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**The Necessity of Supply Chain Planning
Software in Modern Business**
Quintiq Company Case Study

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<p>Abstract</p> <p>The main goal of the thesis is to point out the significance and necessity of Advanced Planning Systems (APS) in Supply Chain Planning process. In attempt to prove that, the research focuses on a Dutch Software Company, named Quintiq, which provides various software solutions in the areas of scheduling, planning and optimization. The company focuses on KPI-based planning. Key Performance Indicators help in evaluation of benefits of use of Quintiq's SCP solutions. The overall aim is to find out how Quintiq software solutions improve an efficiency of supply chain planning and, consequently, supply chain activities in different industries.</p> <p>The study is based on four case studies – Quintiq's client companies, functioning in different industries, requiring dissimilar software planning solutions in various supply chain departments and possessing individual objectives. The cases' descriptions provide answers to the overall purpose of the thesis and prove that in every industry a thorough planning implemented by a software is vital. Moreover, case studies contribute to the general knowledge regarding APSs, as they define industrial use of these systems. The study reveals several enhancements that businesses have reached by implementing Quintiq software solutions and it concludes that the software can support various planning processes.</p> <p>Qualitative method was utilized by the author of this study, based on the primary archived data, which are comprised of organizational internal reports and video recordings. The material provision was arranged by the researcher's mentor within the case company and which was further used specifically for this research project.</p>		
<p>Keywords Advanced Planning Systems (APS), Key Performance Indicators (KPI) Supply Chain Planning (SCP), Supply Chain Management (SCM), Quintiq software solutions.</p>		

ABBREVIATIONS

APS	Advanced Planning Systems
KPI	Key Performance Indicator
QPLC	Quintiq Project Lifecycle
IT	Information Technology
SCP	Supply Chain Planning
SCM	Supply Chain Management
ERP	Enterprise Resource Planning
QAD	Quintiq Architecture Document
QID	Quintiq Integration Document
BMD	Business Mapping Document
EQPLC	Express Quintiq Project Lifecycle
PKCT	Port Kembla Coal Terminal
ANSP	Air navigation service providers
FRMS	Fatigue risk management system
OTIF	Delivery on Time, In Full
WIP	Work in progress
NDA	Non-disclosure agreement

CONTENTS

1	INTRODUCTION	6
1.1	Research objectives	Error! Bookmark not defined.
1.2	Research questions	7
1.3	Thesis structure	7
2	Literature review	8
2.1	Supply Chain Management	9
2.1.1	The objective of Supply Chain Management.....	12
2.1.2	Key Performance Indicators for Supply Chain.....	13
2.1.2.1	Supply Chain Responsiveness and Flexibility	13
2.1.2.2	Delivery performance.....	14
2.1.2.3	Costs and Efficiency	15
2.2	The role of Information Technology for the Supply Chain.....	17
2.2.1	Advanced Planning Systems.....	18
2.3	Planning Tasks (Solutions) Along the Supply Chain of the Case Company	20
2.3.1	Supply Chain Planning.....	21
2.3.2	Sales and Operations Planning.....	23
2.3.2.1	Demand Planning	24
2.3.2.2	Supply Planning.....	25
2.3.3	Logistics planning.....	26
2.3.4	Production Planning	27
2.3.4.1	Master Production Scheduling.....	27
2.3.4.2	Detailed Scheduling.....	28
2.3.4.3	Order Promising	29
2.3.5	Workforce Scheduling	29
2.3.6	Advanced Analytics.....	30
2.3.6.1	Self-Learning Supply Chain	31
2.3.6.2	Price Optimization and Revenue Management	32

2.3.7	Public Transport Planning	33
2.4	Optimal Planning	33
2.4.1	Optimization technology	33
2.4.2	Quintiq Platform	34
2.4.3	Quintiq project lifecycle (QPLC)	35
2.5	Summary of literature review	38
3	Methodology	39
3.1	Research strategy.....	39
3.2	Sample selection	40
3.3	Research purpose	42
3.4	Research method	43
3.5	Data acquisition	44
3.6	Data analyses	45
4	Results and discussions	46
4.1.1	Port Kembla Coal Terminal	46
4.1.2	Airservices.....	49
4.1.3	ELVAL Group	51
4.1.4	Marquis	54
5	Conclusion.....	56
5.1	Summary of key findings	56
5.2	Evaluation of own research	59
5.2.1	Research credibility.....	59
5.2.2	Limitations and suggestions for further research.....	60
6	References	62

1 INTRODUCTION

While studying International Business, Supply Chain Management was always the researcher's topic of interest. Supply Chain Management is increasingly becoming an essential task in the achievement of competitive advantage in most companies in the world market. To produce high-quality services and goods, a lot of international organizations have to constantly reconstruct their operations with an aim to respond to continuously changing market dynamics. In this case, an effective and efficient planning is the key to success.

Supply Chain is a very complex system, which consists of different activities, processes and operations, like mining, transportation, stocking, production, product development and distribution. The successful implementation of supply chain processes can be a tremendous advantage in terms of competitiveness among other firms. Moreover, among other benefits of efficient supply chain management are the reduction of operating costs and the improvement of financial and commercial results.

Here it becomes very important for the managers to thoroughly plan and optimize every operation against the most essential business KPIs. Thus, this thesis uses Quintiq company - one of the most successful companies that develops software solutions that match business requirements and generates continuous integration of short, middle, and long-term strategic planning. Furthermore, this thesis presents the practical ways in which the proposed study should be conducted.

The researcher of this thesis believes that by writing this thesis, she will be able to provide herself with more intensive learning, while reading books, articles, and case studies of the company and implementing research. Moreover, she will gain some experience in the field of Supply Chain management, which can contribute in her future career.

1.1 Research objectives

The research centers on a Dutch Software Company, named Quintiq, which provides various software solutions in the areas of scheduling, planning and optimization. These software solutions can solve most planning challenges through its deep functionality and configurability. (Payne et al. 2014.) Quintiq operates in various industries, such as aviation, broadcasting, field service,

healthcare, logistics, manufacturing, metal, natural resources, public transport, rail, retail, and security.

The major objective of the thesis is to find out how Quintiq software solutions improve efficiency of supply chain planning and, consequently, supply chain activities in different industries. Moreover, the thesis aims to determine the most essential KPIs that are affected with the utilization of supply chain planning system.

Among other objectives of this study are an understanding and analysis of the current case company software solutions and activities. Additionally, the research aims to thoroughly analyse case studies and implement the data collection. The researcher was provided with the case company document which describes the main company's own working methodology, named Quintiq Project Lifecycle (QPLC). QPLC gives the best understanding of how the software company implements their projects. Besides, the researcher utilized four case studies, that are focusing on Quintiq's client companies, functioning in different industries, requiring dissimilar software planning solutions in various supply chain departments and possessing individual objectives. The case studies accurately describe the main companies' problems that have to be solved, the "AS-IS" situation, how the company implements the challenges and what are the ultimate results.

1.2 Research questions

The main research question of this thesis is as following: How does Quintiq software help companies in improving their Supply Chain Management (SCM) Key Performance Indicators (KPIs)?

Sub-questions play an essential role in obtaining an answer to the main research question. Hence, the sub-question of this thesis is as following: What are the factors that influence companies to use Quintiq (software) in planning their supply chains?

1.3 Thesis structure

It is vital to depict the thesis structure. First of all, an introduction chapter presents and establishes the main research topic to the reader, followed by

the objectives and research questions that the researcher has to answer. The literature review section will contain all the important information about the topic of this thesis in order to teach an unacquainted reader to comprehend all thesis aspects. Afterwards, methodology section will present the methods selected for obtaining information to answer the main research question. Particularly, methodology part will include the main research strategy, detailed tools for sample selection, research purpose, the major research method, data acquisition and data analyses. The proper research outcomes can be found in the results section followed by a discussion of these findings. Finally, the conclusion chapter will introduce the key findings summarized by the researcher. In the same chapter, the researcher will also evaluate the research and provide recommendations and suggestions for future researchers.

2 LITERATURE REVIEW

Looking a little bit ahead, the research strategy used for this thesis is case study, the aim of which is to conduct an in-depth analysis of organizational and managerial processes of a specific case company. Case study method must prove that it is related to a theoretical framework. (Tellis 1997.) Theory is a vital part of the case study research. Yin (2012, 27-28) affirms that one of the most significant strategies for managing an efficient case studies is the reliance of theoretical concepts to direct data collection and design. Furthermore, theory can help to point out how and why the ultimate findings should be applicable to other similar situations or conditions and respectively, assist in enhancing the case study value (Yin 2012, 29).

The literature review section introduces the relevant literature that assisted the researcher to build the study of findings part. In the beginning of theory section, it is significant to shortly introduce several definitions of various authors on supply chain management. After that, the objectives of supply chain management are discussed. Furthermore, Key Performance Indicators for the supply chain are indicated. A brief introduction to the impacts of Information Technology on supply chain followed by a clarification of such IT tool, as Advanced Planning Systems (APS) are presented afterwards. The major part of literature review is assigned to planning solutions along the

supply chain of the case company, an interpretation of company's optimisation technology, as well as, company's own working methodology (QPLC).

2.1 Supply Chain Management

There are various definitions offered in literature for the identification of the concept of supply chain. Simply stated, supply chain is the alignment of organizations that deliver product or service to a market. (Lambert et al. 1998.) It consists of all activities and organizations related to the transformation and stream of goods from the phase of raw materials, through to the ultimate client, as well as the related financial and information flows (Handfield & Nichols Jr. 2002).

