. Especially companies that work as a business-to-business (B2B) organizations and have several important clients. In fact, it is important to understand how to keep them.

1.2.2 Inventory control and optimization

1.2.2.1 Inventory control

The control over the levels of inventory is truly important when it comes to managing it. Even more, if talking about optimization of inventory there is a need to understand, firstly, how the

inventory can be controlled. Nevertheless, the control of the entire inventory that a company owns is not necessary (Sharma 2008). It is more significant to control a small amount of items with high inventory value. According to the Pareto principle, a significant amount of inventory value is represented by as much as around 20% of the overall number of inventory items. This is why a company should identify these items, classify them and accordingly control them more seriously.

Priniotakis and Argyropoulos (2018) in their paper investigate the concepts and techniques for classifying and controlling inventory, avoiding stock-outs and increasing consumer satisfaction. When it comes to these authors, they define inventory management as the process where inventory level is controlled and monitored, while ensuring appropriate replenishment in order to meet customers' demands. They actually highlight the importance of inventory and its control – since it is one of the crucial factors affecting performance. The virtue of managers can especially be seen if they succeed in increasing consumer satisfaction, having minimum stock-outs and keeping costs to the lowest possible point. In order to better understand and control inventory, companies firstly need to classify it. In fact, this is done in Priniotakis' and Argyropoulos' (2018) paper. Therefore, authors use the ABC classification - a very popular inventory control technique. They point out that managers need to be attentive to them and understand how to make the best possible trade-off between the costs of inventory and the costs of stock-outs.

Inventory management has the role of keeping balance between investment into inventory and customer service and for many companies inventory is the most expensive asset that takes around 50% of invested capital (Ivanov, Tsipoulanidis and Schonberger 2017). These authors further discuss several basic and essential aspects of inventory management that will be explained in detail further long. The following are some of them: ABC-XYZ classifications, safety stock, service level, reorder point, EOQ, etc. All of these are very crucial for the functioning and performance of companies and they are all deserving of the best attention.

Inventory control and management has many different functions and each of them is important in its own way. The proper management and control can improve the logistics process, the customer service of a company, etc. However, most important for the purpose of this master thesis is the fact that inventory management and control, as well as the optimization, can be a source of financial benefits and savings for the company. Is because of this, that a special attention to inventory (as a significant part of working capital) should be paid.

1.2.2.2 Inventory optimization

At this stage, the study should not continue deeper into the research questions without understanding what does the optimization of inventory mean. One of the areas where the optimization could bring companies to great benefits certainly is the optimization of inventory – in terms of finished products as well as semi-finished products or materials (Paluch 2019).

According to Wisniewski (2018), the efficient management of a supply chain brings companies closer to the optimization of their inventory. Additionally, by efficient supply chain management, the author understands reducing the levels of inventory and responding to the demands of the clients as fast as possible. Since management of inventory is a crucial part of the supply chain management, the aim of this author's work is to understand the peculiarities defining inventory management - how do the changes in the goods ordering plans influence the levels of inventory, while taking into consideration the uncertainty of demand.

Scheuffele and Kulshreshtha (2007) also put their focus on the optimization of inventory. Going from the fact that there are some difficulties in reducing inventory with the traditional, or even some more advanced models, the authors stress that inventory optimization has become an urgency, instead of a necessity. Thus, the proper inventory optimization would mean better control of the inventory-driven costs, while paying attention to the demand volatility and the complexity of the supply chain. According to Scheuffele and Kulshreshtha (2007), supply chains have become more complex, therefore the need for substituting traditional techniques rises, which do not match this complexity of the supply chains.

Additionally, in the paper of De Cuypere et al. (2013), the authors investigate the optimal inventory management method under price fluctuations. Hence, it can be concluded that for these authors, not only demand is important; instead, besides the demand fluctuations they include the price fluctuations as well. Moreover, the authors are implementing a mathematical model based on several assumptions. As they introduce several models, finally they make conclusions and comparisons between them. However, what this paper does not implement, is the information about the plans clients might have. It would not be a mistake to assess this paper and the proposed models as good and relevant to a certain extent. However, the main drawback of this paper would be that it is inside looking and limited with inclusion of other important and interested parties, by whom the inventory optimization depends.

According to Scheuffele and Kulshreshtha (2007), inventory optimization is a significant tool for problem solving. One of its main goals is to deal with uncertainty – a factor that has pushed

companies to keep high inventory levels. The authors add that due to uncertainty, companies often tend to overstock and keep more inventory than needed. Hence, it is truly important to understand the issue of inventory optimization and to understand what will be the objectives from the optimization of inventories. The issue of uncertainty and its relation with inventory optimization was studied by Wisniewski (2018) as well. The author proposed a technique for simulation modeling for inventory management practices under the conditions of uncertain demand. In fact, the author states that in order to reduce inventory costs and be successful in satisfying customer expectations, companies need to know how to manage the uncertainty, as this is one of the key factors of the successful optimization of inventory.

As it was already covered, according to Singh (2008), a synonym to managing working capital is the management of inventories. The author states that in order to have an optimal level of working capital, companies need to set such a level of current assets that will result in minimal costs. Analogically, if this statement is followed, that since inventories represent a big part of the overall working capital, this makes working capital management a synonym for inventory management. Hence, from this point of view, it can be concluded that the optimal inventory is the one that minimizes costs. Another point of view is the inclusion of clients' plans in the process of inventory optimization, through applying predictive measures. Thus, because in order to propose inventory optimization methods, specific criteria need to be stated, this master thesis would take this aspect into consideration and they will be clearly specified in the next chapter.

1.3 Predictive inventory optimization

When it comes to management and optimization of inventory, what is really important is that companies need to be predictive in this matter. In the paper of Huang et al. (2017), the issue of prediction (or forecasting) is addressed, adopting two areas of forecasting. The first one is economic (used by government agencies, financial institutions, etc.) and the second is management forecast, used by companies for operational management and control. In this paper, the interest is directed towards the second area of making predictions. Several methods for optimization and prediction in inventory management were proposed by the researchers. Among them, we have the reorder point policy, the economic model predictive control, etc. However, they miss one important point of view when talking about inventory – the collaboration in the supply chain as a tool to being predictive in inventory optimization.

Subramanian, Rawlings and Maravelias (2014); Maestre, Fernandez and Jurado (2018) in their research papers use the economic model predictive control for inventory optimization and

prediction. The optimal inventory management, according to Maestre, Fernandez and Jurado (2018), would be reducing the stock levels as much as possible, whilst minimizing stock-outs. Additionally, in order to obtain the optimal inventory levels, they propose taking the minimization of inventory related costs – costs incurred due to the inventory operations management. They criticize the fact that some inventory management policies do not take into account some important factors and are highly based on the employees' manual work.

Before the implementation of their model, the reorder point policy was used for inventory optimization. However, it is not a good approach for this purpose, because there is nothing predictive within this policy. Additionally, the reorder point policy supposes ordering inventory when a certain level of inventory is reached. In this sense, the orders are not predictive, nor collaborative.

Therefore, the authors propose taking into account the stock levels (maintaining them as low as possible while satisfying demand needs), inventory related costs (to have them minimized) and the number of orders (minimal level of orders placement). Hence, the author use the Model Predictive Control in their predictive inventory optimization. It is a mathematical model, which uses a model of the controlled system for prediction of its evolution, represented as an evolution of steps during specific horizon. Nevertheless, this model could be criticized because of the fact that it is based solely on one controller who makes all the decisions alone. It does not pay attention to the importance of collaboration in the supply chain.

Huang et al. (2017) suggest using predictions for decision making, planning and simplifying the management and operations. Even though it is not possible to foresee the future with exact accuracy, it is important to develop ways for improvement of the predictions, hence the management and operations of companies.

1.4 Collaboration in the supply chain

What has become quite interesting and often highlighted nowadays is the concept of collaboration among the organizations. Collaboration in the supply chain is something that is interesting for researchers; however, it is a relatively new subject of research in the field of supply chain management. It is apparent and expected that the collaboration among businesses has always existed; however, it is especially in today's business environment that the collaboration has become a truly relevant and significant issue.

For understanding what supply chain collaboration actually is, Holweg et al. (2005) provide four different types of supply chain configurations. Each of the configurations is different

from the other, based on the distinction in planning collaboration and inventory collaboration. These configurations are presented on the following figure.

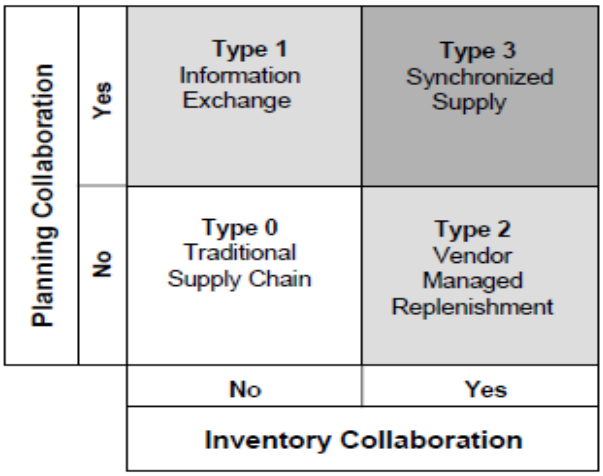

Figure 1. Basic supply chain configurations for collaboration

Source: Holweg et al. 2005. "Supply Chain Collaboration: Making Sense of the Strategy Continuum"

There is no planning or inventory collaboration in Type 0 supply chain collaboration. As the authors define: "'Traditional' means that each level in the supply chain issues production order and replenishes stock without considering the situation at either up or downstream tiers of the supply chain." (Holweg et al. 2005, 10). Overall, a conclusion can be brought, that the Type 0 model is definitely a source of more disadvantages, instead of being a source of advantages.

Type 1 supply chain collaboration is about the information exchange between companies. They are still working independently, and they only share information about their action plans. In fact, they are not proactive and they are still not supporting each other's' processes. According to the authors, the benefit of this type of collaboration is that it helps creating a more predictable and visible demand. At this stage of supply chain collaboration, it is still difficult for companies to integrate their inventory management largely.

Type 2 collaboration is organized in such a way that replenishment orders are given to the supplier and the supplier's role is only to be responsible for maintaining the client's inventory.

When it comes to Type 3 collaboration i.e. the *synchronized* supply, several things need to be pointed out. Companies usually do not include customer demand information within their inventory control processes (Holweg 2005). They usually exchange information, and this is often where the collaboration stops. Instead, companies should change their actions according to their clients' plans. Moreover, according to the author, within Type 3, the demand in the end of the

supply chain determines the inventory control and management plans, bringing additional benefits as a result.

Barrat (2004) addresses supply chain collaboration in his research paper, where he tries to discover more and answer some crucial questions regarding collaborative supply chains. This paper tries to provide answers to the questions as why companies need to collaborate, where can they collaborate and with whom they can collaborate. Barrat (2004) specifies two types of collaboration. He distinguishes vertical and horizontal supply chain collaboration. Vertical collaboration refers to the collaboration with customers and suppliers. Horizontal collaboration refers to the collaboration with competitors. He stresses the importance of collaboration proposes adding that companies should not try to collaborate with every partner they have. Instead, they should focus only on the key partners, the ones that are the most relevant for them, in order to have the collaboration bring some positive results and financial benefits. In order to do this, companies need to understand the elements that create collaboration in the supply chain and learn how to become better in this matter.

Collaboration is extremely important for companies nowadays. The relevance of the issue of collaboration in the supply chain comes from the fact that it has become a crucial factor in the long-term shape and future of company's functioning (The Economist Intelligence Unit 2006). The survey conducted by The Economist Intelligence Unit (2006), showed that for 28% of the survey respondents, the collaboration with other companies in the supply chain exceeded their expectations about its ability to create value. According to this research article, collaboration in the supply chain brings the benefits of having competitive advantage, sales and marketing benefits, as well as benefits of improved profitability.

In the paper of authors Ivakina and Zenkevich (2017), a special attention is paid to the coordination of working capital management in the collaborative supply chain. In fact, "…there is a growing recognition among company executives that today's business competition is no longer between individual firms, but between supply chains" (Ivakina and Zenkevich 2018, 6). As the above-mentioned authors state, today's companies still cannot understand the importance of coordination with their partners. Moreover, they are focused on their own interests and their individuality, instead of looking at the collaboration and coordination as a way to improve relations with partners and profitability through the improvement of their own individual performance. The authors are focused on planning, managing and optimizing cash flows in the supply chain, using the concept of financial supply chain management, therefore developing a coordinating working capital model for collaboration in the supply chain. Having in mind the importance the authors put on

collaboration it is becoming more and more clear why it is important for the purpose of this master thesis to understand inventory management of the company with the aspect of their clients' plans. These authors addressed the question from the cash flow perspective, while in this master thesis it will be addressed from inventory management perspective. Hence, the research should go beyond the analyzing, fixing and adjusting only company's own inventory, but it is important to have in mind the supply chain collaboration and the importance of company's support to clients' processes and plans.

Lam and Ip (2011) propose a Customer Satisfaction Inventory Model for managing inventory in the supply chain. With this model, the authors improve the existing inventory model since they add the customer satisfaction. This article is one of not-so-many articles developed in this field of research. This is why it is important to continue going deeper into the research and be able to look beyond the boundaries of only companies' own needs.

Another very interesting aspect when studying supply chain collaboration is the relationship between the supply chain collaboration practice and operational performance. Supply chain collaboration can bring advantages to the members that are participating. As a result, they are able to experience an increase in the common market shares and profitability (Sridharan and Simatupan 2009). The previously mentioned relationship is addressed in their research paper. The main research question is that they are investigating is whether this collaborative practice actually leads to better operational performance. Furthermore, they state that the companies (members of supply chains) need to synchronize the operations and decision-making, share information and employ incentive schemes. The results of their study showed that the operational performance had improved with the use of the collaborative practice. From this standpoint, the value of this master thesis research can be addressed once again, having in mind the research and results of the previously mentioned paper.

Going from the acknowledgement of the significance of collaboration in the supply chain, Flynn, Huo and Zhao (2010) also focus their research on the relationship between supply chain integration and performance, by using a contingency and configuration approach. They pose the hypotheses in order to test these relationships – internal and external integration *and* its relation with operational and business performance. What is most important for the purpose of the research within this master thesis is the finding that, according to the contingency approach, the external integration, specifically with customers, is positively related with operational performance. On the other hand, based on the configuration approach, it can be said that the most important finding for the purpose

of the research within this master thesis is that supply chain integration in general is positively related with operational and business performance. These are important insights that justify the relevance of this master thesis even more.

As it is the situation in any different matter, the collaboration in the supply chain has some barriers (The Economist Intelligence Unit 2006), According to this study, these are lack of trust, sharing intellectual property or difficult competitor relationships. Barriers like these may cause problems in companies' planning and operations.