According to Mentzer et al. (2001) supply chain is a group of three or more firms that are connected by one or more of the upstream and downstream services, products, informational and financial flows from an origin to a consumer. Mentzer et al. (2001) differentiate between base, extended and final supply chain. As shown in Figure 1, base/direct supply chain is composed of a central firm, direct supplier and direct user/customer; an extended supply chain involves the direct supplier's suppliers and the direct user's users; and final/ultimate supply chain includes all firms from the primary supplier to the final user.

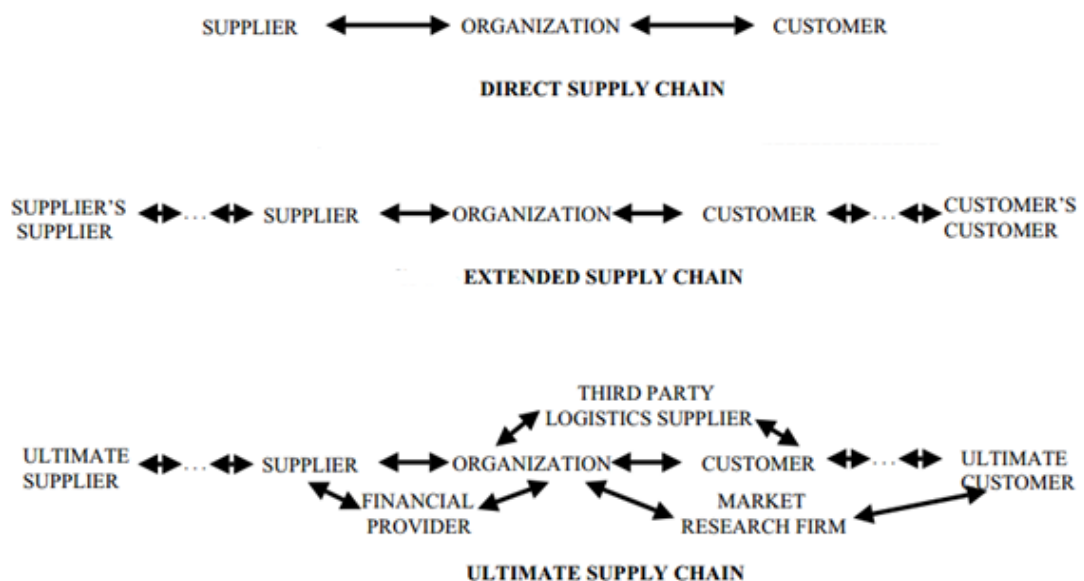


Figure 1 Types of channel relationships (Mentzer et al. 2001).

Cooper et al. (1997) determine the framework of the supply chain as 'dirt to dirt', which implies the flow of raw material to the ultimate consumer and the return procedures that recycle, reproduce, or reuse products and materials.

Supply chain management encompasses various functional areas inside the organization. Warehousing, inventory control, procurement, supply management, inbound and outbound transportation are all these activities involved in the functional areas. Moreover, supply chain planning, logistics planning, sales and operations planning, production planning, workforce scheduling, anticipating, order handling, customer service are among those fundamentals important for the process, as well. (Zigiaris 2000.)

Hugos (2003, 4) describes SCM as the organization of production, transportation, location and inventory that enables the attainment of the best combination of effectiveness and responsiveness for the market, if implemented correctly. Stevens (1989, 3) stated that the major goal of SCM is to match the requirements of customers with the suppliers' materials flow to stabilize the contradictory objectives of low inventory management, high customer service, and low unit costs. In addition to that, Hugos (2003, 4) also believes that often various requirements of supply chain have conflicting needs. However, there are ways to be found to efficiently balance diverse demands if these requirements are perceived together as parts of a greater picture.

The authoritative Council of Supply Chain Management Professionals based in United States claimed that supply chain management embraces the governance and planning of every activity engaged in conversion, sourcing and procurement and the entire activities of logistics management. Moreover, it involves organization and cooperation with channel members, such as suppliers, intermediaries, third-party providers of service and consumers. (Council of Supply Chain Management Professionals 2013.) Based on this definition, logistics is one of the essential elements of the SCM that focuses on the physical and monitoring collaborations among firms (Mentzer et al. 2001). Supply chains set up the general missions and managements during the whole set of activities engaged in the flow of product and service starting to final product supplied to an ultimate consumer. The supply chain develops the foundation for logistics activities. (Skjøtt-Larsen et al. 2007.)

Supply chain management interprets supply chain and its organizations as an individual, single entity, which leads to a systematic approach to understanding and handling the diverse actions that are essential for managing the flow of services and products to respond to business requirements and to serve the final consumer in the best way. Efficient SCM demands synchronized enhancements in both the company's inner operational efficiencies and customer service levels. Customer service means constant large order rates, delivered on time and the ability of the company to retain the customer. High rates of return on investments and low sales and operating expenditures means an effective planning and implementation of supply chain activities of the organization. The capabilities of the company are designed by the markets served and by its supply chain. (Hugos 2003.)

It is important to remember that there is no organization that is capable to operate independently and it is connected to interrelation of other organisations in a network relationship. Due to the expansion of reach and easy information and communication technology accessibility, it is also understandable that no organization can be good at all things. Accordingly, to implement the activities needed to accomplish the process, organizations are concentrated on the management of the processes that involve other firms. The comprehension of this attitude is essential for the survival in the intense competition for global markets, growth and for meeting the market inquiries while managing the rapid change in technologies and developing customer requirements. (Skjøtt-Larsen et al. 2007.)

To conclude, nowadays, the most successful organizations realize the significance of proper execution of supply chain management activities that bring product to market and if implemented efficiently, satisfy customers. Markets are constantly changing and its development is indefinite. For that reason, organizations must be aware of the supply chains they are involved in and realize which roles they play. (Hugos 2003.) The supply chain arose since it offers possible resolutions to the problems of responsiveness and unnecessary duplication. Substituting both the hierarchy and the market as the means to control the process of flow, it comprises an idea of direct, extended organization of activities throughout the whole supply process. (Skjøtt-Larsen et al. 2007.) Strong supply chains are vital in achieving a

competitive advantage among markets, which in the end is the prevalent objective of every company (Hugos 2003).

2.1.1 The objective of Supply Chain Management

The maximization of the overall value produced - is the goal of every supply chain. The difference between the expenses of the supply chain to fulfil the needs of a customer and the worth of the ultimate product for the customer is the major value generated by supply chain. Value, for most commercial supply chains, goes in conjunction with the profitability of supply chain. In this case, profitability is the difference between the general price within the supply chain and the revenue that customer brings. For instance, when the customer buys a product for a certain price, it represents the revenue received by supply chain. The conveyance of the information, the production and transportation of components and its storage, the transition of the funds, etc. are those organizations of supply chain that incur expenses. The alteration between the price paid by a customer and the totality of all incurred prices during the process of production and distribution of the product represents the profitability or surplus of the supply chain. The profitability or surplus in the supply chain is the overall income to be distributed across all the stages of supply chain and mediators. However, it is important to understand that not all SCM actors get to share the profits equally. The supply chain is effective in case of higher profitability. Thus, the efficiency of supply chain must be identified not in terms of the revenue at an individual stage, but from profitability point of view. (Chopra & Meindl 2007.)

Furthermore, it is essential to concentrate on the source of revenue, - the customer. Customer, who purchase the product, is the only one to provide a positive cash flow for the supply chain. Another cash flows are merely fund exchanges occurring in the supply chain, since other stages have other holders. The corresponding management of product, information, or funds flows is vital to the success of the supply chain since they generate costs across the supply chain. An efficient implementation of supply chain management includes the control of supply chain assets and flows of fund, product and information in order to take the full advantage of overall profitability. (Chopra & Meindl 2007.)

2.1.2 Key Performance Indicators for Supply Chain

There are several measures of performance that can be applied in most settings, even though every supply chain is distinctive and special treatment is required. Key Performance Indicators cover various supply chain areas and are grouped into four classifications: supply chain responsiveness and flexibility, delivery performance, and costs and efficiency. (Stadtler & Kilger 2000.)

KPI based performance is one of the key aspects in the business world, as it allows to not only clearly understand the development of a particular indicator, but helps in evaluation of benefits of use of Quintiq's SCP solutions. In this section, the major KPIs will be discussed.

2.1.2.1 Supply Chain Responsiveness and Flexibility

Supply chain responsiveness indicates how fast the products are delivered to the ultimate client (Cohen & Roussel 2005). It includes the time that passes from receiving a client's order to finished delivery (Jonsson 2008). Within these time frame limits, supply chains must reply to major demands of a customer to ensure the competitiveness. To measure the responsiveness of the supply chain, it is vital to pay attention to such factor, as order fulfilment lead time. Order fulfilment lead time determines the number of days from receiving an order in customer service to obtainment of delivery at the client's dock. (Bolstorff & Rosenbaum 2003.) As mentioned by Taylor (2004), the consideration of the lead time variability is also important in measuring the supply chain responsiveness. Companies might have short average lead times, but they still can change significantly. Sometimes it can be more useful for companies to have durable but less altering lead times.

Supply chain flexibility shows how agile organizations are in responding to unsystematic variations in the marketplace to obtain or keep the competitive advantage (Wisner et al. 2012). Thereby, flexibility is a performance measurement, which examines how fast automotive producers are able to react to the clients' unique needs (Jonsson 2008). The two flexibility indicators are production and supply chain response time (Cohen & Roussel 2005). The amount of days for the supply chain to respond to variations in marketplace

without fines is measured by supply chain response time (Bowersox et al. 2010).

Another important indicator of supply chain responsiveness is the measurement of forecast accuracy. It calculates the capability of future demands prediction and connects actual quantities to forecasted quantities of sales. Smaller variations in already set manufacturing plans and plans of distribution occur in case of better forecasts of consumer behaviour. (Stadtler & Kilger 2000.)