Nevertheless, having all the above-mentioned statements in mind - it can be concluded that the collaboration is very important when it comes to the predictive inventory management in a proactive management of working capital. Moreover, the stimuli for emphasizing the need for collaboration in the supply chain arise from the dynamic and proactive nature of today's business environment as well.

1.5 Conclusion and research gap

For a company to be able to maximize its value, a well-established working capital management must be put in place. In order for companies to have good financial health and to be able to achieve their long-term objectives, they firstly need to take care of the short-term matters that are of great importance for their overall performance and well-being.

Working capital and its management have been widely studied, and there is a great amount of literature devoted to studying its peculiarities. Firstly, it will not be a mistake saying that the greatest amount of working capital management literature is devoted to studying its influence on company's performance and profitability. What most of these research papers have in common, is the fact that they all show that indeed, working capital management does positively influence these measures.

Going further with the analysis of the existing and recent literature, there was a possibility to conclude that the most important part of working capital is the inventory, as it often takes a big portion of the overall working capital. Thus, in order to better manage working capital, companies must be able to understand how to classify, control, optimize i.e. manage their inventory. Going from the perspective that some authors suggest using working capital management and inventory management as synonyms, makes it possible to understand how important their connection is. Moreover, the erroneous inventory management can be a source for great amount of costs that arise from keeping either too much or too little inventory or it will result with unhappy clients. Therefore,

a conclusion is made upon the importance of inventory management is, especially in terms of its influence on companies' profitability and performance.

What is also important, coming from the major significance of inventory in current assets, is the fact that companies need to be predictive in inventory management and optimization. Several authors proposed new or improvements of existing methods for predicting the optimal inventory levels. However, they all miss the fact that companies do not function alone in the business world and that they need to collaborate in order to obtain some beneficial results.

Hence, one of the ways in which inventory and working capital management could be improved is through the collaboration in the supply chain. This idea was fundamental in the studies of the authors doing their research in this field. What the authors conclude is that companies should tend to collaborate, to the degree of even having their processes synchronized. Such collaboration would definitely bring positive effects, as improved operational and financial performance. Even though the need for collaboration in the supply chain is emphasized, as the reviewed literature showed, still there are many contributions to be brought to this field of study. In fact, many of the authors of these research papers identify this necessity and propose their research in terms of emphasizing the importance of it. Only some of them have introduced some methodology that would improve the collaboration in the supply chain and therefore the working capital management. However, as it appears, not much literature is devoted to looking at this issue through the inventory management perspective – hence, the research gap.

Research gap. Even though working capital management is a very popular subject and has been explored a lot, still there are some points of view that are not so developed and are in need for additional research and improvement. Analogically, many researchers investigate the relationship between working capital management and company's performance, as well as other aspects, mentioned in the literature review. However, they often miss the fact that there are other points of view, besides performance, that need to be taken into consideration.

There really is plenty of research about the working capital management and inventory management separately, but there are only several attempts to combine working capital management decisions and inventory management decisions. Even though authors have tried to show the importance of working capital components as well as their interactions and peculiarities, this is still something that has been relatively neglected by researchers.

After having reviewed the literature, it can be concluded that the research gap lies in the fact that most of the researchers do not take into account the importance of being predictive and

proactive in working capital management through collaboration in the supply chain. The collaboration is needed in terms of understanding the plans that companies' clients have. The importance of this issue arises especially when it comes to B2B oriented companies, which are working with clients that are valuable in their sales perspectives and financial well-being. Specifically, as Barrat (2004) states, companies should focus on the most important, key partners. Hence, the collaboration in the supply chain must be considered for this purpose as a tool for predictive inventory optimization.

According to the study of Ruiz-Torres and Mahmoodi (2010), one of the suggestions for expanding their research in terms of practical significance is to develop a method that would set off the change in the levels of safety stock. Their findings show that when analyzing historical data, safety stock turned out to be not sufficient or excessive, depending on the volatility of demand. Therefore, the recommendation these authors make is to direct the future research towards the meaning of being proactive in the inventory management. In this sense, comes the importance of the research within this master thesis i.e. the importance of being proactive and forward-looking in managing working capital and inventory. The existing methods for inventory control, management and optimization are mainly inside looking and not enough, especially when it comes to today's business environment.

CHAPTER 2 METHODS AND DATA DESCRIPTION

Firstly, for understanding how the research goal would be reached and therefore providing answers to the proposed research questions, the research design, strategy and methods need to be identified. The research design for this master thesis is an exploratory study, which will produce a way of connecting the research questions to the conclusions. It is an exploratory study, because with the conducted research an attempt was made to assess the issue of inventory and working capital management from a new perspective. In fact, the strategy of the conducted research would be a case study and would try to put a new perspective into the traditional inventory management practices and obtain predictive inventory optimization methods in a proactive working capital management.

The exploratory study is the research design on which the entire further research was made. The research strategy following the chosen research design is a case study – all of the research and findings will be based and applied on the case of a company, i.e. one particular business/organization. In fact, according to Saunders, Lewis and Thornhill (2016), when talking about case studies, it is important to understand what the case would be. In this sense, the case needs to be defined, and the authors propose options of what the case can be – a person, a group, a change process, an organization, an event, or any other case. Having in mind their distinction between quantitative (as numeric) and qualitative (as non-numeric) research, using a quantitative research method, a model is constructed and research questions are connected with the results through the data analysis and making prediction for acquiring valuable information. Additionally, non-numeric method is implemented too in order to study the research problem from a qualitative perspective. In addition, let us explain and justify these statements and definitions of things, through the findings of Yin (2014).

Using this author's work (who provides an entire understanding of dealing with case studies) with the purpose of justification of the chosen research method is valuable, as many researchers confirm. For example, according to Yazan's (2015) findings in his research paper about the comparison of three approaches for case study analysis, it can be concluded that Yin's work in particular, is the best for the purpose of this master thesis. This is based on several aspects that make this approach the better choice. Analogically, it can be said that such a conclusion is based on the aspects in terms of epistemological commitments, definition of case study, data gathering process, data analysis and validation.

Yin (2014) has clearly stated criteria on which a decision should be made about what research design to use. His statements help reasoning how it can be concluded that a research is a

case study research, connecting why this type of study is appropriate for this master thesis. In fact, he proposes three conditions that are supposed to help in the process of research design identification. These conditions are used for validation of the research design choice for this thesis.

Firstly, according to this author, in order to determine the research design and strategy there is a need of looking into *the type of research questions.* Therefore, a conclusion is made, that case studies as a research strategy are the result of "how?" and "why?" research questions. Even though that there is an opinion about these types of questions being related to explanatory study, the author clearly explains that case studies can be used in any research design, thus, in an exploratory study as well. Hence, as it can be seen from the research questions in the introduction into the master thesis, the case study approach is applicable to the current research, as all of the proposed research questions are "how?" questions.

The second and third criterion, for determination of the type of research to be conducted, are *the extent of control an investigator has over behavioral events* and *the degree of focus on contemporary as opposed to historical event.* In this sense, according to Yin (2014), case studies are used when examining contemporary events, while not manipulating relevant behaviors. As it happens in this master thesis, particularly this would be done. The past-looking inventory optimization method would be compared with the forward-looking, predictive, inventory optimization method, in order to become proactive in working capital management and achieve financial benefits as a result.

Finally, it can be concluded that these three criteria are the core grounds on which the research design, strategy and methods were chosen. Now, as the use of a case study approach is proved applicable, the methodology of conducting the research needs to be explained. The following part of this chapter is devoted to the research design of a case study approach.

2.1 Research design and methodology

The scheme presented below, represents the most important five components of a research design, when there is a case study based research. Within this part of the master thesis, each of these stages would be explained in more detail – generally and in terms of their applicability to the conducted research in this thesis.

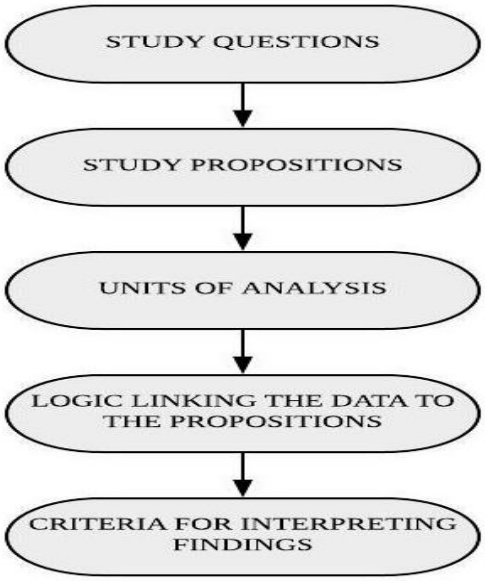

Figure 2. Case study components

Source: Created by author, based on case study components identified by Yin (2014).

Study questions. As it was previously shown, the research questions in this master thesis were clearly specified. The research questions can be seen in the "Introduction" part of this master thesis. It is important to mention once again that they represent "how?" and "what" questions, which was an indicator itself about the appropriateness of using case study as a research strategy. The research questions were specified on the base of the research problem in general. Thus, existing literature was reviewed, with the purpose of objectively justifying the research questions specification. This way, the existing state of the art literature is taken into consideration when addressing the importance of the existing research gap and the importance of answering these research questions as a result.

Study propositions. According to Yin (2014), case studies should have propositions, representing the things that need to be further examined and proved. These propositions are the base on which the research questions would be answered and they would secure the right path of the conducted research. Thus, the following propositions, based on the respective research questions, are established:

Proposition 1: A company can make its working capital management proactive, if it collaborates with clients and includes their plans into its inventory optimization and management.

Proposition 2: A company can adjust its inventory to the clients' plans if it implements a predictive inventory optimization method.

Proposition 3: The proactive working capital management through a predictive inventory optimization method would mean costs reduction.

Proposition 4: The proposed predictive inventory optimization method brings more benefits for the company, instead of the past-looking one.

Having stated the propositions, the research continues to establishing methods that would prove their viability and help in the research questions answering.

Units of analysis. The main issue that is supposed to be solved by identifying the units of analysis is approaching the explanation and clear definition of what the case actually is (Yin 2014). In the process of conducting the research, and once research questions and propositions were defined, several main units of analysis can be specified. The main one is the analysis of the inclusion of client's sales plans into a company's inventory management and optimization. Moreover, an additional unit of analysis is identifying whether there are some discrepancies in the financial benefits, when the company is using the past-looking inventory optimization method and the predictive one.

Of course, when conducting the research, other specific areas will be included in the overall research; however, these cannot be characterized as units of analysis. As Yin (2014) states, the definition of these units of analysis (i.e. the definition of the case itself) is coming from the research questions that are stated in the beginning of the research and they represent the core research area.

The logic linking the data to the propositions. According to Yin (2014), the theoretical explanation for the designing of case studies does not provide specific guidelines or definitions about how to link data to the propositions. As the author states, this can be done in many ways, depending on what is more suitable for the research in question. In short, what follows is the logic for linking the data to the propositions, in terms of the research conducted within this master thesis. As it can be seen, even though this is a case study based on a single case, still, there are different aspects that need to be covered, in order to connect the data with the propositions that are posed.

First of all, in order to start with the further and deeper investigation of the predictive inventory optimization methods in the proactive working capital management, there is a need to represent the overall working capital management condition in the company. Based on calculations and exploration of the situation, the current working capital management analysis results will show if this practical situation is actually applicable i.e. if it supports the literature review and research gap identified earlier.

Secondly, once the applicability is established, the inventory and its classification would be represented, with the purpose of identifying which inventory items need better control and management. As literature review and practice show, it is difficult to control and pay equal attention to the entire inventory. In this sense, inventory classification will be conducted, with the purpose of identifying which inventory items need more attention and control.

Once the second step is finished, the inventory management and optimization methods need to be established. Firstly, the specified inventory is analyzed based on the past-looking model. This model establishes the economic order quantity, safety stock, reorder level, as well as the optimal level of inventory – all of these metrics, based on the historical data.

Once the initial, past-looking model is built, the research will be directed to the implementation of a new, predictive method for inventory optimization. It would be interesting to find out what the gaps between the plans and actual data would be and how the company would have adjusted its inventory had it known their client's plans.

As a result, it is expected to find out whether the company that would collaborate with clients and include their plans in the working capital management would be considered proactive. It is expected to discover whether clients' plans could be a basis, on which the company adjusts its inventory. Additionally, it is expected to find out whether all these efforts would bring benefits for the company. Finally, there is an expectation about being able to distinguish the two methods by showing the gaps or discrepancies that arose.

Criteria for interpreting the findings. In order to interpret the findings, there is a need of setting some criteria on several aspects of the research in this thesis. In order to be able to make viable conclusions, criteria for the following metrics within the study would be set. As one of the crucial, key aspects in this master thesis are the optimization of inventory and the predictability in inventory management. Both of these aspects, when viewed together, would be the reference for identifying the proactivity in working capital management.

Optimal inventory level. As it was reviewed within the first chapter, devoted to the existing literature, it is important to specify on which criteria the optimization of inventory will be assessed and measured. Scheuffele and Kulshreshtha (2007), Singh (2008), De Cuypere et al. (2013), Wisniewski (2018) – all of them have investigated the issue of inventory optimization. What all of these authors have in common, is that in terms of optimization, all of them are focusing on the importance of reducing inventory costs. Following the logic of these authors, the criteria for

assessing the optimal inventory level are identified. The optimal inventory level will be the one that is *reducing the inventory-related costs* – it being the criterion for assessment.

*Predictive inventory management***.** In order to explain what it means to have predictive inventory management, a criterion needs to be identified. The criterion for assessing the predictability in inventory management would be whether the company takes into account client's plans i.e. the expected demand from end-users. If the company is considering this aspect, then it means that it can know, in advance, what the clients' plans are i.e. what their expectation for decrease/increase of demand for a products is. This means that the company is predictive in their inventory management.

Proactive working capital management. Both of the criteria mentioned earlier, when considered together, would be the reference for identifying the proactive working capital management. The proactive working capital management would mean that the company is considering clients plans in the optimization of its inventory. Moreover, this does not mean that the company is supposed only to gather the information. In fact, the proactive working capital management would mean that the company is acting on the valuable information acquired. In other words, the company should tend to have a synchronized collaboration where processes would be interconnected (Holweg et al. 2005). The expected flow of the proactive working capital management is shown on the scheme below. It represents the interconnection of processes, together creating the proactive working capital management through the predictive inventory optimization methods.

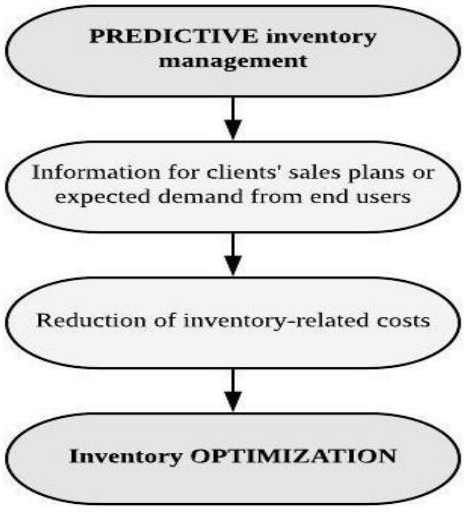

Figure 3. Proactive working capital management through a predictive inventory optimization method

Source: Created by the author based on identified criteria

2.2 Data collection and case studied

2.2.1 Data collection

When it comes to data collection, firstly, it can be said that for the purpose of this master thesis secondary data was used. The research was conducted on the example of a company; therefore, data was collected from the company on which this methodology is applied – it provided all the information and data needed. The data is mainly related with inventory, specifically the inventory that is regular in the company's business. It is also important to mention, that the data provided is a portion of the overall inventory in the company, and it represents the part that is significant for the company.

The secondary data was used and helpful for creating the model and establishing the methodology. This type of data contains valuable information about the inventory – its behavior and main characteristics. In fact, the inventory-related data provides information about the history of movement of inventory: received and released items over 3 years period; different types inventory-related costs – ordering costs over one and a half year period, warehouse expenses, opportunity costs, etc.; inventory's service levels; supply chain specifications; client's purchases from the company over 2 years period. Additionally, company's Balance Sheet and Income Statement were provided for the purpose of working capital management exploration. These financial statements cover the period from 2008 to 2018.

2.2.2 Case studied

This master thesis applies the proposed model and methods on an example of a particular company and the intention is to fulfill research gap based on the case of this company. The company is "ASK-Roentgen" Ltd., founded in 1991 as a joint venture with the German company Rich. Seifert & Co GmbH & Co KG. This company has the mission to improve the quality of Russian manufacturers' products by providing them with high quality equipment and consumables for non-destructive testing and other industrial applications. "ASK-Roentgen" Ltd. has been successfully fulfilling this mission, supplying the Russian market with nondestructive testing equipment from leading world manufacturers for more than 25 years. The main activity of the company is the production, distribution, commissioning and maintenance of industrial X-ray equipment for automated fluoroscopic control. The company is an exclusive official representative of GE Measurement & Control Solutions/ GE Sensing & Inspection Technologies, Helmut Fischer GmBH, Chemetall GmBH. (ASK-Roentgen 2020). In fact, GE is one of the key players in the non-destructive testing industry (Grand View Research 2020).

This company operates is the X-ray Non-Destructive Testing (NDT) industry. The NDT equipment is the equipment used for materials', components' or structures' inspection, identifying defects and discontinuity (PR Newswire, 2019). In the forecast period from 2020 to 2027, the NDT market is expected to have a growth of the compound annual growth rate (CAGR) due to the increased manufacturing activities in the developing countries (but in the developed also), which is characterized as the main driver of NDT industry's growth (Grand View Research 2020). According to the previously mentioned report, specific growth is expected in the radiographic (X-ray) testing, which covers the main sphere of activities for "ASK-Roentgen" Ltd. The X-ray NDT industry, where the company operates is very competitive, hence the need for this study. As it was mentioned on various occasions, the improvement of inventory management and its optimization will bring the company to a proactive working capital management, providing competitive advantage, as well as financial and other benefits.

"ASK-Roentgen" has a B2B business orientation. Its business highly relies on inventory. As it is expected to be seen in the assessment of the working capital management situation, this company would have the inventory as a significant part of the current assets. This is why, for the company it is crucial to understand how it can adjust its inventory management, while taking into account their clients' plans.

The company has a major role in the X-ray NDT industry in Russia, operating as a distributor of the X-ray films and this part of the inventory is meaningful enough for the company. In this sense, within the scope of this master thesis, the focus is only on part of the company's inventory – which is the X-ray film. There is an independent demand for the X-ray films. The independent demand is the demand that arises for a final product (Dooley 2005). According to this author, the demand for final products is uncertain, thus more attention should be paid to them. In fact, he states that the key for reducing inventory levels and meeting customer expectations is the management of this uncertainty. Additionally, this uncertainty can be decreased with the supply chain collaboration, therefore reducing the inventory-related costs

On Figure 2 (presented below), the supply chain configuration of ASK-Roentgen can be seen. The information presented about the functioning of the supply chain, as well as the configuration made are based on the information provided by company's representatives. The first part of the supply chain is the suppliers who provide the inventory to the company. The supply lead time is 2-3 weeks, and this is the time needed for the products to reach the company's warehouse after being ordered. Due to the branched dealer network (who are the main clients of the company),

end-users can save time and resources, buying consumables necessary in daily work (ASK-Roentgen 2020). Once the company receives the ordered X-ray films, it is ready for meeting the demand of the clients (i.e. the dealers). The clients, then, sell the products to the end-users. The main part of end-users is companies from the oil and gas and the aerospace industry. Other end-users are businesses operating in the chemical, automotive, shipbuilding, nuclear industry; as well as forensic science and security *and* museums and archeology.

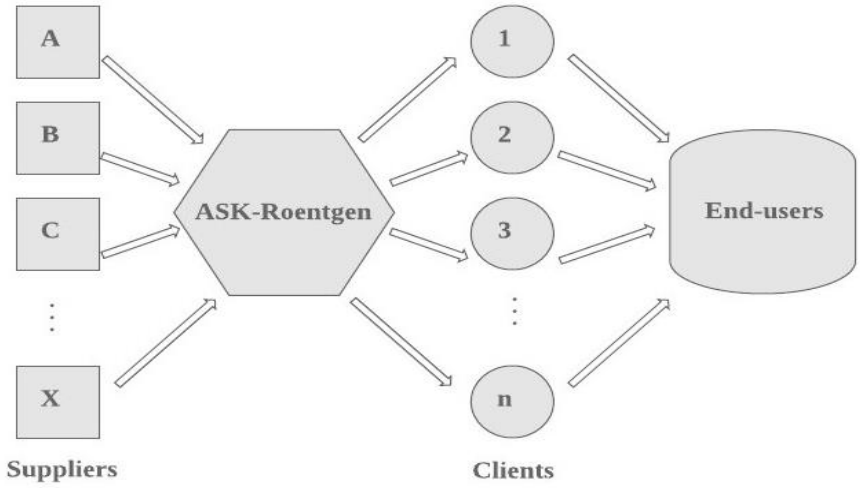

Figure 4. ASK-Roentgen supply chain configuration

Source: Created by the author

Inventory optimization methods are proposed and applied on the example of the company. Once the two methods give their results, a comparison should be made for identifying why it is better to collaborate in the supply chain.

2.3 Model specification

In order to answer the research questions by proving the study propositions, models need to be specified on which the entire research would be based. As previously mentioned, a model will be presented within the scope of this master thesis, which would further be developed by introducing a new method for being predictive in inventory optimization. The basic model would be compared with the one done by applying the new method, with the purpose of drawing conclusions and identifying existing discrepancies.

2.3.1 Classification of inventory

Before starting with the exploration of the inventory optimization models, the most important inventory needs to be identified. In order to start with the analysis of the inventory management, optimization methods or the models, firstly, inventory needs to be classified.

Inventory management and control will show the best results if efforts are organized properly, as there is not enough time available to be dedicated to the detailed control over each item individually (Wild 2002). Classifying, or grouping, the inventory can help in inventory's more effective control and monitoring. A more effective management of inventory can be achieved based on the classification of inventory. This more effective management is a result of the reduced overheads from managing the inventory groups, as well because of the acknowledgement that it is better and easier to manage inventory groups instead of managing each particular inventory item individually (Millstein, Yang and Li 2014).

There are several methods of classification of inventory and one (or more) has (have) to be chosen. Some of the most popular possible methods for classification of inventory are ABC, XYZ, FSN (Fast-moving, Slow-moving or Non-moving items), HML (High, Medium or Low price items), VED (Vital, Essential or Desirable items), etc. (Dhoka and Choudary 2013; Kumar et al. 2017).

For the purpose of the analysis within this master thesis, the most adequate method that will classify the inventory in the best way is the combination of ABC and XYZ analysis, i.e. the ABC-XYZ method. This method was chosen because it emphasizes the items' value and variability or fluctuation of demand, which are the most important for the purpose of this research. This is the case, because within this master thesis, the criterion for assessing optimization of inventory is the minimization of costs. In order to do this, firstly, items need to be classified with the ABC analysis, then continue to the XYZ analysis, so that it is finally finished with the combination of the two.

2.3.1.1 ABC classification method

Using the ABC method for classification of inventory, companies are able to set management priorities for different groups of inventory (Ravinder and Misra 2016). According to these authors' research, in most textbooks, before even starting a discussion about inventory models, there is a discussion of the ABC classification method.

In doing this classification, three groups of inventory items are created: A, B and C. The general and traditional ABC analysis is based on the Pareto Principle; hence, by using this principle, the few most valuable inventory items are separated from the many trivial ones. According to the Pareto principle, 80% of the effect is the result of 20% of the causes. Wild (2002) states, that the Pareto analysis is significant for all inventory and businesses do not obey precisely the 80/20 rule.

Another important thing when conducting the ABC analysis, is to set a criterion by which inventory will be divided. Different authors use many different criteria. These can be – the volume of investment into inventory, the costs of the investment into inventory, usage rates, unit price,

annual volume, etc. Once the criterion is chosen, the inventory can be classified. Accordingly, based on Wild (2002) methodology, the inventory is distinguished, that:

- *A items* are those items which are small in quantity, but have the highest impact on the value.
- *B items* have a medium impact on the value and represent a medium quantity of the overall inventory.
- *C items* have the smallest impact on value, but take a big portion of overall number of inventory.

Finally, as a result of the classification, recommendations for using the acquired results are provided. Once the inventory items are distributed, general inventory control recommendations can be set for each group. Teunter, Babai and Syntetos (2010) conclude that companies even set service levels based on the ABC analysis i.e. for different class of items, different service levels are set.

2.3.1.2 XYZ classification method

Another method that is used in the fields of inventory control and optimization is the XYZ analysis. In the XYZ method for classification of inventory, the items are classified in three categories X, Y and Z, based on the variability of their demand, or consumption (Krajcovic and Plinta 2012; Bulinski, Waszkiewicz and Buraczewski 2013; Kumar et al. 2017). The main goal of this analysis is to manage inventory in such a way that will provide minimum costs and will provide more flexibility in working capital management. The variability of demand is measured with the coefficient of variation. According to the XYZ analysis, the following three classes of inventory need to be identified (Dhoka and Choudary 2013; Kumar et al. 2017):

- X items – items, which have fixed size of need and have small or even uniform fluctuations in demand; they have sufficient accuracy in forecasting.
- Y items – items that have moderate fluctuations in demand and have an average accuracy of forecasting;
- Z items – the ones that have irregular, abnormal demand and have low accuracy of forecasting.

2.3.2 Past-looking inventory optimization model

Having extracted the most important inventory and knowing to which part more attention should be paid, the research should precede to the model establishment. In this sense, the past-looking model is presented. By saying “past-looking”, it is meant that the model is based on

historical data that is collected. In order to identify the optimal stock balance using this model, several variables and metrics, which contribute to its identification, need to be explained.

Safety stock. With the goal of identifying the optimal inventory level, firstly, the safety stock levels need to be identified. As Wild (2002) suggests, the amount of safety stock that an organization should keep, depends on the variability of demand, the reliability of supply and the dependability of transport. According to his suggestion, the safety stock should be set at a level that covers for the variability of demand, and the other two aspects should work as tools for adjustment, if needed, as they are rather insignificant. The author suggests that inventory's movement in and out of stock is a valuable information and essential data for identifying the level of safety stock. Based on the author's work, what is more important is the demanded amount, instead of the number of movements themselves.

Safety stock should be kept for many reasons. One of them is in order to increase the system responsiveness with the purpose of dealing with changes in the demand in the short-term (Van Kampen, Van Donk and Van der Zee 2010). These authors seek to find out if it is better to use safety stock or safety lead-time in the process of dealing with the uncertainty of demand and supply. In order to understand this, the authors adopt the safety lead-time and safety stock definitions. The first is defined as the difference between release time and due date, additionally subtracting the supply lead-time. The latter is defined as the average amount of inventory needed to permit uncertainties in demand and variability in supply in the short-term. One of the main things to take away from these authors' work is the distinction that both of these metrics have benefits. By using the safety lead-time, the benefit is the increased flexibility and for the safety stock – that is the increased responsiveness. An additional finding is that safety stock should be favored when having uncertainties related with demand. This is yet another reason why safety stock is important to be included within the model. Tonetti (2019) explains that one of the main reasons why companies keep safety stock is to make sure that they provide the goods quicker and to make sourcing or production ahead of having any information about the actual demand for that particular inventory. Additionally, according to him, in order to identify the safety stock, several variables need to be included, such as service level, standard deviation and supply lead-time.

Service level and service factor. The service factor, or the z score, is a one-tailed lookup from a z table of normal distribution (Tonetti 2019). The study of Ruiz-Torres and Mahmoodi (2010) makes a distinction between two existing definitions for the service level. Firstly, the service level can be defined as the percentage of times demand is fully served during a cycle. Secondly, it

can be defined as the average percentage of demand that the available inventory could fulfill. As the authors state, the second definition is more representative and relevant. That perspective of service level is adopted within this master thesis as well, thus, when the service level is mentioned the second definition should be taken into account. The service factor is derived by the service level, which shows how often the designed stock level meets the demand, during a specified period (Wild 2002). According to Teunter, Babai and Syntetos (2010), a conclusion can be made that the most important measure when assessing the inventory control is the service level.

Standard deviation. In order to measure the variability of demand, standard deviation needs to be calculated. For the standard deviation to be more accurate there should be larger sample i.e. larger period in history (Wild 2002). This is why, within this research, for the calculation of standard deviation of inventory items, monthly movements of inventory are examined within a period of one year.

For representation of the variability of demand, this author suggests another metric besides the standard deviation. This metric is the Mean Absolute Deviation (MAD). Both, standard deviation and MAD, measure the same variable. However, in this master thesis, specifically the standard deviation is used as a metric for variability of demand. This is because of the fact that, as the author states, standard deviation is more theoretically accurate, it is widely used in statistics and it is usually a programmed function in computers. MAD however, is simpler to use but the results are questionable.

Supply lead-time. Another part of the safety stock calculation is the supply lead-time. Supply lead-time is the period from the order placement, to its due date i.e. to its receipt (Hammami, Frein and Bahli 2017; Ivanov, Tsipoulanidis and Schonberger 2017). Hammami, Frein and Bahli (2017) address the importance of this metric, referring to it as one of the main things that brings competitive advantage and that attracts demand.