The time between the start of two ensuing planning cycles is determined as another field-related measure called the planning cycle time. Long planning cycle times avert the plan from considering the short-term variations in the real world. Because the particularly planned actions are based on old data that is accessible at the planning cycle beginning, they can no longer correspond to the real situation at the end of a planning cycle. The corresponding time of planning cycle should be defined in regard to the level of aggregation of the planning horizon, planning effort and the planning procedure. (Stadtler & Kilger 2000.)

2.1.2.2 Delivery performance

Performance of delivery is an important indicator for the entire performance of supply chain, since the main constituent element of Supply Chain Management is customer orientation. As claimed by Wisner et al. (2012), order delivery lead time comprises the implementation of the orders' average percentage amid supply chain members that arrive complete, in time, free of damage and satisfying the needs of a client. Since the promised delivery dates can be overly belated according to the customer, the performance of delivery must be calculated from the actual delivery date point of view compared to the date of delivery that was reciprocally negotiated. Customer satisfaction is ensured by ideal fulfilment of an order that is achieved by delivering the right product at the right time and place. The enhancing performance of delivery can advance the supply chain competitiveness and contribute in supplementary sales. (Stadtler & Kilger 2000.)

On time delivery is one of the most crucial indicators, as well. It is determined as the number of orders supplied on or before the date required by the consumer. When there are low on-time deliveries, the order promised are not fulfilled for the customer as expected. This can be caused by order promising that is based on an impracticable manufacturing plan or due to transportation or production activities not being carried out as planned. (Stadtler & Kilger 2000.)

Last but not least, is the order lead-time indicator. In the opinion of consumers, the order lead-times determine the average interval of time from the date of placing the order to the date the customers receive the cargo. Short lead-times order is significant for surviving in the competitive market, as consumers are progressively demanding. Finally, the satisfaction of consumers is achieved through short and also reliable lead-times, even though both these types of lead times have dissimilar aspects of costs. (Stadtler & Kilger 2000.)

2.1.2.3 Costs and Efficiency

The eventual objective for every company will always be profit. Thus, it is important to mention the financial measures. Cost based measures is the focal point here. (Stadtler & Kilger 2000.) Cost is an essential performance indicator for supply chain. Supply chain costs encompass all costs related to operating the supply chain, comprising the cost of production and total cost of supply chain management. (Bolstorff & Rosenbaum 2003.) Mostly, supply chain costs are related to transportation, inventory, manufacturing, warehousing, administration, procurement, customer service, etc. (Burt et al. 2010).

Transportation costs are associated with the movement of everything from raw material to completed goods among various intermediaries in a supply chain. The compromise amid efficiency and responsiveness is demonstrated in the transport mode selection. For example, such quick mode of transport, as airplane is very responsive but more expensive. Ship and rail, on the other hand, are not as responsive, but cost-efficient. Taking into consideration various modes of transportation, like ship, rail, trucks, airplanes, etc. and the facilities' location in a supply chain, it is vital for managers to design networks

and routes for the movement of products. With regard to supply chain planning software, the systems enable the calculation of the materials' quantity which has to be delivered to specific locations and at a certain time. The systems also give the possibility to compare various transportation modes, routes and carriers. Additionally, the systems ensure such information, as shipping tariffs, fuel costs, and mileage. Thus, by utilizing these software systems, transportation plans are created. (Hugos 2003.)

Inventory is distributed across the supply chain and involves everything from raw material to work in process to completed goods that are held by the distributors, retailers, and producers in a supply chain. Holding big amounts of inventory permits an organization or the whole supply chain to be very responsive to variations in customer demand. Nonetheless, it is costly to create and store the inventory and in order to reach high efficiency levels, the inventory cost has to be kept as low as possible. There are three types of inventory: cycle, seasonal and safety. Cycle inventory is the inventory necessary to correspond to product demand over the period of time amid placing orders for the product. Seasonal inventory occurs when organizations or a supply chain with a fixed volume of production capacity decide to manufacture and stockpile products in anticipation of future demand. Safety inventory is required to offset for the demand uncertainty and order lead times in a supply chain. There are four ways to reduce inventory: decrease uncertainty of demand (by implementing better predictions of product demand), decrease order lead times (shorter lead times imply less safety inventory necessary for coverage), decrease lead time variability (diminishes necessity for safety inventory) and decrease availability uncertainty (guarantee product accessibility when demand appears). (Hugos 2003.)

Manufacturing concerns the capacity of a supply chain to produce and store goods. Warehouses and factories are the production facilities. When making production decisions, managers must decide how to solve the trade-off amid efficiency and responsiveness. If warehouses and factories are built with a lot of surplus capacity, they may be flexible and quickly react to broad fluctuations in demand of products. Objects where nearly all capacity is being utilized are not able to respond easily to demand swings. On the contrary, capacity is costly and excess capacity is capacity which is not used and, thus,

unprofitable and inefficient. Thereby, it is vital for the managers to know what, how and when to produce in order to stay cost-efficient. (Hugos 2003.)

In conclusion, warranty costs indicate the quality of product and assist in identifying problem areas. This is especially significant because excellent quality of product is not a characteristic feature of supply chain, but a propelling principle of business in overall. (Stadtler & Kilger 2000.)

2.2 The role of Information Technology for the Supply Chain

Current SCM is driven by a lot of factors, such as evolution of the Internet, high-speed technological advancement, mainly information technology, worldwide nature of current business processes, global recessions and security threats, and an alteration in customer welfare. All these factors empower organizations to function in real-time across huge distances and made SCM an indispensable factor in terms of global competitiveness. Thereby, it is imperative for the companies to understand that the information systems are critical in supply chain planning and, in consequence, monitoring the activities. (Zigiaris 2000.)

New opportunities are opened with the evolvement of new information and telecommunication technologies in combination with effective, quick and comparatively economic global transportation systems. Deprived of the investment and challenges of direct ownership, this allows organizations to achieve beyond their geographical and organisational borders to monitor processes and management over the whole supply chain. Thus, in order to attain organizations that are not directly engaged with the flow of product, information networks outstep beyond physical operations. (Tapscott 1997.)

Furthermore, with the emergence of the network economy, the idea of the supply chain as a network of individual, independent entities leads us to reevaluate the traditional concept of enterprise. IT is the foundation for the evolving the supply chain as the borderless, extended enterprise. (Tapscott 1997.)

Business processes have been altered by the IT through processes automation, control over distant operations and operations within the borders

of the organization, and by information flow. The evolvement of the supply chain with Internet technology, which has a substantial potential and suggests easy and quick ways to convey difficult information, is also formed by IT. Such processes as documentation and inside operations can be automated by information technology. Without human support, orders can be processed and fully completed. IT means new possibilities that have to be taken into consideration by organization since it transforms both strategy and operations. (Skjøtt-Larsen et al. 2007.)

Visibility of the whole supply chain is the main contribution. Dealing with complicated processes in conjunction with the environmental uncertainty is the biggest SCM challenge. At a certain stage in the chain, organizations can face problems of not being acquainted with actual requirements of the clients and late deliveries. These problems lead to unexpected situations and insecure supplies. The resolution to decrease this uncertainty is to improve the capacity to manage information and to set the cross-functional coordination. With the help of IT, organizations can diminish redundant inventory, extend the management sphere and make justified operational solutions in different parts where before there was a lack of information. Regardless of the geographic location, IT manages and controls operations and permits supply chain associates to run operations utilizing shared data. (Skjøtt-Larsen et al. 2007.)

2.2.1 Advanced Planning Systems

Organizations that strive to achieve success in the competitive markets, must not only manage their flows of supply chain (funds, product and information), but also carefully design, plan and operate their supply chain (Chopra & Meindl 2007). There are millions of continuous, individual decisions of different significance that should be made and coordinated in a supply chain. Planning maintains decision-making by indicating alternatives of tomorrow activities and choosing several good ones or the best one. (Stadtler & Kilger 2000.)

Planning may be divided into several stages: recognizing and analysing the decision problem, defining purposes, anticipating future development process, identifying and assessing possible activities and selecting good resolutions (Domschke & Scholl 2003).

However, in order to improve the performance of the business, an unaccompanied integration of inner operations is not enough. The major

influence on business performance is shaped by exceptions and unplanned variations, for instance, late suppliers' delivery, production volume reduction by an unanticipated equipment defects, unexpected enlarged customers' order etc. The proper reaction to such variations can enhance the level of the service, stimulate the improvement of sales and revenues and, in consequence, save a lot of money. (Stadtler & Kilger 2000.)

Nowadays, modern planning procedures for sales planning, inside operations planning, advance supply planning etc. help to diminish the number of exceptional cases and make companies more profitable, while maintaining them in a standard regime of operation. These influential planning operations and practices and fast responses to variability and exceptions can be accomplished by Advanced Planning Systems (APS). An APS develops the consecutive database and united standard workflows assured by Enterprise Resource Planning systems to control maximum speed in industry. Owing to this new development, the APS software suppliers contribute in progress in company extensive planning and cooperative planning among the associates in a supply chain. (Stadtler & Kilger 2000.)

Advanced Planning Systems are striving to "computerize" planning, by supporting the choice of one or a several solutions that are effective in terms of predetermined criteria from a major set of possible actions. There are three main benefits of APS: visualization of information, reduction of planning time, and easy use of optimization methods. Nevertheless, although these planning systems are very advanced, human skills, knowledge and experience are essential, because these planning systems support human decision-makers. (Domschke & Scholl 2003.)

APS help organizations with supply chain management and manufacturing planning from the strategic to operational levels (Mattik 2013). There are three key attributes of APS: integral planning, true optimization and hierarchical planning system (Stadtler & Kilger 2000).

Integral planning plans for the whole supply chain, from the providers towards the consumers of a single company, or of more extensive companies' network (Stadtler & Kilger 2000). In other words, integral planning indicates that the APS comprises the supply chain in its entirety (Mattik 2013). True optimization is implemented by correctly identifying alternatives, goals, and limitations for

the different planning challenges and by utilizing optimizing planning methods, either precise ones or probing (Stadtler & Kilger 2000). Nevertheless, it is hard to plan for the whole supply chain and simultaneously implement optimization for each piece of the puzzle. Thus, hierarchical planning system was evolved (Laha 2007). Hierarchical planning system - exclusive framework that allows the conjunction of the two previous properties (integral planning and true optimization) at the same time. Hierarchical planning is about compromising between the review of the interdependencies amid the planning tasks and feasibility. (Stadtler & Kilger 2000.) APS are based on hierarchical planning structure and take into account the planning demands for such supply chain stages, as, for instance, production, sales, distribution and procurement and for all time horizons (short, medium and long terms) (Laha 2007).

The developments in means of communication (exchange of electronic data through the Internet), in information technology (effective systems of database management), and in techniques to resolve big quantitative models by mathematical programming, - paved the way for planning and monitoring flows within a supply chain. The anticipation of demand and market tendencies, orders of consumers can be instantly directed to all members in the supply chain. To ensure the timely execution of orders, precise schedules are implemented. In contradiction to traditional ERP, APS systems are trying to pick up possible, optimum plans throughout the entire supply chain. (Stadtler & Kilger 2000.)

2.3 Planning Tasks (Solutions) Along the Supply Chain of the Case Company

At various points in time, software organizations have launched Advanced Planning Systems that include various software components that cover series of particular planning tasks. However, a general structure underlying the majority of APS can be distinguished. Commonly, APS are composed of few software modules that cover a specific diapason of planning tasks. Depending on the certain supply chains and industries correspondingly, the planning tasks can be varied. Realizing this situation, providers of APS suggest several software modules dealing with the identical planning tasks, while adapting certain features of supply chain. Only those software components that are crucial for the business or a certain industry are purchased, installed and assimilated by the clients. Occasionally, modules of various providers of APS

can be matched. (Domschke & Scholl 2003.) As shown in Figure 2, particular planning sections of the SCP-Matrix are usually covered by a corresponding software module. For example, long-term procurement, production, distribution and sales are covered by a strategic network planning module. Or, for instance, master planning module coordinates mid-term procurement, production and distribution. The modules' names change among different APS providers, but supported planning tasks are basically the same. (Stadtler & Kilger 2000.)

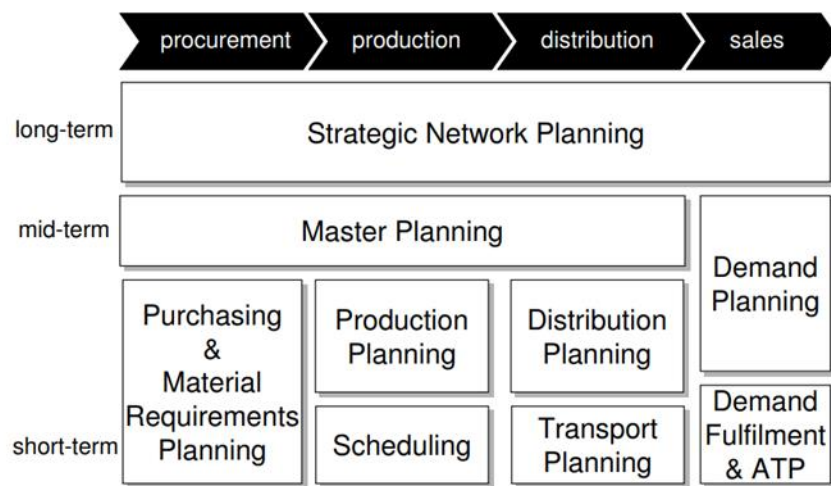


Figure 2 Software modules covering the SCP-Matrix (Stadtler & Kilger 2000).

Focusing on Quintiq, there are several major software *solutions* for supply chain planning that are supported and implemented by the case company. These software solutions include: supply chain planning, sales and operations planning, logistics planning, production planning, workforce scheduling, advanced analytics, public transport planning and optimal planning. (Quintiq, n.d..a)

2.3.1 Supply Chain Planning

In this section, the researcher would like to describe a general concept of supply chain from Quintiq' point of view. Referring to the case company, the proper handling of every element of the chain is not the only key to effective supply chain planning. It is significant to plan and optimize in its entirety. In consequence, the supply chain is the total amount of each function and distinctive attribute of the business. The successful attainment of the quality, services, and effectiveness needed to bring the business to the following

stage is reached when such organizational KPIs, as supply chain responsiveness, flexibility, delivery performance, costs and efficiency are identified and aligned to every business function. Quintiq plans and optimizes supply chain from large-scale strategic planning to the smallest details on the marketplace, while operating on one integrated platform. KPI-based planning/ performance is one of the key aspects for Quintiq, as it allows to not only clearly understand the development of a certain indicator, but helps in evaluation of benefits of use of Quintiq's SCP solutions. (Quintiq, n.d..b)

The company's planning solution makes it possible to model the supply chain with complete precision, by properly responding to "what-if" questions that are essential in every business (Quintiq, n.d.c). "What-if" questions help to analyse scenarios in complicated and unpredictable contexts. It is possible to compare various scenario outcomes, since "what-if" model consists of trials where one or several APS factors or data can vary. Without interrupting operations, a number of options of the system can be examined, as well. (Onkal & Aktas 2011.)

The visibility necessary to recognize the influence of each business decisions and the performance of long-term strategic planning of the supply chain are also provided by Quintiq. Quintiq software helps to make justified choices concerning such important activities, as customer services strategies, product mix portfolio, outsourcing and inventory, capital investments and deprivation. (Quintiq, n.d..c)

The facilitation of decision making process is contributed by fast scenarios. For the successful decision making, clients should match optimized scenarios by KPIs concerning the performance of delivery, costs, revenue and levels of inventory and evaluate the efficiency, sustainability of every arrangement and potential profitability. Locally, the process optimizes production, inventory and distribution; globally – the whole supply chain, while making ready for eventualities and preventing from risks. (Quintiq, n.d..c)

Inventory planning is one of the major elements of the supply chain planning in Quintiq company, as well. Inventory planning is an essential indicator and substantial task for most of the companies. Inventory planning is especially important for businesses that produces services and goods and utilizes "Make to Stock" production strategy, which assist in matching production and

inventory with forecasts of consumer demand. The main goal of inventory planning is low inventory levels and no stock outs. However, it is not that simple. Continuously growing range of shorter lifecycle products, the segmentation of supply chain, seasonality and numerous stocking locations must be managed, as well. While having pressure from rival demands from various business parts, it is important not to forget about the reduction of inventory costs and exemption of working capital. (Quintiq, n.d..d)

All these difficult issues are taken into consideration by Quintiq, by comparing such factors, as production and demand, depot workload, congestion of bottlenecks, idle materials, work-in-progress inventory, etc. It consolidates data from across the company for authentic visibility of supply chain. Moreover, it optimizes and supports efficiency and productivity, optimal levels of inventory, consumer satisfaction, and profits at each planning level. (Quintiq, n.d..d)

In Quintiq, inventory planning encompasses several tasks: visibility, multi-echelon optimization, uncertainty management, surplus and outdated stock minimization, financial modelling and intuitive user interface. *Visibility* allows to observe inventory data in real time. In case of menaced inventory levels, the users are going to be instantly notified in order to take the needful measures. Based on demand ambiguity and supply changeability, *management uncertainty* factor determines precise and thorough security stock levels. *Multi-echelon optimization* creates clever segmentation strategies for custom-made, made-to-stock and finish-to-order, etc. and defines the optimum combination of completed and semi-completed goods, raw materials and components. *Surplus and outdated stock minimization* helps the avoidance of inventory, which has to be thrown away or sold out at vastly decreased prices. *Financial modelling* assists in the achievement of the balance between customer service levels and inventory investment. *Intuitive user interface* focuses on monitoring of the factors that influence inventory and helps to gain quick access and comprehend necessary information. (Quintiq, n.d..d)

2.3.2 Sales and Operations Planning

When investing in sales and operations planning solution of Quintiq, it is essential to answer complicated, however, important questions of what to manufacture, purchase, stock and transport; in addition, at what price, when

and where each of these activities have to be accomplished. To make optimal decisions and reach business objectives, Quintiq uses data from each aspect of the business and helps to bridge the gap between sales and operations. Complete visibility into each detail of operations, marketing, sales and finance is provided, as well. With the help of the progressive modelling and vindicated in-memory optimization facilities to simulate any scenario in sales and operations planning cycle, Quintiq answers all "what-if" questions and contributes in making the right choices that bring the greatest value. (Quintiq, n.d..e)

Sales and operations planning platform functions in several areas: product mix optimization, responsiveness, forecasting, optimization, scenario planning, and revenue management. *Product mix optimization* takes on thorough demand analysis for the product portfolio. *Responsiveness* implements efficient unforeseen and continuing short and long-term plans. *Forecasting* makes precise predictions of demand, delivery and cost. Based on historical and objective data, *optimization* is accountable for decisions of distribution and sourcing. *Scenario planning* explores "what-if" questions to be prepared for any contingency. Finally, by selling the right product to the right customer at the right time and price, *revenue management* maximizes profitability. (Quintiq, n.d..e)

It is proved that Quintiq's sales and operations planning enhances efficiency, decreases inventory, improves overall performance of delivery and eventually enlarges profitability (Quintiq, n.d.e).