Lead-time is very important and valuable in terms of inventory management as well. In fact, in Graves and Willems' (2008) paper, the authors use lead-time in order to determine a strategic safety stock, which will bring to a higher service level to the final customer. Lead-time is included in order to make compatible the time used for the calculation of standard deviation (Tonetti 2019).

Demand. Another important part within this model is the demand, and the methodology of measuring demand. Within this analysis, the quantity of items that were released will represent their demand, and as it was discussed earlier, this is the independent demand. The average demand in a

month, along with the safety stock will represent the optimal inventory level. Once the safety stock is added over the average demand, the inventory's availability increases (Wild 2002). However, according to this author, if there is some disruption, a lot of stock will be needed for fixing the situation. Hence, the need for going outside the borders of the company, and ask clients for their plans and needs, so that such situations are minimized.

In order to understand better the inventory management and control system of the company, there is a need to calculate some additional parameters as well that would help in the process. It would be important to understand what is the reorder point of the company, as well as what is its economic order quantity (EOQ). In addition, their importance and relevance is addressed and explained.

Reorder point. In the inventory management and control, some systems for recording inventory use the minimum stock as a reference for ordering; however, that should not be the case (Wild 2002). In fact, according to the author, it is because the minimum inventory level happens right before the delivery, that inventory needs to be ordered in advance, before its minimum is reached. Thus, for better control and management, the reorder point should be used. The minimum stock would be signaled by the safety stock. The reorder point is used for understanding when to order (Ivanov, Tsipoulanidis and Schonberger 2017). These authors address the issue of reorder point calculation, saying that it would depend on the demand and the lead-time. In order to get a clearer picture about the inventory management practices within the company, reorder point is one of the main parameters that need to be studied and identified.

Economic Order Quantity (EOQ). For understanding how much to order for each order placement, EOQ is used (Asadabadi 2016; Ivanov, Tsipoulanidis and Schonberger 2017). As it was previously mentioned, Brealey, Myers and Allen (2011) say that a good inventory management is the one where a good trade-off between inventory ordering and carrying costs exists. Some authors, like Dooley (2005), also include the stock-out costs, which represent the costs of not having inventory available for sale. However, in the case studied within this master thesis, such costs do not exist; hence, this category would not be considered. On the other hand, ordering costs are the costs related to the order preparation, delivery/receiving the inventory and invoice processing (Paluch 2019). Additionally, carrying costs are the costs to hold inventory in the warehouse and usually they consist of capital costs, service costs, storage costs and risk costs (Dooley 2005). Therefore, the sum of the two types of costs is minimized when the economic order quantity is ordered (Brealey, Myers and Allen 2011; Ivanov, Tsipoulanidis and Schonberger 2017).

Based on these variables and metrics, the model is represented below in a general form, with general notations. This general form of the model has the purpose of showing how all of the previously mentioned variables and metrics would be synthesized. The specifics of the model would be calculated, explained and presented in the next chapter among the other results of the case study research. Therefore, the data would be implemented within this model, as part of the next chapter.

Past-looking model	**Inventory item name**	
Total quantity received/released in the year:	Q received	Q released
Supply lead time (months)	months	
Usage rate (pieces per month)		pcs
Standard deviation		σ
Service level		%
Service factor (z-score)		z
Economic order quantity	EOQ	
Reorder point	ROP	
Safety stock	SS	
Optimal level	**N items**	

Table 1. Past-looking model for inventory optimization

Source: Created by the author

The main reason why this model is not enough and why it should be improved is that it is highly relied on historical data. It does not assume any changes in for the upcoming periods. Moreover, this model would be characterized as Type 0 supply chain collaboration, i.e. bringing excessive inventory holdings and higher uncertainty, reduced customer satisfaction, lost revenues, reduced productivity, etc. (Holweg et al. 2005). Additionally, this model is put in a shadow if the part that was covered in the literature review is added also, about the importance that collaboration in the supply chain has. How important it is to know client's expectations and be predictive; to be able to implement their operational plans, hence the importance of being proactive in terms of finding out their plans and adjusting own inventory to meet and support their plans. All of these statements are the reason for introducing new and improved inventory optimization method. The predictive inventory optimization model, based on this method, will be a source of cost savings and improved relationships with clients.

2.3.3 Predictive inventory optimization method

When trying to optimize the inventory, as literature review showed, it is not enough to do this simply by looking within the borders of the company. Instead, companies need to collaborate,

share their operational plans, implement and act upon the acquired information. In this master thesis, the research will be focused on Type 3 supply chain collaboration, as a concept introduced by Holweg et al. (2005) and covered in the literature review part. As it was explained, supply synchronization happens when the supplier plays a big role in the inventory replenishment of its clients, and this visibility of client's plans makes it possible for the supplier to plan their own supply operations. Going from their statements that it is not enough for companies to work by themselves, or to have only partial collaboration (by only information sharing or vendor managed replenishment), companies should tend to implement *synchronized* supply chain collaboration. Even though each of the other supply chain systems has their own advantages, as well as disadvantages, still the Type 3 collaboration brings value on several aspects, making it more interesting and important.

Even though authors have identified the different types of supply chain collaboration, still there is no specific method explaining how this should be done. In this sense, this master thesis proposes the methodology for being predictive in the inventory optimization, hence being proactive in working capital management. The methodology is an extension of the past-looking inventory optimization model. It is an improvement done using the information about clients' plans within the companies' own inventory management and optimization.

In his sense, as Barrat (2004) suggests, companies should collaborate externally with a small number, but strategically important, customers and suppliers. This suggestion is applied within the scope of this master thesis as well, as the company's most important clients are taken into consideration. As Barrat (2004) states, companies could not collaborate with every one of their clients. In this sense, the proposed methodology would be applied to the example of the company, using 10 of its most valuable clients. The data derived based on these client's information is expected to provide significant insights about the most important inventory, within the chosen part of the inventory. As companies cannot focus on every client they have, they also cannot focus on every type of inventory items they have. Thus, the most important inventory, identified using the ABC-XYZ classification, would be used once again.

In order to extend the past-looking inventory optimization model, there is a need of including some additional information to it, expanding its perspective. Thus, the information about the expected increase or decrease of demand should be attached to the existing model. For this purpose the following approach was applied.

Clients' expected demand increase or decrease would be assessed, based on data about quantity demanded. The data used for identifying the expected increase or decrease of demand is represented by each client's purchases from the company, for a period of two years. If assumed that the clients knew their plans one year before, therefore – if the second year is taken as a prediction, the percentage of increase or decrease could be calculated. In this sense, for the calculation of expected increase/decrease in demand, the data for clients' purchases from Q2 2018 to Q1 2020 is used. Therefore, the first year, Q2 2018 – Q1 2019, would be analyzed against the second year, Q2 2019 – Q1 2020. The difference between the sum of purchases in the second and the sum of purchases in the first year, related to the sum of purchases in the first year (it being the base year), would provide the expected percentage of increase or decrease in demand. In other words, this percentage would represent the demand increase or decrease in the second year, in relation to the base year. Accordingly, the following formula is used:

$$\Delta D(\%) = \frac{\sum purchases\ Y2 - \sum purchases\ Y1}{\sum purchases\ Y1}$$

This formula would be used to provide the percentage of increase or decrease in demand for each of the clients which are under the analysis. In the case analyzed within this master thesis there are 10 clients, on which the methodology is based and applied. Once the expected increase or decrease is identified for each client in particular, the average percentage for all of these clients would be taken into consideration, in order to obtain one general percentage of expected increase or decrease in demand.

Regarded from the viewpoint of acquired information about the plans for amount of inventory needed, the company should adjust its inventory. The newly obtained information about the percentage of increase or decrease in demand should be added to the past-looking model, producing changes in the amount of released items. Using this methodology, companies could find out how would they adapt and adjust their inventory, having known the plans which their clients have. As a result, companies could be able to acknowledge the benefits that this synchronization brings.

Once the information is adapted to the model, some discrepancies are to be found. Hence, companies, with the new method of inventory management, would expectedly come closer to the optimal inventory level, through the predictive inventory optimization method.

CHAPTER 3 RESULTS OF THE ANALYSIS

This chapter is devoted to the representation of empirical findings, based on the research and methodology that was used in the master thesis. For the purpose of processing the data and analyzing it, Microsoft Excel was used.

In the first part of this chapter, a working capital management analysis of the company will be made, as well as an explanation for what it means to be proactive in working capital management and what benefits it could bring. Understanding the importance of inventory management within working capital, the biggest part of this chapter would be devoted to the inventory management and optimization methods. A new predictive inventory management method would be introduced for the optimization of inventory levels, based on the plans of company's clients.

3.1 Working capital management analysis and proactivity

Before continuing with the deeper exploring of the research questions, it is necessary to understand and explain the working capital management conditions in the company. For the sake of identifying trends and making conclusions, the condition with working capital management for this company in its experience in the past years needs to be investigated. In order to do this, an analysis on the financial statements of the company was conducted. The purpose of this analysis in the overall model construction is to understand what is the general situation with the management of working capital in the company, as well as to discover whether the company under analysis is truly applicable for such research and explorations. Moreover, this part of the research would be a base in terms of seeing why working capital is in need of becoming proactive and why inventory management is so important.

The analysis will be conducted based on the company's previous experience, because as Sagner (2014) states, there are no two organizations that are completely the same and this makes it hard to make a comparison. Additionally, the analysis will be conducted on wider range of time i.e. years 2008-2018, in order to be able to identify trends and make appropriate conclusions.

As it was covered during the literature review, when looking into the management of working capital, the best representative for it is the cash conversion cycle (CCC). Deloof (2003), Nobanee, Abdullatif and AlHajjar (2011), Stojanovic (2014), as well as many other authors, say that the longer the cash conversion cycle is, the larger the investment into working capital will be. On the other hand, the shorter cash conversion cycle will mean quicker turnover of inventory, quicker collection of cash from receivables and prolongation of payments towards suppliers. Hence, according to the authors, the formula for calculating the cash conversion cycle is*:*

$$CCC = DSO + DIH + DPO$$

Where:

Days sales outstanding (DSO):

$$DSO = \frac{Account\ Receivables}{Sales/365}$$

Days inventory held (DIH):

$$DIH = \frac{Inventory}{COGS/365}$$

Days payables outstanding (DPO):

$$DPO = \frac{Account\ Payables}{COGS/365}$$

What follows is a table containing the necessary accounts from the balance sheet and income statement for the years 2008-2018, using which, the CCC was calculated. By implementing the previously stated formulas, DSO, DIH and DPO were calculated, leading to the final CCC calculation.

in 000 rubles	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Acc. receivables	23,816.00	12,156.00	20,968.00	37,567.00	43,514.00	67,713.00	79,865.00	110,924.00	98,173.00	135,072.00	247,625.00
Inventory	22,067.00	26,669.00	28,914.00	67,087.00	52,792.00	73,982.00	102,466.00	120,116.00	135,305.00	108,057.00	92,782.00
Acc. payables	29,361.00	35,615.00	66,078.00	93,488.00	74,789.00	99,675.00	168,151.00	195,896.00	127,143.00	166,399.00	187,678.00
Sales	225,073.00	277,251.00	423,067.00	664,518.00	742,296.00	768,822.00	857,575.00	1,062,156.00	1,236,742.00	1,082,517.00	1,229,496.00
COGS (abs.)	171,815.00	207,302.00	315,930.00	491,357.00	575,454.00	582,446.00	663,424.00	831,059.00	897,815.00	780,496.00	826,317.00
Current assets	77,043.00	52,578.00	86,164.00	125,467.00	120,584.00	150,481.00	192,738.00	247,430.00	246,488.00	271,252.00	342,109.00
Current liabilites	47,161.00	42,606.00	66,078.00	93,488.00	72,107.00	99,675.00	168,155.00	198,808.00	157,909.00	181,578.00	300,010.00
DSO	38.62	16.00	18.09	20.63	21.40	32.15	33.99	38.12	28.97	45.54	73.51
DIH	46.88	46.96	33.40	49.83	33.49	46.36	56.37	52.75	55.01	50.53	40.98
DPO	62.37	62.71	76.34	69.45	47.44	62.46	92.51	86.04	51.69	77.82	82.90
CCC	***23.13***	***0.25***	***-24.85***	***1.02***	***7.44***	***16.05***	***-2.15***	***4.84***	***32.29***	***18.26***	***31.59***
Share of inv. In CA	*0.29*	*0.51*	*0.34*	*0.53*	*0.44*	*0.49*	*0.53*	*0.49*	*0.55*	*0.40*	*0.27*

Table 2. Working capital management condition in the company

Source: Calculations by the author based on financial statements data

3.1.1 Conclusions based on the working capital management analysis

Once the calculations have been made, conclusions of the analysis should be extracted. As the literature review showed, CCC represents the efficiency of managing and using working capital. Therefore, a shorter cycle would mean that the company is efficient in the working capital management. Even though in the years 2008-2015 the company has had quite a short CCC (in some

years even negative), still it can be concluded that this is not the case in the recent years. In the recent years, the CCC has even overstepped a period of one month - in 2016,it is 32.29 and in 2018, 31.59.

The company must work with the aim of reducing this conversion period, because in any case, in order to be able to succeed in the long-term, first it must put its short-term matters in better condition. To decrease the CCC it means that a company has to try to decrease the time during which it has resources tied up in its working capital. By doing so, the company will start being released from inefficiencies that come due to the long cash conversion period.

One of the ways to reduce the CCC is to manage inventory better. As it can be seen, the case of this company supports the statements that other authors have said in their papers. As Sharma (2008, 32) states: "Inventory often makes up more than forty per cent of firm's current assets and therefore, requires close scrutiny". Indeed, as it can be seen, in this case, and in accordance with the author, inventory takes a significant portion of the current assets. Inventory's significant share in the current assets of the company is of great importance for the working capital and its management. Hence, CCC could be reduced by shortening the days inventory held (or, the inventory conversion period) by processing and selling the goods to the customers faster.

In this sense comes the need to implement a method that would help companies be predictive in their inventory management, by taking into account the plans of their clients. Companies do not need only to understand what their clients plan, but they also need to be proactive and act accordingly.

3.2 Inventory optimization methods

As it was brought out, knowing that inventory indeed is an important and significant part in the current assets of the company; the stimulus for improving the management of inventory is even bigger. One of the ways in which inventory can be understood and managed is if companies analyze their past trends and practices. However, having in mind the dynamic business environment, the need for collaboration in the supply chain, as well as the uncertainty that businesses face, it can be concluded that the past-looking method is not enough. What this master thesis has as one of its objectives, is to represent the inventory optimization with the two methods and point out the differences between these two methods.