2.3.2.1 Demand Planning

In Quintiq, demand planning is one of the major tasks of the sales and operations planning. The improvement of customer service, increase in sales and reduction in costs can be achieved by accurate demand anticipation. Because of that, one of the most important tasks for supply chain leaders is to overcome the demand uncertainty. Quintiq assists in determination of what's to come and how to profit from it by analysing the market intelligence and historical inquiry. The users can launch the whole process of planning that involves tracking of changes of the requirement plan, product launch planning,

and identification of collaborators' contributions to the process on a single platform. (Quintiq, n.d..f)

With Quintiq, through enhanced statistical predicting, it is easier to anticipate the demand, cooperate more efficiently with external clients and inside sales teams and discover demand scenarios in order to enhance sales.

The demand planning works through statistical forecasting, effective collaboration, demand analytics, exception management, consensus forecasting and demand scenarios. *Statistical forecasting* includes advanced algorithms that serve for demand segmentation and automatic calculation of the optimal statistical forecast by analysing trends, seasonal changes and events. *Effective collaboration* provides all customers with simultaneous access to the newest version and creates a demand plan, which involves input from marketing, finance, sales, etc. *Demand or real time analytics* track variations in forecasts and where forecasting challenges of the users lie and show how business is benefited by the demand planning. Helping to manage the time, *exception management* receives real-time forecasts notifications that require attention. *In consensus forecasting*, to include such multiple inputs as overrides of management and consumer orders, demand plans are configured. To manually or automatically achieve a consensus, different options have to be considered. Ultimately, multiple *demand scenarios* control risks and opportunities and conduct demand generation and diapason-based forecasting. (Quintiq, n.d..f)

2.3.2.2 Supply Planning

Supply Planning is another main task of the sales and operations planning, which is directly connected to demand planning. Once the forecast is prepared for the process of supply review, the application of such restrictions, as production capacity, inventory, people and materials makes the distance between what has to be produced and what the firm is able to produce wider. To prevent this, Quintiq's supply chains and demand are fully integrated and linked, because planners work simultaneously from both areas. By generating and comparing supply and demand scenarios, they fill up the gaps (for instance, by recruiting more employees or generating more shifts, involving

promotions, discovering extra sources of supply, etc.), maximize efficiency and gain supplementary possibilities of sales. (Quintiq, n.d..g)

Quintiq's supply plans can be implemented with: optimization, quicker and higher quality scenarios, support for all planning maturity levels and flexible configuration. *Optimization* increases manufacturing, distribution, inventory and sourcing on a local level. It helps to optimize the whole supply chain, protect from risks and make plans in case of unforeseen circumstances. *Faster and higher quality scenarios* speak for themselves: it creates precise basis plan, tests it against multiple scenarios, and assess every result in order to define the best way of operation to meet and go beyond business' Key Performance Indicators. To *support all planning maturity levels*, Quintiq helps to accomplish best practice models for every sales and operation planning activities: from balancing the capacity of supply and demand, to complex business planning and analysis of financial influence. To produce the most exact supply chain model and optimize it with few clicks, *flexible configuration* is responsible for all the restrictions, regulations and KPIs. (Quintiq, n.d..g)

2.3.3 Logistics planning

During several years, Quintiq collaborates with various customers, providing them their logistics planning and optimization solution. With the help of intuitional planning interface, real time reporting instruments concentrated on KPI, and modern automated planning facilities, planners are able to optimize logistics plans. The entire visibility and control over the whole planning and optimization process, such as planning a long-term network strategy, route planning and everyday workforce planning became accessible for dispatchers, planners and managers. (Quintiq, n.d..h)

There are four types of Quintiq's logistics planning: execution planning, operational planning, enterprise planning and strategic planning. To correspond with the realities of everyday operations, firstly, Quintiq's *execution planning* updates plans in real time. Secondly, to depict such unforeseen occurrences, as adverse weather conditions or emergency handling, the system is effectively reoptimize schedules on the run. Thirdly, it enables communication among workers and planners in the plans' field that stays precise and state-of-the-art. *Operational planning* is responsible for matching concrete resources and workers to orders and, for revision and

updating plans to reflect the flowing operational state and any orders' backlog. Moreover, it optimizes in opposition to such specific resource restrictions, as, for instance, driver-shift preferences and allows for urgent situation maintenance with negligible price and disruption. In *enterprise planning*, planners analyse the supply chain in accordance to Key Performance Indicators, correspond volume with certain orders, define and set deadlines, plan directions and optimal cargos throughout numerous storehouses and, finally, plan current service for minimal price and disruption. *Strategic planning* is based on explicitly introduced overviews of capacity, demand, and performance history. It evaluates, aligns and allocates capacity and sales budget; plans and models the geographical scope of the network; explores practical routes and channels; simulates such “what-if” scenarios, as alteration in driver guidelines; designs the whole supply chain. Quintiq’s logistics planning system quickly implements and ensures transparency of planning and fast returns. (Quintiq, n.d..h)

2.3.4 Production Planning

With the help of Quintiq's production planning software manufacturers are provided with the competitive advantage, by avoiding such general barriers to efficiency and profitability as poor performance of supply, high inventory levels, excessive waste and low yield. Production planning software focuses on value creation and improving competitive advantage. To produce the highest throughput with the lowest inventory, Quintiq possesses the planning techniques and instruments, while providing high performance of delivery and quality. (Quintiq, n.d..i) Production planning of Quintiq is accountable for three main tasks: master production scheduling, detailed scheduling and order promising (Quintiq, n.d.i).

2.3.4.1 Master Production Scheduling

The combination of such processes, as creating an effective work orders, monitoring inventory and maintaining high customer service levels is always a big challenge. Such everyday decisions on timing and size of production,

which runs for various products have to be implemented. Furthermore, factors, like performance of delivery, campaign effectiveness, stock envelopment and resource usage have to be considered. Most importantly, the realization of all these activities is constrained by time limits. (Quintiq, n.d..j)

The availability of the right systems allows the increase of control level over manufacturing, the improvement of inventory levels, customer service and the dependability of lead times, while allowing to concentrate on achievement of optimal plans (Quintiq, n.d.j).

Master Production Scheduling operates in six main areas: capacity planning, scenario planning, campaign planning, efficient order combination, material reservation, and flow optimization. *Capacity planning* takes into consideration the latest evolvments, such as the feedback from the planning or shop floor, unforeseen layups or updated external demand. *Scenario planning* is accountable for making fast comparisons of various opportunities and choosing the option, which influences Key Performance Indicators in the best way. *Campaign planning* organizes certain processes that must be planned jointly based on deadlines and capacities. *Efficient order combination* assigns, combines and optimizes orders based on accessible capacity, demand and level of current stock. The *material reservation* is aiming to build a full supply chain from consumer requirements up to manufacturing of raw materials or procuring input materials. Finally, *flow optimization* ensures an optimal loading of bottleneck resources. (Quintiq, n.d..j)

2.3.4.2 Detailed Scheduling

It is not easy to quantify and model the innumerable scenarios into the planning solution. Nevertheless, the closer the execution time gets, the more likely the improvement of the schedule by human knowledge and expertise. Consequently, Quintiq's planning and optimization platform provides its clients with the support for right decision making, while keeping them responsible for each of their decision. With one click, Quintiq analyses hundreds of thousands of operations and recommends the optimal action course. It is nearly applicable in any situation, because it is flexible and scalable. It assists planners in establishing more precise and cost-effective schedules throughout the primary process of scheduling. Moreover, it is efficient in optimizing certain

sequences, because it is utilized for aligning schedules with the KPIs, minimizing the risks, increasing the resource efficiency and protecting from disruptions. (Quintiq, n.d..k)

Quintiq's detailed scheduling is implemented through three capabilities: visibility, schedule optimization and immediate feedback. *Visibility* at several stages of production is gained for reduction of WIP (work in progress) and for maximizing the performance of delivery. *Schedule optimization* is accountable for updating the schedule to eliminate disruptions and consistently reorganize tasks for establishment of the best schedule. Ultimately, the *immediate feedback* evaluates the quality of automatically or manually updated schedule with reconsidered KPI values, warns of any limitations and rules violations, and other outcomes resulted by changes. (Quintiq, n.d..k)

2.3.4.3 Order Promising

Quintiq's order promising method determines the availability of capacity and materials that are needed to fulfil the order and makes it possible for quoting a reliable date of delivery.

Quintiq provides its clients with an instant understanding of what they are able to promise and what they should promise through several elements: decision support, scenario planning, integration, KPI-based planning, and responsiveness. *Decision support* allows for acceptance of propositions that are driven by profit and gives a comprehension of how to plan orders. *Scenario planning* assist in figuring out how the performance of the order book is affected by supplementing an extra shift. *Integration* aligns manufacturing plans and logistics to recognize the full effect of order acceptance. *KPI-based planning* gives an insight of how and whether the optimal product mix defined in the sales and operation planning process differentiates from the product mix accepted by the sales executors. *Responsiveness* accommodates these last-minute orders the users just cannot decline, even while being out in the field. (Quintiq, n.d..l)

2.3.5 Workforce Scheduling

Successful enterprises with major and complicated workforces indicate that the bottom line can be significantly affected by optimizing human capital. And

it is not only about the efficiency, but also about long term influences of happier workforce and consumers.

On a single platform, Quintiq's workforce scheduling and optimization software combines the processes of scheduling and planning. Gaining the entire visibility and monitoring over the whole process of workforce, decision makers plan every day task scheduling, long-range capacity, and real-time rescheduling. Workforce scheduling system provides with actionable planning comprehensions that ensure productivity in accordance with such main client's objectives, as retention of customers and first fixed rates. (Quintiq, n.d..m)

There are six crucial facilities for business that are involved into each of Quintiq's solution: manpower planning, rostering, employee self-service, task assignment, time and attendance, day-of-operations workforce management. *Manpower planning* helps to recognize how the long-term recruitment plans can meet the demand. *Rostering* takes into consideration all the distinctive scheduling limitations, like change of preference, labour regulations and leave of absence. Through the Quintiq's mobile application, *employee self-service* increases the contentment of employees, by providing the opportunity to request for vacations, determine their working hours preferences and exchange shifts. To maximize usage and productivity, the *task assignment* is in control of optimizing work order assignments and tasks. It gets the right people at the right time and place. *Time and attendance* capability goes beyond establishing schedules and tracks employee hours. *Day-of-operations* provide planners with real-time awareness to quickly and cost-efficiently solve any malfunctions in operations. (Quintiq, n.d..m)

Quintiq's workforce scheduling and optimization software involves such company's distinctive limitations, as specific requirements of contract, qualifications and skills of employees, resource accessibility and labour regulations. Quintiq provides planners with the desirable and needful tools and knowledge to improve results. (Quintiq, n.d..m)

2.3.6 Advanced Analytics

Current business leaders claim that the reduction of confidence during the process of decision making appears due to information overload. Thus, organizations do not need more information; they seek for more insight. That

is the stage where advanced analytics enters. The enhanced dependability, performance and stability are achieved in case of better comprehension of the cooperation between consumers, network and assets, and precise measurements of the frequency, length and probability of events. (Quintiq, n.d..n)

Quintiq's advanced analytics technology is built to implement complicated calculations on big data capacity to provide predictions, insights and advices and recognize patterns. Firstly, the technology analyses data and convert it into knowledge. For example, the data reports to a producer that with every year of its life a part of machinery works a few minutes slower. Or, with the help of the technology, a logistic planner gets informed about characteristic frequency and length of postponements in a certain coverage area. Secondly, to accomplish even more exact predictions of forthcoming results, Quintiq's technology reviews the historical data. For instance, the knowledge derived from the client's data can disclose to a manager of railway infrastructure when a certain track section needs to be maintained. Ultimately, based on that knowledge, the technology assists in optimizing and planning its clients. It defines a suggested action course, which maximizes such crucial performance metrics, as levels of effectiveness, satisfaction of customers, and profitability. (Quintiq, n.d..n)

The efficiency and quality of schedules and plans are always increasing due to self-learning algorithms that study more about the client's business. Thus, owing to the growth of system's comprehension and more precise and accurate scheduling, the service and performance delivery is stabilized. (Quintiq, n.d..n)

2.3.6.1 Self-Learning Supply Chain

Quintiq provides the self-learning supply chain advantages, where self-learning algorithms unceasingly update and advance the information precision and insights dependability, which leads to improved forecasts, recommendations and planning. The process captures such factual data as processing, waiting and setup times as an input. While revealing minor modifications from continuous enhancement attempts, the process empowers

the adjustment of the big and evident changes in the organization. (Quintiq, n.d..o)

To convert information into insight, Quintiq utilizes: price optimization and revenue management, real-time optimization and knowledge discovery through master data management. To recommend optimal costs for existing or new services and products, *price optimization and revenue management* combines market trends with the historical data and customer behaviour predictions. The income is maximized and the accessible volume is optimally priced in case of accurate reading of sensitivity of price. *Real-time optimization* technology operates in real-time to help in identifying and responding to varying situations and maintaining optimal plans. To deliver state-of-the-art and precise calculations of setup times, travel and service times, duration of the tasks, and other related aspects, Quintiq derives valuable business knowledge, concealed in the data, through *master data management*. (Quintiq, n.d..o)

Moreover, Quintiq's self-learning system contributes in *on-time delivery*, which helps to predict service and travel times, based on recent and up-to-date data. By accurately estimating service and travel time, plans are accomplished as was aligned. Consequently, it decreases business failures and improves commitment to planning. (Quintiq, n.d..o)

2.3.6.2 Price Optimization and Revenue Management

To predict behaviour of customers, advanced analytics technology of Quintiq utilizes its client's historical data. It influences on market trends to propose optimal prices for existing or just appeared services and products. Algorithms determine prices and price elasticity, while considering such market forces, as demand, supply and rates. It also gives organizations an insight into the financial influence of pricing decisions and, subsequently, optimizes product mix and protects margins. (Quintiq, n.d..p)

Due to the maintenance of historical data, Quintiq's price optimization solution is consistent and accurate. The uncertain decisions that ruin the trust of customers to brand, are avoided.

Furthermore, with the help of the solution, managers may concentrate on such added-value activities as handling pricing campaigns, assessing the tendering processes, and reconstructing pricing strategies. To examine decision outcomes beforehand and estimate decision impacts on the total profitability, managers focus on creating “what-if” scenarios that increase the velocity and reliance of decisions made. (Quintiq, n.d..p)

2.3.7 Public Transport Planning

To correspond the requirements of rapidly-developing cities, the companies must be able to manage short-term demand uncertainties and unforeseen failures as well as plan for the long term.

Firstly, based on predictions of historical data and demand, Quintiq's public transport planner designs the future network. Secondly, by simulating the influence of the alternatives on flowing operations, it reveals concealed potential and savings advantages, and explores and analyses various scenarios. Thirdly, to maintain accuracy and high service levels, it tracks resources and status of service and quickly recognizes and resolves any kinds of problems. Fourthly, by fleet and crew optimization, it provides secure service, keeps costs low and, hence, achieves a competitive advantage in the process of tendering. Fifthly, it helps to retain employees and increase consumer satisfaction, by ensuring equitable work distribution and by considering personal preferences and labour regulations. Finally, it reduces gaps, minimizes the amount of unoccupied vehicles and maximizes usage of network, thereby, increasing efficiency. (Quintiq, n.d..q)

2.4 Optimal Planning

2.4.1 Optimization technology

To ensure the collaborative work of material, labour and time in order to meet the client's Key Performance Indicators, the complicated processes in Quintiq's supply chain are optimized. Optimal planning works in collaboration with an accurate business model and is set in conformity with a certain business. The results are delivered through Quintiq's optimisation technology. (Quintiq, n.d..r) There are five optimization technologies that shape a major part of Quintiq's optimizer: quill, mathematical programming, constraint

programming, graph programming and path optimization algorithm. (Quintiq, n.d..s)

Quill (Quintiq Intelligent Logic Language) is patented language of configuration and is at the centre of optimizer. Quill unites the optimization technologies, contributing an efficient and effective work in its entirety. Firstly, it provides with uncomplicated expression of local search heuristics and construction heuristics - this is equivalent to processes that human planners implement, while establishing from scratch solutions and locally improving solutions. Secondly, to generate solutions that rely on the forces of every five elements, Quill integrates optimization technologies in one optimizer.

Mathematical programming is steady and mature. By selecting the proper group of building blocks that jointly compose the preeminent solution, regardless of complicated restrictions and relationships, mathematical programming helps to resolve puzzles. For instance, it assures the highest level of service and shortest distance, by determining the best feasible routes' combination. *Constraint programming* is efficient in continuous elimination of potential solutions in accordance with the restrictions that can be non-linear. It also effectively solves the scheduling puzzles. *Graph programming* is utilized to discover solutions, since a lot of practical puzzles have a graph element. It is utilized to struggle with such challenges, as crew diagramming and routing of vehicles. *Path optimization algorithm* is Quintiq's own large-neighbourhood-search technology, which investigates much bigger neighbourhoods than local search. It is mainly utilized in production planning and routing of vehicles.

(Quintiq, n.d..s)

2.4.2 Quintiq Platform

With version 5.0 of Quintiq's supply chain planning and optimization software, it is possible to optimize and plan both each link and the entire supply chain with higher levels of service and more control on a single platform.

To guarantee efficient outcomes, Quintiq concentrated on adding value in four main areas: agility, mobility, intelligence and the human touch. Firstly, to represent the flowing operations' status, Quintiq 5.0 version simplifies the update of plans for planners, regardless of the varying annual distribution of sales with an intention of the company to provide more capacity to a developing market or of the absence of senior engineer-technologist due to

health issues. Secondly, it allows an access to mobility server that helps to monitor the ongoing interaction between mobile workforce and Quintiq and empowers step-by-step reconcile among the supply chain realities and optimal schedules. Thirdly, to create an exact fit model, Quintiq understands and analyses each business aspect. Its software is designed to provide quick evolvement of a stabilized and accurate model and to allow for an easy update of the model anytime. Lastly, by means of the interaction among machines and people, an optimal planning is reached. Quintiq provides planners with complete visibility and control that enables modification of the plan optimization. The interface can be shared among co-workers and is totally user-specific. Through customizable Key Performance Indicators dashboards and sensors, planner may track the main performance indicators remotely. (Quintiq, n.d..t)

2.4.3 Quintiq project lifecycle (QPLC)

Quintiq project lifecycle (QPLC) is own working methodology of Quintiq, which gives the best understanding of how the software company implements their projects. Every Express QPLC phase has its own objective and critical path, which determines the minimum time needed for an operation, since it is analysed on a computer for a big enterprise. (Quintiq 2016a.)

Figure 1 presents the planning of project phases in terms of milestones. It is not possible to start a new phase until the prior phase has been accepted and closed, since all the phases are interconnected and dependent on the deliverables of the earlier stage. The project efficiency can be negatively impacted, in case of not meeting any milestone due date or phase end date. In consequence, the project end date is delayed and the budget is increased. (Quintiq 2016a.)

The main aim of the **Initiation phase** is to have a productive start to the project from the beginning, so that the entire project is following the QPLC principles, and all parties included understand the impacts of these principles on project organization, budget, timeline, scope and information structures. The licenses purchasing is a prerequisite to fulfil this obligation and must be implemented at the beginning of the project. The initiation phase includes the following duties: setting up the Quintiq and customer team, completion of applicable introductory e-learnings, finalizing the project plan, kick-off meeting

and meeting with the Steering Committee, QAD (Quintiq Architecture Document) and QCS (Quintiq Integration Document) documentation. The Project plan will be accepted if it describes in detail the expected activities and due dates for the duration of the project. The QAD will be accepted if it describes in technical terms the flow of data that enters and leaves the Quintiq system. (Quintiq 2016a.)