3.2.1 Inventory classification using ABC-XYZ method

Continuing with providing the results of the analysis, and based on the previously explained methodology that would help answering the research questions, there is a need of classifying the company's inventory according to the ABC-XYZ method. In order for the classification and analysis to be compatible, in both methods a period of one and a half year is used. In the following analysis, a part of the overall inventory was taken into consideration. For doing this analysis, 77 items of company's inventory undergo the data analysis and calculations. Thereafter, once the most relevant and important ones are identified, they are chosen for further modeling and optimization. All the needed information was acquired from the company, thus the following data analysis and description were possible to be conducted.

3.2.1.1 ABC method: data description and analysis

As previously explained, in the ABC method for classification of inventory different authors take different criteria by which they go about classifying the inventory. In this particular case, since one of the most important parts of the thesis is the cost of investing into inventory, and how to save as much as possible and have as much benefits as possible, the cost of investing into inventory will be the determining criterion. When it comes to the classification, and based on the literature reviewed, the following tranches were identified. *A items* would represent 10% of the total number of items and account for approximately 70% of the value. *B items* represent 20-25% of total number of items that account for a value of 20%. *C items* take a big portion of the overall number of inventory (70%), but represent the remaining items' participation with 10% share in total value.

Having the data provided and criterion chosen, the total cost of investing in inventory needs to be identified and an explanation on how it was calculated should be provided. In order to distribute inventory by A, B and C groups, the share that each inventory item has in the overall total cost for the investment into inventory needs to be measured.

First of all, the total quantity that was acquired per each item in the specified period is available. Furthermore, the average final purchase price is also available, which is the average amount of money invested into each item of inventory, over the length of the period. By multiplying these two metrics, which were obtained (quantity purchased per item and average amount of money invested into the item over the period), the total cost of investing into each particular item is obtained. Once the total cost from all of the inventory items is summed together, the overall total cost for investing into inventory is obtained. By calculating each items individual total cost participation in the overall total cost for investing into inventory, each item's share in the overall

total cost is obtained. The share each inventory has in the overall cost of investing into inventory is sorted in a descending sequence in order to calculate the cumulative share in overall total cost, starting from the most valuable inventory item.

Therefore, the tranches for distribution of classes A, B and C became visible. Six items were distributed to class A and these take 72.6% of the value of total cost. Twelve items were distributed to class B taking 20.3% of the total value of total costs. The remaining 59 items were distributed to class C and they take 7.1% of the overall total costs (see App. 1).

Having conducted the data analysis and inventory classification, there are several conclusions that can be made within this part. The practical results showed great resemblance to the existing theory. Here, as well as in the theory and analyses conducted by different authors, class A represents those six inventory items, which have the greatest impact on value; but they are small in quantity. Nevertheless, the importance that these items have due to their significant impact on value requires that a special attention is paid to them and a control that is more regular is necessary. Thus, these items can be classified as the most valuable for the company. The 12 inventory items from class B require medium control since they have medium impact on value and take medium portion of the inventory quantity. In the end, the 59 class C items are those that take a big portion of the inventory, but have small impact on value. Thus, it can be concluded that the ABC classification showed the expected results and valuable items were successfully distinguished from the trivial ones.

3.2.1.2 XYZ method: data description and analysis

Once the ABC classification is obtained, in order to be able to proceed to the final ABC-XYZ method for classification of inventory, there is a need for the inventory items to be classified as X, Y or Z, according to the variability of their demand. Within this analysis, the quantity of items that were released i.e. their consumption, will represent their demand (Scholz-Reiter et al. 2011). In order to proceed with the calculations, the demand needs to be distributed monthly along the whole period. This distribution will be a base for the further calculation of the coefficient of variation. Based on the data provided, the standard deviation was calculated, which represents the variation of the demand. In order to obtain the coefficient of variation, the standard deviation is divided by the average value of demand per item. This way, the coefficient of variation is calculated and it represents the base for inventory items' classification.

According to the study conducted in the research of Kumar et al. (2017), the coefficient of variation (CV) is set at the level of being $CV \leq 0.3$ for class X, $0.3 < CV \leq 0.56$ for class Y, and

over 0.56 for class Z. To the class X, with coefficient of variation below 0.3, only one item was distributed. Nine items were distributed to the next class – class Y, with coefficient of variation between 0.3 and 0.56. All of the remaining and majority of items were distributed to class Z – the class with coefficient of determination above 0.56 (see App. 2).

As a conclusion, it can be stated that this classification successfully distinguishes items in classes according to their variability of demand. It is possible to identify items that have demand that is more regular and have some accuracy in forecasting – class X. For the class Y it can be stated that these items are characterized with less regular, or average, demand and average accuracy in forecasting. Class Z represents those items that are quite irregular and are difficult to forecast. The most attention should be paid to classes X and Y, since these items appear more often and have the possibility to affect some of the processes in inventory management.

3.2.1.3 Final classification

Now, that both of the analyses took place, their combination can be conducted. This type of analysis provides clearer view of the inventory the company manages and it can represent a base for getting to know how to manage it even better by knowing on which inventory items to focus. This statement comes from the fact that the company will be able to focus only on the important and relevant items that have high or medium impact on value, which have regular or average regularity of demand. This type of analysis is the foundation on which the following work should be made, and on which the company could attain future financial benefits and cost savings. Thus, the ABC labels are matched with the XYZ labels; hence, the following classes of items are created, each with its own characteristics (Scholz-Reiter et al. 2012; Bulinski, Waszkiewicz and Buraczewski 2013):

AX – items that have high impact on value and regular demand;

AY – items that have high impact on value and average regularity in demand;

AZ – items that have high impact on value and irregular demand;

BX – items with medium impact on value, but regular demand;

BY – items with medium impact on value and average regularity in demand;

BZ – items with medium impact on value and irregular demand;

CX – items with smallest impact on value and regular demand;

CY – items with smallest impact on value and average regularity of demand;

CZ – items with smallest impact on value and irregular demand.

The result of this analysis and classification showed that the majority of ASK-Roentgen's X-ray film type of inventory belongs to the class CZ. None of the items belongs to class CX, CY or

AX. One item belongs to class BX, four to BY and seven to BZ. Five items belong to the classes AY and one to class AZ.

	A	B	C	Grand Total
X		1		**1**
Y	5	4		**9**
Z	1	7	59	**67**
Grand Total	**6**	**12**	**59**	**77**

Table 3. Number of items per class according to ABC-XYZ calculations

Source: Created by author based on the conducted ABC-XYZ classification

The conducted inventory analysis is indicative of the practical application of the ABC-XYZ analysis. The data analysis helped in distinguishing the items that need further attention and more control, over the items that are less relevant and there is no particular need for considering them when modeling. Moreover, by combining ABC and XYZ analyses, stock management policies, systems and procedures can be set, taking into account both demand volatility and the value that each item brings in the investments into inventory. However, maybe one of the most important things that can be drawn as a conclusion of this type of analysis is the possibility to have a base on which the research would continue. From the 18 most important items, 4 were excluded because they are shown in m^2. Thus, they are excluded in order to have the analysis based on compatible measures of inventory items – number of pieces. Having these items identified, the company will be able to focus on reducing the costs, optimizing the inventory, and having financial benefits.

Additionally, it is important to mention that the inventory items with the following notations were classified as the most important: 28LUZ, EB96A, 27J78, 3ZUYV, 3ZUVP, HNLY6, 3ZUWR, HNKDU, 35TBN, 3W54O, 38WRN, 35TAL, 28TSU, 3ZUPC. In order not to disclose the actual names of the inventory items, the codes were set by the case study company, and they will continue to be used in the following parts of the master thesis.

3.2.2 The past-looking model for inventory optimization

At this point of calculations done and results presented, the research should continue getting closer to the core idea of the master thesis. Once the inventory is classified and the most important items are identified, the research should be directed to the implementation of the proposed inventory optimization methods. Based on the secondary data analysis and calculations done, a past-looking model could be created. The past-looking model is based on an existing methodology for calculation of the metrics contained within. The model has the optimal inventory level as its main

end-result. In order to determine this level of inventory and to explain the inventory management, several metrics, or variables, need to be identified and calculated. The model would be a representation of the optimal inventory level, through the establishment of all relevant parameters related to the inventory management. A general form of the model was presented in the second chapter. Thus, the calculations were applied in order to implement practically the methodology of the model into the research.

3.2.2.1 Safety stock

The importance of safety stock was addressed in more detail in the second chapter, alongside the explanation of the methodology. It is very important for companies to keep safety stock in order to be able to respond to the demand in the short-term. Another very important thing is to set the safety stock level correctly. In that sense, calculations of safety stock were done on the inventory items that were identified as the most important, for a period of one year. As it was previously stated, the variables that identify the safety stock are the service factor, standard deviation and supply lead-time (Tonetti 2019). Moreover, Wild (2002), Yadollahi, Aghezzaf and Raa (2017), Tonetti (2019) agree on the method of safety stock calculation. They all agree that the safety stock calculation formula should be as follows:

$$SS = z \times \sigma \times \sqrt{\frac{LT}{t}}$$

Where the following notations are used:

SS – safety stock;

z – service factor

σ – standard deviation;

LT – supply lead-time;

t – period.

The components of the formula need to be calculated. What follows are the explanations of the calculations of the service factor, standard deviation and supply lead-time.

Service factor. As previously explained, the service factor is determined based on the service level. Based on the studied literature, the service level was defined in the previous chapter as the average percentage of demand that the available inventory could fulfill. In accordance with ASK-Roentgen's representatives, the information about the service level percentages was obtained. For each of the 14 previously identified inventory items, the company shared their assessment for the service level percentage. Thereafter, the service factors needed to be identified. For example, for

the customer service factors and assuming a normal distribution (see App. 1), when stock is increased by one standard deviation, the service level increases to 84%. Similarly, when stock increases by two standards deviations, the service level increases to 97% and vice versa.

The model (shown below) represents the service levels and service factors for each inventory item. As it can be seen further, all of the inventory items have quite solid service levels. In fact, most of the items are categorized with service level of 99.99%, whereas several are categorized with a level of 90%. Based on the table (which belongs to Appendix 1), the identified service level can be connected with the service factors. Thus, the respective service factor for the service level of 99.99% is 4 standard deviations. For the service level of 90%, a service factor of 1.28 standard deviations was set. Hence, one of the inputs for safety stock calculation was identified.

Standard deviation. The chapter devoted to the methodology, proposed two metrics for measuring variability of demand. For this purpose, and as it was reasoned previously, the standard deviation was chosen as the most appropriate metric. Within this case study, the standard deviation was calculated for every item classified as important. The analysis is based on monthly fluctuations within a one-year period. Standard deviation is very important because many of the metrics connected to the safety stock calculation are adapted towards the standard deviation as a significant metric that shows the availability of demand.

Supply lead-time. Another important part of inventory management in general, and more precisely – of the safety stock, is the supply lead-time. As elaborated, it represents the period from an order-placement, to the receipt of ordered goods. After a discussion with company's representatives, the supply lead-time could be included. What is acquired as information regarding all of the important inventory items is the fact that the supply lead-time is 2-3 weeks, depending on the specifications of each order. In that sense, in order to obtain what is the supply lead-time on average and generally, for the entire inventory items classified as important, 17 days were taken as the average of 2 and 3 weeks. Conclusively, it can be said that it takes 17 days on average, for the ordered goods to arrive at ASK-Roentgen's warehouse. Since the standard deviation is established on a monthly basis, all of the other parts that form the safety stock calculation formula need to be transformed in a monthly basis. In that sense, supply lead-time is transformed in months i.e. $\mathrm{LT} = \frac{17}{31} = 0.55$ months.

Period. In order to make the entire analysis viable and compatible within the safety stock calculation and compatible to the additional aspects of inventory management, a compatible period

needs to be identified for the analysis (Wild 2002). Accordingly, the analysis is done based on monthly-distributed data, over a one-year period – from July 2018 to June 2019.

3.2.2.2 Reorder point

As covered in the second chapter, the reorder point (ROP) is the inventory level at which the company should place the order for stock replenishment. The ROP is calculated for each of the inventory items identified as important. Results are shown in the table presented further. The formula proposed by Ivanov, Tsipoulanidis and Schonberger (2017) is to be used:

$$ROP = LT \times Usage\ rate + SS$$

Once again, in order for the metrics to be compatible and to have the opportunity to work together, everything should be in the same period. In that sense, as it was already covered, there is the supply lead-time and the safety stock, which are both presented on a monthly basis. Therefore, the usage rate should also be presented in the same manner. Hence, the usage/consumption of an item within a year was divided by 12. This way, the monthly average usage rate of the items was acquired. Accordingly, the ROP was calculated, using the specified formula.

3.2.2.3 Economic order quantity (EOQ)

As the issue of when to order was covered, now the issue of how much to order needs to be taken into consideration. By identifying EOQ, the company identifies the quantity of inventory to be ordered for making the most beneficial tradeoff between the ordering and carrying costs. The formula for calculating the EOQ is adopted by many authors (Brealey, Myers and Allen 2011; Ivanov, Asadabadi 2016; Tsipoulanidis and Schonberger 2017; Paluch 2019), and it looks like:

$$\mathrm{EOQ} = \sqrt{\frac{2 \times \mathrm{D} \times \mathrm{O}}{\mathrm{C}}}$$

Where the following notations are used:

EOQ – Economic Order Quantity

D – annual demand

O – ordering cost

C – carrying cost

The data provided, contains the information about the annual demand as well as the costs.

Firstly, ordering costs are presented. They include the purchasing cost and additional costs related to the purchase.

Secondly, the carrying costs are calculated. As Dooley (2005) explains, carrying costs are the costs of holding inventory. They include the opportunity costs, warehouse expenses, risk costs and service costs. In the case of "ASK-Roentgen", carrying costs are identified as the sum of warehouse expenses and the opportunity cost, since no insurance or service costs were identified. Hence, the opportunity costs are set at the level of 12.5% of the ordering costs based on the logic that they are the possible alternative use of the money invested into inventory. In this sense, according to the information provided by the company's representatives, the 12.5% represents the average interest rate. In other words, if the company did not keep their money tied in inventory, it would have used it to pay off the debt with 12.5% interest rate. Additionally, the warehouse expenses are obtained based on information provided by the company's representatives. According to the information provided by the company representatives, these costs on average are €18,693.92 per year. Once these costs are distributed to 7,500 items daily in stock, the warehouse expense per item could be calculated – and it is €2.49. Finally, when opportunity costs and warehouse expenses are summed up, the carrying cost per unit and in Euros is obtained.

At this point, the annual demand, ordering costs and carrying costs are known and could be used for the EOQ calculation. Using the formula, the economic order quantity is obtained. Based on it, the company could also understand how many times per year to order, as well as on what period of days orders should be placed. Besides the EOQ being part of the model, the results from its entire analysis and calculations are shown as part of Appendix 4. The final model, containing all the metrics presented above, is represented as follows. The 14 items under analysis are separated in two tables with the purpose of being more clearly representative.