Data Mapping phase ensures that the customer's processes and data are mapped to the standard functionality of the product. The required data type and format should be clear. Among data mapping obligations are: completion of Key User Training e-learnings, creation of data collection plan, examination of environment, infrastructure and connections to existing legacy systems, working with the client interface and defining and agreeing on Optimizer Benchmark acceptance criteria¹, and the number and type of benchmarks. It also includes: data questionnaire, Business Mapping Document (BMD) and Quintiq Integration Document (QID), capable and consistent subject matter experts, third-party System Interfaces and remote access to customer test environment. (Quintiq, 2016a.)

The goal of the **Data Collection & Loading phase** is to guarantee that sample data, which is representative of the data used in current systems, is collected, loaded and cleaned. It is essential before the model can be confidently tested during the model validation phase. It includes: Data Loading Milestones (as per collection plan), Model Test data², 100% width, 50% depth, Knowledge Table data, Model Test data, 100% width, 100% depth (data quality, all correct and complete), Performance Test Design, Load Test Design, Model Validation test plan, clean quality views, Performance Benchmark, Load Benchmark. Moreover, standard scenarios have to be adapted and agreed and third-party System Interfaces must be ready. (Quintiq 2016a.)

The main aim of the **Gap Analysis** phase is to identify and document any essential additional functionality to be added to the model. It also prepares user stories for building the functionality and additional scenarios to test the

¹ The customer provides the number and type of benchmarks to be used for the acceptance criteria.

² Client will provide a data set weekly that is generated from live data without manual interference. Alternatively, it can be generated in a similar way to sample data, if that is representative of live data.

functionality. Moreover, during the gap analysis phase, the remaining project plan and budget should be revisited considering insights gained in this phase. The phase focuses on: updated BMD (Business Mapping Document), QID, QAD, project plan and modelling voucher. (Quintiq 2016a.)

Express Modelling phase enhances the standard software to include a limited amount of additional functionality. During this phase, the client updates the test scenarios and the test plan that will guide the activities during the Model Validation phase. Such deliverables, as updated Model Test data and test scenarios, interim functionality demonstrations, pre-test of all core Test Scenarios, Model Validation Test plan and Third-party System Interfaces are included in the phase. (Quintiq 2016a.)

Model validation phase validates that the Quintiq Product has been correctly configured to meet the scope, prior to moving it to a production environment. To reach this goal, Quintiq depends heavily on the involvement of the customer. The phase contains: key user training, customer interfaces smoke test, successful manual planning check³, Performance Test Results and Load Test Results on Quintiq and customer environment, User Documentation and frozen issue list. Besides, during this phase, all test scenarios are accepted, Agreed Test Scenarios are touched, live environment to QID and QAD are set up. (Quintiq 2016a.)

Implementation phase ensures that the system is ready to go live. Amid implementation phase deliverables are: end user documentation, trained end users, passed parallel passive and active tests, Agreed Project Voucher⁴, passed Support Audit, and signed support contract. (Quintiq 2016a.)

The goal of the **Post Go-Live Support** phase is to provide support to the key users when they use the new Quintiq solution in a live environment. Thus, it supports expert planners, monitors KPI and schedules value scan. (Quintiq 2016a.)

³ The customer can create a plan in Quintiq and this plan is considered feasible by the planner and application.

⁴ The **Project Voucher** is an important means to facilitate going live. It is an agreement that consists turning any outstanding high priority issue into a fixed number of consulting days to be provided by Quintiq before project closure. It allows the customer the flexibility to re-prioritize what they would like Quintiq to work on in case other priorities are discovered after going live.

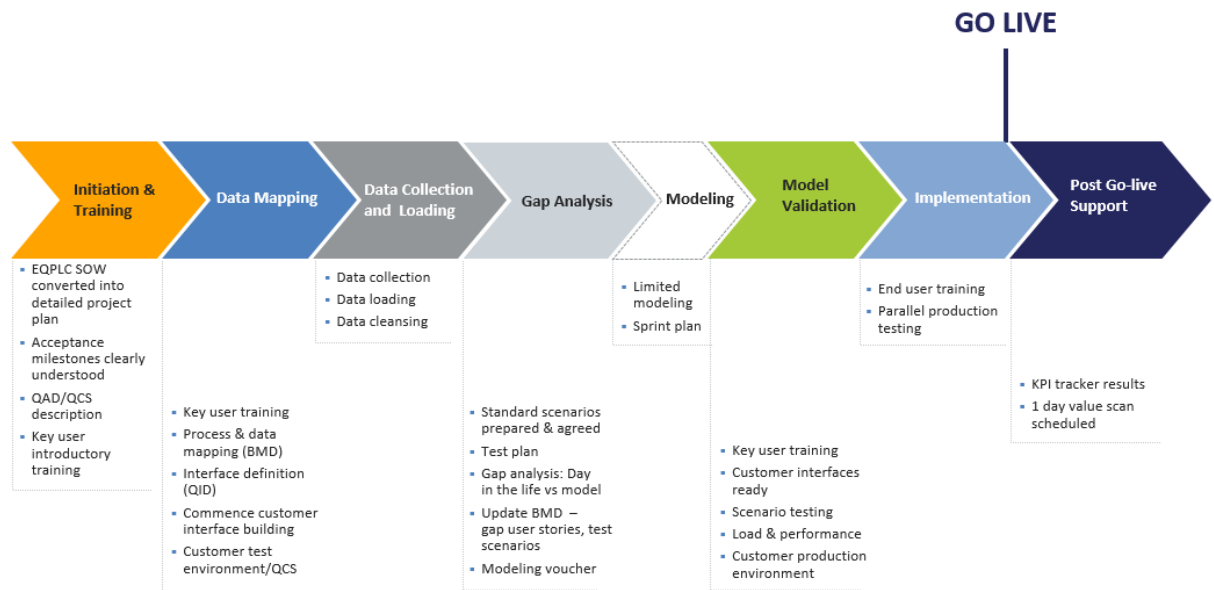


Figure 3 The Express Quintiq Project Life Cycle (EQPLC) methodology (Quintiq 2016).

To sum up, an important part of project management responsibilities is to continuously assess, monitor and mitigate project risks. It is important that both Quintiq and its clients take part in creating the initial list of risks to ensure that all potential project risks have been identified and can be mitigated to minimize the overall project risk.

2.5 Summary of literature review

This section will summarize key points from literature review. The theory section started from the interpretation of such terms, as supply chain and supply chain management, associated with the research study. Several authors' views on the identification of the concept of these two terms were presented. A brief introduction to the impacts of Information Technology on supply chain followed by a clarification of such IT tool, as Advanced Planning Systems (APS) that "computerize" planning by supporting the choice of one or a several solutions, were presented. Benefits of APS, such as visualization of information, reduction of planning time, and easy use of optimization methods were detected. Additionally, key attributes of APS were defined and explained. It was important to give a brief understanding of APS term, since this thesis focuses on the software company, which specializes in advanced planning.

The major part of theoretical section was assigned to planning solutions along the supply chain of the case company. An identification and a thorough

explanation of these solutions were provided with an eye to give unfamiliar reader an understanding of how the company implements its operations. The planning tasks depend on the certain supply chains and industries, what further will be shown in the case studies of the company.

In the following section, a brief interpretation of company's optimisation technology was provided. It was revealed that the company's optimizer includes five optimization technologies, such as quill, mathematical programming, constraint programming, graph programming and path optimization algorithm. Through this optimizer, the company meets the client's Key Performance Indicators and delivers results that ensure the collaborative work of material, labour and time.

The last section of the literature review accurately described Quintiq project lifecycle (QPLC), which is considered as own working methodology of the case company. QPLC gave the best understanding of how the software company implements their projects.

3 METHODOLOGY

3.1 Research strategy

This research study focuses on one specific company (Quintiq) and aims to discover answers to questions posed in a real-life context. Thus, the research strategy used for this thesis is case study, the aim of which is to conduct an in-depth analysis of organizational and managerial processes of a specific case company, to answer the main research questions and, in consequence, to make contribution to the knowledge of organizational phenomena. Robson (2002, 178) determines case study as a strategy for implementing investigation that includes an empirical inquiry of a certain contemporary phenomenon in its real-life context utilizing several sources of proof. A case study strategy has a substantial capability to produce answers to the 'how' as well as 'why' and 'what' questions. Thereby, the case study is mostly utilized in exploratory and explanatory research. (Saunders et al. 2009.) The case study strategy seems to be the most appropriate strategy for this thesis since the main research question that needs to be answered is: "How does Quintiq software help companies in improving their Supply Chain Management (SCM)

Key Performance Indicators (KPIs)?" This type of "how" question is a justifiable rationale for implementing an exploratory case study, the purpose being to elaborate relevant hypotheses and proposals for further investigation. (Yin 2003.)

A well-constructed case study strategy can be a very useful method of examining existing theory, can enable the researcher to argue about an existing theory and provide an origin of new research questions, as well (Saunders et al. 2009). Moreover, case study assists in explaining both the process and result of a phenomenon by means of analysis of the cases under investigation (Tellis 1997).

Even though the research focuses on and studies a single organization overall, several logical sub-units inside the organization are involved. These sub-units are the company's clients that utilized the software. Consequently, the research analyses more than one unit, which indicates that the research strategy utilizes an embedded case study. These sub-units add considerable possibilities for extensive analysis, while increasing an understanding of the single case (Saunders et al. 2009).