4.1)

Inventory item	28LUZ		EB96A		27J78		3ZUYV		3ZUVP		HNLY6		3ZUWR	
	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.
	8570	8249	11520	10827	5816	5465	1860	1751	4160	4304	2000	2759	3940	3903
Supply LT	0.55		0.55		0.55		0.55		0.55		0.55		0.55	
Usage rate		687		902		455		146		359		230		325
Standard dev.		303.14		270.63		238.18		86.50		116.28		118.43		140.75
ABC-XYZ class		**AY**		**AY**		**AY**		**AY**		**AZ**		**AY**		**BZ**
Service level		99.99%		99.99%		99.99%		99.99%		99.99%		90%		99.99%
Service Factor		4		4		4		4		4		1.28		4
EOQ		349		395		279		248		198		226		158
Reorder point		1275		1296		287		215		144		185		93
Safety Stock		898		802		37		18		18		7		13
Optimal balance		**1,585**		**1,704**		**492**		**377**		**248**		**332**		**159**

4.2)

Inventory item	HNKDU		35TBN		3W54O		38WRN		35TAL		28TSU		3ZUPC	
	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.
	4100	4614	9792	10195	541	505	4176	4715	7792	7629	629	653	670	862
Supply LT	0.55		0.55		0.55		0.55		0.55		0.55		0.55	
Usage rate		385		850		42		393		636		54		72
Standard dev.		106.71		216.26		86.22		117.06		175.79		21.06		53.48
ABC-XYZ class		**BY**		**BX**		**BZ**		**BY**		**BY**		**BY**		**BZ**
Service level		99.99%		99.99%		90%		99.99%		99.99%		99.99%		90%
Service Factor		4		4		1.28		4		4		4		1.28
EOQ		228		281		86		209		227		95		107
Reorder point		227		499		27		234		376		33		42
Safety Stock		17		34		4		18		27		3		3
Optimal balance		**401**		**883**		**46**		**411**		**663**		**58**		**74**

Table 4. Past-looking inventory optimization model (separated in two parts 4.1 and 4.2)

Source: Created by author

3.2.2.4 Concluding remarks on the resulting past-looking inventory optimization model

The model presented above, is the one that summarizes the inventory management parameters, which are representing the situation. By using this model, the company should be able to identify several important things. Firstly, their optimal balance of stock to be kept. The optimal stock balance is the inventory representing the sum of the average usage rate per month and the safety stock. Secondly, the safety stock, which would be the minimal level of inventory needed in order to avoid stock outs. Thirdly, the next level above the safety stock that should be a signal for an order to be placed, i.e. the reorder point. Finally, the optimal amount of items to be ordered, in order to have the ordering and carrying costs in balance.

The table below shows the results if the past-looking model for inventory optimization is used. What the past-looking model represents is the optimal functioning of the company, in terms of inventory management. If the company is to implement this model, it would incur savings in the form of not having money tied in inventory. In order to identify the amount of money that is tied in inventory and that would be released if this model is used, besides the identification of the optimal balance, the average monthly level of inventory held needs to be taken into account. Once the optimal balance is subtracted from the average monthly inventory level held, the differences (ΔQ_1) can be identified. When ΔQ_1 is multiplied by the ordering costs, as well as by the monthly carrying costs, the amount of money tied in inventory is identified for each item. Once they are summed

together, the total amount of money tied in inventory is calculated. If the company implements this past-looking model, it could have €673,029 available to operate with, as part of the working capital.

	28LUZ	EB96A	27J78	3ZUYV	3ZUVP	HNLY6	3ZUWR	HNKDU	35TBN	3W54O	38WRN	35TAL	28TSU	3ZUPC
Optimal balance	1,585	1,704	492	377	248	332	159	401	883	46	411	663	58	74
avg. monthly inv. level held	1,884	1,990	1,594	915	462	697	466	1,100	1,918	265	1,047	1,686	146	161
ΔQ_1	**298**	**286**	**1,102**	**538**	**214**	**364**	**307**	**698**	**1,035**	**218**	**636**	**1,023**	**88**	**86**
Ordering costs	242.45	182.17	163.60	169.49	154.29	89.35	161.73	48.17	18.71	222.60	27.68	14.51	124.97	102.14
Carrying costs	32.80	25.26	22.94	23.68	21.78	13.66	22.71	8.51	4.83	30.32	5.95	4.31	18.11	15.26
Money tied in inv.	**73,100**	**52,630**	**182,337**	**92,299**	**33,363**	**32,962**	**50,179**	**34,140**	**19,779**	**49,109**	**17,918**	**15,211**	**11,107**	**8,895**
Total	**€673,029**													

Table 5. Results of using past-looking inventory optimization model

Source: Created by author

This model would work well if the company was to function in some ideal conditions and all by itself, concerned only about how much stock is needed and when to have it in place. This inside-looking method of managing inventory has several missing areas, which need to be covered by presenting the new predictive method.

Firstly, as discussed in the previous two chapters of the master thesis, as part of a dynamic business environment, the company should collaborate in the supply chain. It should always tend to have synchronized processes with its suppliers and especially with its clients. As Holweg et al. (2005) state, the supplier (which in the case of this master thesis would be "ASK-Roentgen"), should be integrated in the client's inventory management on the operational level, aiming to implement this visibility of client's plans into their own supply operations, planning and budgeting. According to the authors, such collaboration would mean that the company is predictive and is prepared for the demand variability. Hence, what this type of collaboration represents is the successful linkage of the external demand and information about inventory, with the internal inventory management, planning and control.

Secondly, some of the parameters do not actually work in reality. For instance, as explained by Wild (2002), the EOQ is a parameter that does not work in reality. This is because this model supposes fixed ordering costs. In addition, if service levels are considered, it can be seen that the service factors are taken assuming a normal distribution, which is not the case in reality. Ruiz-Torres and Mahmoodi (2010), on the other hand, say that traditional models assume that the demand

has a normal distribution during the supply lead-time. As these authors review, the normal distribution is not able to represent the true condition in reality.

Based on everything covered before, it can be concluded that there is a need for introducing a new method for inventory optimization – one that will be predictive and forward-looking and that will make working capital proactive through the synchronization of processes.

3.2.3 Predictive inventory optimization methods

Even though the past-looking model has some advantages and benefits, still it is not enough. As previously mentioned, this model does not work well because of several reasons which were explained. What is the most important among them is the fact that the company is not alone in doing its business. It has its suppliers, as well as its clients, who are the intermediary with the end users.

The plans of the clients need to be included into the company's own planning. Companies need to collaborate and work as a synchronized system in order to get the best results. In this sense, the expected percentage of increase or decrease in demand (ΔD (%)) should be identified. In order to calculate this percentage the previously explained methodology was used. As mentioned, the company should not tend to collaborate with every client it has. Hence, data for 10 most important clients are taken into account.

The data represents the purchases from each client over the period of two years, from Q2 2018 to Q1 2020. In order to identify the expected increase or decrease in demand, the sum of purchases in one year (Q2 2018 – Q1 2019) would be compared with the sum of purchases in the second year (Q2 2019 – Q1 2020). For this purpose, with the help of the formula which was introduced in the second chapter, the percentage of increase or decrease in demand could be obtained:

$$\Delta D(\%) = \frac{\sum purchases\ Y2 - \sum purchases\ Y1}{\sum purchases\ Y1}$$

By using this formula, the percentage of increase or decrease in demand for every client was calculated. The resulting percentages coming from the implemented calculations are represented in the following table. Table 6 contains the specific expected change in demand for every client. The actual names of clients would not be disclosed, they would be named with numbers, starting from "Client 1" and finishing with "Client 10". Based on these results, the average expected increase or decrease in demand was obtained.

	ΔD(%)
Client 1	1.7728%
Client 2	13.9189%
Client 3	11.8732%
Client 4	12.2190%
Client 5	15.9337%
Client 6	73.7185%
Client 7	16.2182%
Client 8	16.6388%
Client 9	8.6338%
Client 10	3.5782%
Average for all clients	**17.45%**

Table 6. Expected increase or decrease in clients' demand

Source: Created by author

According to this calculation, the percentage of 17.45% was identified – representing an expected increase in the demand by 17.45%. This is the average increase for all of the 10 clients in question. Thus, this expected demand increase needs to be incorporated into the model, in order to take into account clients' plans. Additionally, by doing so, the company would be able to cope with the uncertainties related to variability of demand. So, in order for the company to be able to support their clients' business, first it needs to acquire the information about the expected changes in demand, coming from the changes in the client's demand from the end-users.

This method of inventory optimization would be applied to the existing model, in order to improve it. Hence, once the percentage was identified, it needs to be applied to the past-looking inventory optimization model.

The percentage of 17.45% was incorporated to the released items, which are distributed monthly. Doing this, the company would be taking into account the expected increase in demand. Automatically, even though they are calculated in the same way as explained before, the incorporation of ΔD (%), would mean that the usage rate, standard deviation, EOQ (see App. 5), reorder point and safety stock – they would all change, because now they also incorporate this percentage of increase in demand.

As a result, the final optimal balance to be held has also changed, in relation to the past-looking inventory optimization model. What can be concluded also is that if the company does not expand its past-looking inventory optimization model, the demand could not be met, because the company would not be prepared for such an increase.

The changes in the model are presented in the following tables, they being two parts off the same expanded model.

7.1)

MODEL 1	28LUZ		EB96A		27J78		3ZUYV		3ZUVP		HNLY6		3ZUWR	
	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.
Total Q	8570	9688	11520	12716	5816	6419	4160	5055	2000	3240	3940	4584	1860	2057
Supply LT	0.55		0.55		0.55		0.55		0.55		0.55		0.55	
Usage rate		807		1060		535		421		270		382		171
Standard dev.		356.04		317.86		279.74		136.58		139.09		165.31		101.59
ABC-XYZ class		**AY**		**AY**		**AY**		**AY**		**AZ**		**AY**		**BZ**
Service level		99.99%		99.99%		99.99%		99.99%		99.99%		90%		99.99%
Service Factor		4		4		4		4		4		1.28		4
EOQ		378		428		303		269		214		245		171
Reorder point		1497		1523		337		252		170		218		110
Safety Stock		1055		942		43		21		22		8		16
Optimal balance		**1,862**		**2,001**		**578**		**442**		**292**		**390**		**187**

7.2)

MODEL 1	HNKDU		35TBN		3W54O		38WRN		35TAL		28TSU		3ZUPC	
	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.
Total Q	4100	5419	9792	11974	541	593	4176	5538	7792	8960	629	767	670	1012
Supply LT	0.55		0.55		0.55		0.55		0.55		0.55		0.55	
Usage rate		452		998		49		461		747		64		84
Standard dev.		125.33		254.00		101.26		137.49		206.47		24.74		62.81
ABC-XYZ class		**BY**		**BX**		**BZ**		**BY**		**BY**		**BY**		**BZ**
Service level		99.99%		99.99%		90%		99.99%		99.99%		99.99%		90%
Service Factor		4		4		1.28		4		4		4		1.28
EOQ		248		305		93		227		246		103		116
Reorder point		267		587		32		274		441		39		49
Safety Stock		19		39		5		21		32		4		3
Optimal balance		**471**		**1,037**		**54**		**483**		**779**		**68**		**87**

Table 7. Inventory optimization model with a predictive inventory optimization method

Source: Created by author

3.2.3.1 Concluding remarks on the resulting predictive inventory optimization method

The implementation of the predictive inventory optimization method into the model for inventory optimization would mean that the metrics for identifying the inventory management would change in value. Thus, analogically – there are changes in the usage rate and standard deviation, as well as the EOQ, reorder point and safety stock. That happens as a result of the clients' plans being included into the process of inventory management. Additionally, the optimal balance would change as well, as a result of this implementation.

Using the predictive inventory optimization method means that the company is collaborative in the supply chain, it takes into account their clients' plans and is proactive in its inventory management. Because of that, again, the amount of money tied in inventory needs to be calculated. This represents the financial benefit that the company would have if it uses the proposed method for predictive optimization of inventory.

Following the previous procedure, if the optimal balance is subtracted from the actual average monthly level of inventory held, the differences could be identified (ΔQ_2). These differences are the base on which the amount of money tied in inventory would be calculated. Now, when ΔQ_2 is multiplied by the ordering costs and the monthly carrying costs, the amount of money tied in inventory is identified for each item. When summarized, the total amount of money tied in inventory is calculated. In other words, it could be explained by saying that had the company worked by the predictive inventory optimization method in its planning and management, those differences would not occur, so that amount of money would be free for use, as part of the working capital. In this case, the amount of money that was tied in inventory is €493.816.

	28LUZ	EB96A	27J78	3ZUYV	3ZUVP	HNLY6	3ZUWR	HNKDU	35TBN	3W54O	38WRN	35TAL	28TSU	3ZUPC
Optimal balance	1,862	2,001	578	442	292	390	187	471	1,037	54	483	779	68	87
avg. monthly inv. level held	1,884	1,990	1,594	915	462	697	466	1,100	1,918	265	1,047	1,686	146	161
ΔQ_2	**22**	**-12**	**1,016**	**473**	**170**	**306**	**279**	**628**	**881**	**210**	**564**	**907**	**78**	**73**
Ordering costs	242.45	182.17	163.60	169.49	154.29	89.35	161.73	48.17	18.71	222.60	27.68	14.51	124.97	102.14
Carrying costs	32.80	25.26	22.94	23.68	21.78	13.66	22.71	8.51	4.83	30.32	5.95	4.31	18.11	15.26
Money tied in inv.	**5,272**	**-2,160**	**168,117**	**81,029**	**26,600**	**27,716**	**45,629**	**30,719**	**16,834**	**47,288**	**15,897**	**13,491**	**9,834**	**7,551**
Total	**€493,816**													

Table 8. Results of using predictive inventory optimization methods

Source: Created by author

DISCUSSION

As it was mentioned in the previous chapters, it is very important for companies to collaborate in the supply chain, share information, incorporate each other's plans and adjust to them. Holweg et al. (2005) found out that the companies are good in exchanging information, but usually the collaboration stops here. The planning process is still not changed and the possibility to have some radical changes for the better within the supply chain is small. As it would be explained, the important thing is to adjust the planning decisions and make them work in synchronization with the clients'. Only by incorporating the information about the clients' expected demand from the end users, would the companies become able to synchronize their processes.

In line with the research, four research questions were established. For each of these research questions, a proposition was made, which was to be proven through the implementation of the proposed methodology. In this sense, each of the research questions with its appropriate proposition will be addressed within this part of the master thesis.

The first research question was posed: *How can a company make its management of working capital proactive, through the better understanding and management of inventory?* In order to answer this research question, a proposition was made that: *A company can make its working capital management proactive, if it collaborates with clients and includes their plans into its inventory optimization and management.* First of all, in order to provide an answer, the *proactive* working capital management needed to be defined. In this sense, by proactive working capital management, it is meant that the company takes into consideration the plans its clients have, but it is also acting upon the gathered information, i.e. it adjusts its inventory levels. As it can be seen from the results shown in the third chapter, they prove this proposition. In fact, within the second model – where the predictive inventory optimization method is applied, this can be seen. Indeed, once the company had started the collaboration with clients and once it had included their plans into its own inventory management and optimization, it had the opportunity of being proactive. Hence, the implementation of clients' plans, and the predictive attitude towards inventory management, has allowed the company to make adjustments within its own inventory levels. Adjustments occurred also in the metrics determining the inventory management, as EOQ, reorder point and safety stock. As a result, the optimal balance was adjusted, once the clients' plans were incorporated. This allows the company to be able to answer to the increased demand which their clients would have. By satisfying the demand, the company is interconnected into the operations of clients, thus is able to

support their business and ongoing activities. By being proactive in inventory management, the company is proactive in the working capital management as well; having in mind the significantly big percentage that inventory holds in the current assets of the company. The methodology used for obtaining results showed that the first proposition could be proved, and indeed a company can make its working capital management proactive, if it collaborates with clients and includes their plans into its inventory optimization and management.

The second research question was set as follows: *How can a company adjust its inventory towards the plans of their clients?* For providing an answer to this research question, a proposition was identified, that: *A company can adjust its inventory to the clients' plans if it implements a predictive inventory optimization.* This proposition, as well as the previous one, was proved by the methodology and obtained results. In fact, as it can be seen, companies need to collaborate with their clients and understand the percentage of increase or decrease in demand, thus adjusting their own inventory. By going through the establishment of this collaboration, companies would become predictive in their operations, inventory planning and budgeting. Therefore, once the prediction is obtained and the percentage of increase or decrease of demand is known, companies could proceed to the adjusting of their own inventory. In this sense, companies would be able to always answer to the needs of their clients, while implementing the information provided by them within its inventory management and optimization. This way, the second proposition, related to the second research question, was proved.

The third research question was: *What benefits proactive working capital management can bring to a company?* The following proposition was set in order to help in answering the research question: *The proactive working capital management through a predictive inventory optimization method will mean costs reduction*. As it could be concluded from the third chapter, where the results are presented, the predictive inventory optimization method truly means cost reduction i.e. indeed the model which has this method incorporated reduces costs. If the company follows the proposed model, the ordering costs and the carrying costs for the unnecessary items might not occur. So, this model allows looking at this amount of money as a cost reduction. Another point of view for it could be that it represents the amount of money that the company has tied in inventory. If the company could be able to be predictive and proactive i.e. understand and implement companies' plans into their inventory optimization and management, it would be able to have this money as part of their available working capital. The results provided in the third chapter, speak in favor to the proving of the third proposition.

The final research question posed was posed as: *How does the predictive inventory optimization method differ from the past-looking one?* Accordingly, the final proposition was introduced, saying that: *The proposed predictive inventory optimization method brings more benefits for the company, instead of the past-looking one*. Coming from this point of view, it can be said that the most important part of the analysis is addressed by this research question and proposition. In this sense, it can be concluded that the plain past looking inventory optimization model differs from the one where client's plans are incorporated. Several important points need to be emphasized. First of all, if the first model is taken into account, it can be seen that it could have €673,029 available to operate with, as part of the working capital. On the other hand, if the second model is taken into account, where clients' plans are included, the amount of money that was tied in inventory is €493.816, thus, by using this model, the company would have the amount of €493.816 available as part of the working capital. If these two amounts of money are considered as a plain number, it could be said that the predictive inventory optimization method releases less money tied in inventory. However, it must be stated, that this matter cannot be looked from that one perspective only. In fact, the main point to be stressed is that by using the predictive inventory optimization method, instead of the past-looking, the company will satisfy more of the clients' demand. This is why the amount may be smaller, because now the company would obtain more inventory, therefore incurring more costs for its obtainment – but this would not be unnecessary. On the contrary, the inventory is obtained on the basis of the analysis, which showed that the demand will increase by 17.45%. This is why the company needs to take this into account and adjust its inventory levels accordingly. Secondly, within this master thesis, it was stressed how important it is to collaborate in the supply chain, in this sense, it can be said that an additional benefit that makes the predictive inventory optimization more beneficial than the past-looking inventory optimization model is the establishment of collaboration in the supply chain. This collaboration could make companies' businesses synchronized; therefore the supplier i.e. "ASK-Roentgen" would be integrated in the client's inventory management, through implementing client's plans into their own supply operations, planning and budgeting. Finally, additional benefit in favor of the predictive inventory optimization method is that by using this method, the company is decreasing the uncertainty and variability of demand. In that sense, it can be said that there would practically be no lost sales, because the company would always be able to respond to the demand needed. This is a benefit that comes from knowing clients' plans in advance, i.e. the benefit of being predictive. The proposed aspects prove the proposition that the predictive inventory optimization method which is applied to

the model, has more benefits instead of the past-looking model which does not include clients' plans.

Managerial implications. The subject of research within this master thesis is surely very important from practical point of view as well. As authors found out and as it was covered in the literature review, inventory has become one of the largest resource and asset for many companies, so it is very important to understand companies' clients and learn how a company can be predictive in the optimization of its inventory.

Inventory often takes a big portion of the working capital, thus companies can relate to this situation and use the work done in this master thesis for the improvement of their operations and financial performance. Since it was proved that the better inventory and working capital management lead to better financial performance, companies could benefit from the implementation of this method for inventory optimization. The main preoccupation of this study was related to the amount of inefficiencies companies could avoid and to the amount of additional benefits that would occur as a result of the proactive working capital management. This definitely applies to the cases in the business environment, where inventory plays quite a significant role, hence, having a method on how to better manage and optimize it, would be very beneficial to today's business world. Inventory takes a significant portion of companies' current assets. Therefore, adapting the proposed predictive method through information gathering by collaboration in the supply chain, was proved to be a good tool for predictive inventory optimization.

Additionally, as it was mentioned previously in the other parts of the master thesis, one of the crucial things in the dynamic business environment is the collaboration in the supply chain. Managers, who would implement this methodology into their businesses, would experience the benefits that this collaboration offers. Not only would the company be collaborative and support clients' processes and business in general, but will also be able to better plan its own activities. Using collaboration in the supply chain as a tool for inventory optimization and prediction, would help companies better plan their operations.

Possible limitations from the research method. When talking about case studies, it can often be concluded that they have a limitation in terms of providing little basis for scientific *generalization.* There is often the question about how the findings can be generalized from a single case.

However, according to Yin (2014), on the other hand there is the experiment as a research strategy, which can also often provide facts based on a single experiment. While they are generalized by conducting multiple set of experiments, case studies are generalized in a different manner.

For case studies, the worst thing to do when trying to generalize the results is to do a statistical generalization. In this sense, the author explains a term called "analytic generalization", where a theory that was explored and developed previously is the base for comparison with the case study's empirical results. In terms of the research conducted in this master thesis, this proves that generalization would not be an issue. In fact, the author of this master thesis is trying to develop the methodology for the past-looking model by implementing clients' plans in it. The new predictive inventory optimization methods are compared with the existing one, in order to find out if some discrepancies and financial benefits exist.

Another limitation of the case study as a research strategy is that it is often perceived as a strictly qualitative one. Saunders, Lewis and Thornhill (2016) make a clear distinction about what is the difference between a *qualitative and quantitative research*. According to them, in order to distinguish between these two types of research, the non-numeric data should be distinguished from the numeric data. In other words, the authors say that the quantitative research is the research related with data collection techniques or data analysis procedures that create or use numerical data. Unlike it, the qualitative research creates or uses non-numerical data through the process of data collection or data analysis.

Thus, it can be seen that the strictly qualitative research is not the case within this master thesis. In fact, as Yin (2014) says, case studies should not be related only with qualitative research. Actually, they are also quantitative, thus, this should not represent an issue for this research. Moreover, as explained before, by using the data about clients' purchase plans the information that will be obtained is strictly quantitative, which is another prove that this limitation is authentic for every case in particular. What additionally speaks in favor of the appropriateness of quantitative research is the fact that it was done based on numeric data that was used and generated throughout the research process. However, in order to connect the research questions to the conclusions, qualitative i.e. non-numeric research must be conducted too. Having all of this in mind, the research methodology within this master thesis could be specified as a mixture of both quantitative and qualitative research.

CONCLUSION

Working capital management, as well as the inventory management in particular, are very important because they have an influence on the profitability, and this is an aspect that has been studied over the years. Many authors address this causal relationship, therefore explaining the peculiarities of each of them. However, a conclusion was made that it is not enough to look at the inventory and working capital only from the perspective of their relation with profitability.

Understanding the interconnections between inventory management and working capital management, we identified the details of these components. As many authors proved, inventory often takes a big portion of the current assets, and this makes it a significant part of the working capital and is important for its management. Thus, it can be concluded that if a company directs its efforts towards better management of the inventory, it would improve its working capital management as well.

In this sense, within this master thesis, the spotlight is addressed to the importance of having predictive inventory optimization method, which would be applied to the past-looking model for inventory optimization. The importance of predictive inventory management applies to the modern environment, where companies have to adapt to very high dynamics, uncertainty and change.. By implementing a method for predictive inventory optimization and management, companies are reducing these uncertainties and become more in control of the situation, being able to respond better to the demand that also varies. Therefore, within this master thesis, a method is proposed about how the company can be predictive in its inventory optimization and management. This method is about including the plans that companies' clients have, into the company's own inventory planning, management, control and optimization.

By being predictive in the inventory optimization, the company would become able to be proactive in its working capital management. In other words, the company could incorporate their clients' plans into their own plans, therefore being able to act upon the acquired information. Once the plans about the demand increase or decrease are taken into consideration, companies would be able to get rid of inefficiencies and would have less money tied in inventory.

In that sense, a case study analysis was conducted, the model and methods are applied to the case of a particular company. The important part of the overall inventory was identified, and thereafter, using the ABC-XYZ analysis the most important inventory items were specified. For each of these items, inventory management metrics were calculated in order to construct the initial past-looking model. The expected increase or decrease in clients' demand was added to the existing

model, in order to implement the predictive way of inventory optimization. As a result, the new, predictive inventory optimization model was presented.

What is important within this research, are the *key findings* which would be essential. These findings are based on the research questions and study propositions. Moreover, they show that the research objectives set at the beginning of the master thesis, are met. First of all, it was proven that a company can make its working capital management proactive, if it collaborates with clients and includes their plans into its inventory optimization and management. Additionally, it was found that a company can adjust its inventory to the clients' plans if it implements a predictive inventory optimization. What was additionally proven is the fact that the proactive working capital management through a predictive inventory optimization method would mean costs reduction and less money tied in inventory. Finally, another finding is that the proposed predictive inventory optimization method brings more benefits for the company, instead of the past-looking one, in terms of not keeping unnecessary inventory, being more collaborative in the supply chain and making several supply chains synchronized, as well as avoiding lost sales.

The essence of this research is the attempt to fill in the research gap about the importance of being predictive in inventory optimization, by being collaborative in the supply chain, while shifting the management of working capital to more proactive. The previously mentioned key findings represent the main aspects that speak in favor of these things and that are supposed to support the importance of this research.

The contribution that this master thesis would have lies in the fact that very often researchers do not take into account the importance of being predictive in inventory optimization through collaboration in the supply chain and hence becoming proactive in working capital management, in terms of understanding the plans that companies' clients have. In this sense, a method is proposed about the incorporation of the expected increase or decrease in demand, based on the plans of clients.

What is very important is the fact that this research is especially significant from practical point of view as well. As mentioned earlier, inventory plays a significant role in companies' current assets or working capital. Therefore, using this predictive method for its optimization and management, which would bring benefits, is of crucial importance from the practical point of view. The managerial implications of this master thesis are truly important, because of inventory's big portion in current assets and its big part in the working capital. Implementing a new predictive

method of managing it, would be beneficial for any firm, based on the findings mentioned above. Moreover, having in mind the increasing importance of collaboration in the supply chain is an additional aspect in terms of the managerial implications. By implementing this method and model, the companies would become more open and collaborative, and this – as seen in the findings of this master thesis – is something that is very valuable in today's dynamic business environment.

For further research, the current study may continue and be expanded to the other components of working capital, besides inventory. Methods for the optimization of some of these components may also be proposed and developed.

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APPENDICES

Appendix 1: Customer service factor

Desired service level (% periods without stockout)	Multiply SD by	Multiply MAD by
50.00	0.00	0.00
75.00	0.67	0.84
79.00	0.80	1.00
80.00	0.84	1.05
84.13	1.00	1.25
85.00	1.04	1.30
89.44	1.25	1.56
90.00	1.28	1.60
93.32	1.50	1.88
94.00	1.56	1.95
94.52	1.60	2.00
95.00	1.65	2.06
96.00	1.75	2.19
97.00	1.88	2.35
97.72	2.00	2.50
98.00	2.05	2.56
99.00	2.33	2.91
99.18	2.40	3.00
99.50	2.57	3.20
99.70	2.75	3.44
99.86	3.00	3.75
99.90	3.09	3.85
99.93	3.20	4.00
99.99	4.00	5.00

Source: Wild (2002)

Appendix 2: ABC classification

Item	Unit	Quantity	Average final purchase price	Total Cost	% in total cost	Cumulative share in total cost	Group (A, B, C)
28LUZ	pcs	13,164	242.45	3,191,611.80	22.5370%	22.5370%	**A**
EB96A	pcs	17,091	182.17	3,113,467.47	21.9852%	44.5221%	**A**
27J78	pcs	9,928	163.60	1,624,220.80	11.4691%	55.9912%	**A**
3ZUYV	pcs	7,077	169.49	1,199,480.73	8.4699%	64.4611%	**A**
3ZUVP	pcs	4,207	154.29	649,098.03	4.5835%	69.0446%	**A**
HNLY6	pcs	5,669	89.35	506,525.15	3.5767%	72.6213%	**A**
3ZUWR	pcs	2,315	161.73	374,404.95	2.6438%	75.2651%	**B**
HNKDU	pcs	6,779	48.17	326,544.43	2.3058%	77.5710%	**B**
4NWJS	*m2*	*25,619.90*	*12.49*	*319,992.60*	*2.2596%*	*79.8305%*	***B***

4NWHQ	*m2*	*22,923.07*	*12.49*	*286,309.17*	*2.0217%*	*81.8523%*	***B***
35TBN	pcs	15,248	18.71	285,290.08	2.0145%	83.8668%	**B**
4N5SB	*m2*	*19,227.70*	*13.13*	*252,459.65*	*1.7827%*	*85.6495%*	***B***
4N5R8	*m2*	*17,203.73*	*13.17*	*226,573.10*	*1.5999%*	*87.2494%*	***B***
3W54O	pcs	879	222.60	195,665.40	1.3817%	88.6310%	**B**
38WRN	pcs	7,019	27.68	194,285.92	1.3719%	90.0029%	**B**
35TAL	pcs	12,432	14.51	180,388.32	1.2738%	91.2767%	**B**
28TSU	pcs	994	124.97	124,220.18	0.8772%	92.1539%	**B**
3ZUPC	pcs	1,045	102.14	106,736.30	0.7537%	92.9076%	**B**
3J1SD	pcs	783	118.99	93,169.17	0.6579%	93.5655%	**C**
3J1SD	pcs	783	118.99	93,169.17	0.6579%	94.2234%	**C**
28TW3	pcs	431	209.24	90,182.44	0.6368%	94.8602%	**C**
3J1EL	pcs	211	372.21	78,536.31	0.5546%	95.4147%	**C**
3ZU46	pcs	227	265.18	60,195.86	0.4251%	95.8398%	**C**
4N4LR	pcs	352	159.77	56,239.04	0.3971%	96.2369%	**C**
29MKR	pcs	415	134.95	56,004.25	0.3955%	96.6324%	**C**
3J1JT	pcs	278	197.92	55,021.76	0.3885%	97.0209%	**C**
3CMHM	pcs	884	58.81	51,988.04	0.3671%	97.3880%	**C**
3J1KV	pcs	784	56.28	44,123.52	0.3116%	97.6996%	**C**
3J1CG	pcs	164	242.93	39,840.52	0.2813%	97.9809%	**C**
3XKVZ	pcs	450	84.76	38,142.00	0.2693%	98.2502%	**C**
28T1C	pcs	58	638.11	37,010.38	0.2613%	98.5116%	**C**
293UB	pcs	121	270.99	32,789.79	0.2315%	98.7431%	**C**
29MOZ	pcs	72	208.08	14,981.76	0.1058%	98.8489%	**C**
4OB6X	pcs	57	260.51	14,849.07	0.1049%	98.9538%	**C**
EBMBU	pcs	217	59.09	12,822.53	0.0905%	99.0443%	**C**
27KK1	pcs	49	249.43	12,222.07	0.0863%	99.1306%	**C**
29MS8	pcs	43	270.50	11,631.50	0.0821%	99.2127%	**C**
37S2J	pcs	249	44.79	11,152.71	0.0788%	99.2915%	**C**
35WGB	pcs	784	10.41	8,161.44	0.0576%	99.3491%	**C**
29MWH	pcs	12	634.71	7,616.52	0.0538%	99.4029%	**C**
3J1Q8	pcs	11	668.69	7,355.59	0.0519%	99.4549%	**C**
3AOQU	pcs	19	369.54	7,021.26	0.0496%	99.5044%	**C**
293q2	pcs	22	278.88	6,135.36	0.0433%	99.5478%	**C**
4OA1J	pcs	40	144.01	5,760.40	0.0407%	99.5884%	**C**

3ZURG	pcs	33	151.52	5,000.16	0.0353%	99.6237%	**C**
27LH1	pcs	11	401.10	4,412.10	0.0312%	99.6549%	**C**
3J1HR	pcs	62	67.92	4,211.04	0.0297%	99.6846%	**C**
EE39G	pcs	25	133.14	3,328.50	0.0235%	99.7081%	**C**
375KX	pcs	27	118.56	3,201.12	0.0226%	99.7307%	**C**
FT5AL	pcs	90	32.55	2,929.50	0.0207%	99.7514%	**C**
3J1WM	pcs	12	236.92	2,843.04	0.0201%	99.7715%	**C**
3GTOS	pcs	8	343.62	2,748.96	0.0194%	99.7909%	**C**
284GE	pcs	7	389.21	2,724.47	0.0192%	99.8101%	**C**
3XJ7K	pcs	50	52.49	2,624.50	0.0185%	99.8287%	**C**
3EZUE	pcs	43	57.12	2,456.16	0.0173%	99.8460%	**C**
3XKG5	pcs	25	91.74	2,293.50	0.0162%	99.8622%	**C**
3JUDS	pcs	5	374.85	1,874.25	0.0132%	99.8755%	**C**
3J1DJ	pcs	12	137.77	1,653.24	0.0117%	99.8871%	**C**
3UEPB	pcs	15	103.49	1,552.35	0.0110%	99.8981%	**C**
3XKNJ	pcs	25	61.94	1,548.50	0.0109%	99.9090%	**C**
3M2HM	pcs	97	15.72	1,524.84	0.0108%	99.9198%	**C**
3EZVG	pcs	25	59.29	1,482.25	0.0105%	99.9303%	**C**
3S5S1	pcs	25	58.32	1,458.00	0.0103%	99.9406%	**C**
3JSJU	pcs	4	301.23	1,204.92	0.0085%	99.9491%	**C**
28TKD	pcs	15	72.91	1,093.65	0.0077%	99.9568%	**C**
34AWF	pcs	11	91.23	1,003.53	0.0071%	99.9639%	**C**
3XJVV	pcs	11	79.00	869.00	0.0061%	99.9700%	**C**
3Q21O	pcs	9	90.64	815.76	0.0058%	99.9758%	**C**
3Q5QF	pcs	2	404.74	809.48	0.0057%	99.9815%	**C**
3ZUTL	pcs	4	170.93	683.72	0.0048%	99.9863%	**C**
28UQU	pcs	4	135.43	541.72	0.0038%	99.9901%	**C**
3BONW	pcs	6	61.69	370.14	0.0026%	99.9927%	**C**
3ZUUN	pcs	2	176.17	352.34	0.0025%	99.9952%	**C**
29DVG	pcs	1	344.55	344.55	0.0024%	99.9977%	**C**
3AOKH	pcs	1	141.52	141.52	0.0010%	99.9987%	**C**
28TOM	pcs	1	119.37	119.37	0.0008%	99.9995%	**C**
29L7Y	pcs	1	68.99	68.99	0.0005%	100.0000%	**C**
Σ				**14,161,681.71**	**100.0000%**		

Appendix 3: XYZ classification

Item	Units	Standard deviation	Average demand	Coefficient of variation	Group (X,Y,Z)
35TBN	pcs	246.3834	876.7222	0.2810	**X**
EB96A	pcs	302.8418	943.6111	0.3209	**Y**
HNKDU	pcs	119.2392	369.7222	0.3225	**Y**
3ZUYV	pcs	134.6181	398.1667	0.3381	**Y**
35TAL	pcs	245.9033	694.6667	0.3540	**Y**
38WRN	pcs	144.3389	382.2222	0.3776	**Y**
28LUZ	pcs	271.0772	683.2222	0.3968	**Y**
27J78	pcs	227.5734	530.6667	0.4288	**Y**
28TSU	pcs	27.91748	56.94444	0.4903	**Y**
HNLY6	pcs	162.661	313.0556	0.5196	**Y**
3ZUWR	pcs	76.21625	133.8333	0.5695	**Z**
37S2J	pcs	6.69162	11.66667	0.5736	**Z**
3ZUVP	pcs	147.4602	252.0556	0.5850	**Z**
3J1SD	pcs	23.29892	38.22222	0.6096	**Z**
3J1SD	pcs	23.29892	38.22222	0.6096	**Z**
4N4LR	pcs	12.63263	20.16667	0.6264	**Z**
28TW3	pcs	16.96729	24	0.7070	**Z**
EBMBU	pcs	9.671295	12.72222	0.7602	**Z**
3ZUPC	pcs	47.12867	58	0.8126	**Z**
35WGB	pcs	36.64073	42.88889	0.8543	**Z**
3M2HM	pcs	4.739185	5.388889	0.8794	**Z**
29MKR	pcs	20.0847	22.77778	0.8818	**Z**
3CMHM	pcs	45.76419	50.16667	0.9122	**Z**
FT5AL	pcs	4.760952	5	0.9522	**Z**
3J1CG	pcs	8.51723	8.888889	0.9582	**Z**
3J1JT	pcs	15.3442	15	1.0229	**Z**
3ZURG	pcs	1.940472	1.888889	1.0273	**Z**
29MS8	pcs	2.581989	2.333333	1.1066	**Z**
3UEPB	pcs	0.993808	0.888889	1.1180	**Z**
3ZU46	pcs	13.29683	11.83333	1.1237	**Z**
3J1KV	pcs	56.07336	45.33333	1.2369	**Z**

28T1C	pcs	3.41565	2.666667	1.2809	**Z**
3EZUE	pcs	3.638359	2.388889	1.5230	**Z**
34AWF	pcs	0.950958	0.611111	1.5561	**Z**
3J1Q8	pcs	0.950958	0.611111	1.5561	**Z**
3J1EL	pcs	18.98318	12.16667	1.5603	**Z**
3W54O	pcs	72.11411	44.33333	1.6266	**Z**
27LH1	pcs	1.20185	0.666667	1.8028	**Z**
27KK1	pcs	5.123475	2.833333	1.8083	**Z**
4NWHQ	*m2*	*2382.546*	*1273.504*	*1.8709*	**Z**
4NWJS	*m2*	*2662.845*	*1423.328*	*1.8709*	**Z**
3J1WM	pcs	1.290994	0.666667	1.9365	**Z**
284GE	pcs	0.755637	0.388889	1.9431	**Z**
3J1DJ	pcs	1.374369	0.666667	2.0616	**Z**
3XKVZ	pcs	53.35937	25	2.1344	**Z**
4N5R8	*m2*	*2137.169*	*955.7627*	*2.2361*	**Z**
4N5SB	*m2*	*2388.6*	*1068.205*	*2.2361*	**Z**
3BONW	pcs	0.650261	0.277778	2.3409	**Z**
3JUDS	pcs	0.650261	0.277778	2.3409	**Z**
29MWH	pcs	1.563472	0.666667	2.3452	**Z**
29MOZ	pcs	9.700452	4.111111	2.3596	**Z**
3AOQU	pcs	2.504933	1.055556	2.3731	**Z**
3GTOS	pcs	1.06574	0.444444	2.3979	**Z**
4OA1J	pcs	6.803231	2.777778	2.4492	**Z**
375KX	pcs	4.003471	1.5	2.6690	**Z**
3Q21O	pcs	1.212079	0.444444	2.7272	**Z**
3ZUUN	pcs	0.31427	0.111111	2.8284	**Z**
EE39G	pcs	4.015787	1.388889	2.8914	**Z**
3EZVG	pcs	4.015787	1.388889	2.8914	**Z**
3S5S1	pcs	4.015787	1.388889	2.8914	**Z**
293q2	pcs	3.598697	1.222222	2.9444	**Z**
3ZUTL	pcs	0.711458	0.222222	3.2016	**Z**
4OB6X	pcs	10.83205	3.333333	3.2496	**Z**
293UB	pcs	22.67354	6.722222	3.3729	**Z**
28TKD	pcs	3.435921	0.833333	4.1231	**Z**
3JSJU	pcs	0.916246	0.222222	4.1231	**Z**

3J1HR	pcs	14.20181	3.444444	4.1231	**Z**
3Q5QF	pcs	0.458123	0.111111	4.1231	**Z**
29L7Y	pcs	0.229061	0.055556	4.1231	**Z**
3AOKH	pcs	0.229061	0.055556	4.1231	**Z**
29DVG	pcs	0.229061	0.055556	4.1231	**Z**
28TOM	pcs	0.229061	0.055556	4.1231	**Z**
28UQU	pcs	0.916246	0.222222	4.1231	**Z**
3XJ7K	pcs	11.45307	2.777778	4.1231	**Z**
3XKNJ	pcs	5.726536	1.388889	4.1231	**Z**
3XJVV	pcs	2.519676	0.611111	4.1231	**Z**
3XKG5	pcs	5.726536	1.388889	4.1231	**Z**

Appendix 4: EOQ (based on past-looking inventory optimization model)

Inventory item	Unit	Ordering cost (€)/unit	Annual warehouse expense (€)	Opportunity costs (€)	Carrying cost (€)/unit	Total usage of item	EOQ	Order X times per year	Order each X days
28LUZ	pcs	242.45	2.49	30.31	32.80	8,249	**349**	24	15
EB96A	pcs	182.17	2.49	22.77	25.26	10,827	**395**	27	13
27J78	pcs	163.60	2.49	20.45	22.94	5,465	**279**	20	19
3ZUYV	pcs	169.49	2.49	21.19	23.68	4,304	**248**	17	21
3ZUVP	pcs	154.29	2.49	19.29	21.78	2,759	**198**	14	26
HNLY6	pcs	89.35	2.49	11.17	13.66	3,903	**226**	17	21
3ZUWR	pcs	161.73	2.49	20.22	22.71	1,751	**158**	11	33
HNKDU	pcs	48.17	2.49	6.02	8.51	4,614	**228**	20	18
35TBN	pcs	18.71	2.49	2.34	4.83	10,195	**281**	36	10
3W54O	pcs	222.60	2.49	27.83	30.32	505	**86**	6	62
38WRN	pcs	27.68	2.49	3.46	5.95	4,715	**209**	23	16
35TAL	pcs	14.51	2.49	1.81	4.31	7,629	**227**	34	11
28TSU	pcs	124.97	2.49	15.62	18.11	653	**95**	7	53
3ZUPC	pcs	102.14	2.49	12.77	15.26	862	**107**	8	45

Appendix 5: EOQ (based on predictive inventory optimization method)

Inventory item	Unit	Ordering cost (€)/unit	Annual warehouse expense (€)	Opportunity costs (€)	Carrying cost (€)/unit	Total usage of item	EOQ	Order X times per year	Order each X days
28LUZ	pcs	242.45	2.49	30.31	32.80	9,688	**378**	26	14
EB96A	pcs	182.17	2.49	22.77	25.26	12,716	**428**	30	12
27J78	pcs	163.60	2.49	20.45	22.94	6,419	**303**	21	17
3ZUYV	pcs	169.49	2.49	21.19	23.68	5,055	**269**	19	19
3ZUVP	pcs	154.29	2.49	19.29	21.78	3,240	**214**	15	24
HNLY6	pcs	89.35	2.49	11.17	13.66	4,584	**245**	19	19
3ZUWR	pcs	161.73	2.49	20.22	22.71	2,057	**171**	12	30
HNKDU	pcs	48.17	2.49	6.02	8.51	5,419	**248**	22	17
35TBN	pcs	18.71	2.49	2.34	4.83	11,974	**305**	39	9
3W54O	pcs	222.60	2.49	27.83	30.32	593	**93**	6	57
38WRN	pcs	27.68	2.49	3.46	5.95	5,538	**227**	24	15
35TAL	pcs	14.51	2.49	1.81	4.31	8,960	**246**	36	10
28TSU	pcs	124.97	2.49	15.62	18.11	767	**103**	7	49
3ZUPC	pcs	102.14	2.49	12.77	15.26	1,012	**116**	9	42