3.2 Sample selection

The research population are the client companies of the Quintiq company. There are 155 company's customers in total. The companies are operating in different industries, such as: manufacturing, metals, natural resources, logistics, aviation, rail, public transport, broadcasting, security, and healthcare. Additionally, the companies are situated in different regions, like North and South America, Europe, Middle East and Africa and Asia Pacific. Due to the time limits to conduct this research, the population needed to be downsized to the fewer companies' number. Ultimately, the embedded unites, specifically four client companies were selected through non-probability, heterogeneous purposeful sampling method. Purposeful sampling focuses on cases rich in information what assist in conducting an in-depth study. (Patton 2015.)

Moreover, it allows using the researcher's discretion to choose cases that will answer research questions and meet the objectives in a best way (Saunders et al. 2009). In heterogeneous sampling method one or more key variables or characteristics must be defined and must vary as much as possible (Barcik 2016a). Thus, the researcher decided to select four organizations, that have

already imported a Quintiq software planning system, however, they are functioning in different industries, requiring dissimilar software planning solutions in various supply chain departments and possessing individual objectives.

	Port Kembla Coal Terminal (PKCT)	Airservices	ELVAL	Marquis
Year of establishment	1849	1995	1971	2006
Area of operation	Australia, south of Sydney	Australia	Greece, Bulgaria, the United Kingdom	United States
Year of Quintiq utilization	2010	2009	2009	2013
Industry	coal exporting terminal	air navigation service provider	aluminium manufacturer	logistics of crude oil
The solution required	maximizing throughput, reducing planner fatigue	workforce planning solution	maximizing capacity utilization, reducing inventory and improving delivery performance	optimize the transportation of crude oil

Table 1: Sample characteristics

The Table 1 above provides the sample characteristics that introduce the important information about the organizations analyzed in this thesis: the year of establishment, area of operation, year of Quintiq utilization, industry the companies operate in, the solution required to be implemented. The chosen case companies are: Port Kembla Coal Terminal (PKCT), Airservices, ELVAL and Marquis. PKCT is a coal-exporting terminal that is situated in Sydney, Australia. It employs approximately 120 workers. Airservices is Australia's air navigation service provider, which has approximately 4,000 employees working in the organization. ELVAL is a leading aluminium manufacturer, the extensive manufacturing base of which includes 12 plants in Greece, Bulgaria and the United Kingdom. Marquis Inc. focuses its business in logistics of crude oil. It conveys crude oil from its origins in the United States to multiple destinations along the Mississippi River System.

The reason for selecting non-probability, heterogeneous purposeful sampling method is justified by the necessity to determine if the successful results after software implementation found in one case occur in other cases and,

consequently, to draw a specific conclusion from these findings. Additionally, it was essential to choose these companies to better present real-life business information, to increase validity of the study and to obtain a rich comprehension of the research context.

3.3 Research purpose

The research questions and objectives and the research purpose are directly dependant on each other. The way the research questions are asked results in the choice of the research nature, which can be classified as exploratory, explanatory or descriptive. In other words, the purpose of the research can be either to explore, explain or describe how and why particular things are happening in specific situations. There can be more than one purpose in the research project and, as stated by Robson (2002), the purpose can also vary over time. (Saunders et al. 2009.)

An exploratory study helps to understand what is happening, specifically in a recondite situation. The study also attempts to find new insights and create hypothesis and ideas in various and further perspective (Robson, 2002). An exploratory study can be used if the researcher wants to clarify a comprehension of an issue, for instance, if the researcher is uncertain of the exact problem nature. Saunders et al. (2009) indicated three ways to conduct an exploratory research: literature search, interviews with experts in the field and focus groups interviews.

According to Robson (2002) the main purpose of descriptive research is to depict profile of situations, events or persons with high degree of precision and accuracy. The descriptive research serves as an expansion or predecessor to a piece of exploratory or explanatory research. It is important to possess an explicit picture of the phenomenon or, in other words, to have an extensive prior knowledge of the researched or described situation in order to be aware of which information to collect.

An explanatory study establishes causal relationships amid variables or, similarly, investigates a problem or situation to explain the relationships amid variables (Saunders et al. 2009). Explanatory research based on both exploratory and descriptive research and it tries to explain why particular things happen (Barcik 2016b).

As stated above, this research adopted a case study strategy, which is most often utilized in exploratory and explanatory research. The researcher aimed to identify the improvements and areas of improvement within a company that are affected by Quintiq software solutions. Due to the fact, that a researcher had little knowledge regarding the topic, an exploratory strategy was used in order to provide initial insight into the phenomena, to explore this certain topic and let the ideas emerge, so that through this exploration process some of the potential factors could be identified. Afterwards, a descriptive research provided a supplementary information in order to expand an understanding of the topic. Correspondingly, an accurate description of an implementation of case company's operations and its main tasks along the supply chain was provided. The description of other relevant literature, like Advanced Planning Systems and its key attributes or Key Performance Indicators for the supply chain was included, as well. Last but not least, an exploratory research explained why the case companies adopted software planning systems.

To sum up, the purposes of this research are exploratory, descriptive and explanatory. The conjunction of these three purposes allowed the researcher to describe a phenomenon, to explain why it happens and to explore factors that impact it.

3.4 Research method

Case study research can utilize either quantitative or a qualitative approach. The major difference between qualitative and quantitative approaches is that qualitative approach cannot be precisely calculated and measured, and is usually expressed in words, rather than numbers, whereas, quantitative approach allows accurate measurement and commonly expressed in numbers. Qualitative data is descriptive in character and hinge on an accurate determination of words' meaning, variables' and concepts' development, and the formation of interconnections amid those. (Walliman 2011.) Qualitative approach concerns the in-depth analysis and is mainly considered as an exploratory research. It is utilized to obtain a comprehension of basic reasons, motivations and beliefs and to provide insights into the problem. Moreover, qualitative research helps in identifying trends in thought and views, and in deeper immersion into the problem. (Wyse 2011.) Among examples of qualitative data are notes of observation, transcripts of interview, historical

records, literary texts, documentary films (Walliman 2011). On the other hand, quantitative research is utilized to quantify the problem through statistics. It quantifies behaviours, attitudes, views, and other specific variables, and generalizes outcomes from a bigger sample population. (Wyse 2011.) Quantitative research methods outcomes can be found through performance data (statistics, calculations, etc.), economic data, census figures (Walliman 2011).

The significance of selecting the correct approach is very challenging, since a proper research has to be trustworthy (Starman 2013). Research objectives assist in understanding which research method is more corresponding and effective to utilize for a certain study. In order to answer the main research question and sub-question, it was important to comprehend the reason behind them and to investigate the subject. Additionally, it was essential to gain a comprehensive insight of the phenomenon and to analyse real cases in the form of Quintiq client companies. Thus, the researcher decided that the application of a qualitative method in this thesis would be more efficient.

3.5 Data acquisition

Primary data, namely archived data, are the major data that were collected for this research. For this type of research project, archived data provide the major source to address the objectives of the research and to answer the research questions.

There are several reasons for archived data utilization for this research. Firstly, due to the limitation of time for conducting this research, it was decided to give preference to archived data, since it enormously saves such resources, as money and time, while ensuring the data promptness and quality. Secondly, during the research project implementation, the researcher had a direct contact with the employee of the case company, Enver Revazov, who takes the position of Business Development Executive. Owing to that, the researcher was provided with the quality and, most importantly, credible data produced by teams of expert researchers with extensive resources and substantial budgets. Thirdly, owing to the data that have already been collected, the researcher had more time to reflect on the theoretical objectives and such essential issues, as deeply investigating and analyzing the case

company, its areas of operation and solutions provided. In consequence, more time and effort were spent to analyze and interpret the data.

This research utilized archived data, consisted of written and non-written materials. The written materials were acquired through organizational records, such as internal reports and communications, like emails and personal interaction with the employee of the case company. Non-written material was collected through video recordings that included interviews with the staff of Quintiq client companies. The interviews were conducted by Quintiq for company's own purposes and before this thesis project was carried out. However, the questions of the interview corresponded to the objectives of this thesis and assisted in answering the major research questions. Thus, the video recordings were used as one of the most essential data collection methods for this thesis. The material provision was arranged by the researcher's mentor within the case company and which was further used specifically for this research project.

3.6 Data analyses

The data analysis process is believed to be one of the most essential steps of research conduction. It permits the researcher to come up with new concepts and evolve conclusions that contribute to the research project. (Saunders et al. 2009.)

As stated above, the collected data is qualitative data, so the researcher utilized the qualitative method of data analysis. Fullness and richness are the major characteristics of qualitative data that are based on the researcher's possibility to investigate a subject in as real way as is feasible. While analysing, the complicated, diverse and non-standardized nature of the data that have been assembled have to be summarized, categorized or restructured as a narrative in order to maintain meaningful analysis. Summarizing, categorization and structuring of meanings can be utilized independently, or in conjunction, to endorse the data interpretation. (Saunders et al. 2009.)

In this research, the analysis process of qualitative data began at the time as the researcher started collecting these data and continued subsequently. With the help of summarizing, the major amount of text was condensed into fewer

words. Qualitative data in form of such organizational documentation, as internal reports were summarized and further analyzed. Initially, both written and non-written materials of this research were provided in the form of narratives. Consequently, comprehension and meaning were encouraged through analyzing data in their original form rather than by fragmenting them by means of a process of evolving categories and coding. The non-written material in the form of video recordings was transcribed and analyzed in order to determine the major ideas that could assist in answering the research questions. These ideas were presented in a form of both direct quotes from the interviewees and narratives.

4 RESULTS AND DISCUSSIONS

As stated above, archived data were collected from the organizational internal reports and video recordings. In order to answer the main research questions, this section concentrates on four Quintiq client companies that operate in various industries: natural resources, aviation, metal and logistics. The types of planning solutions implemented by Quintiq software that are described in client companies' cases correspond to the theory chapter, specifically planning tasks (solutions) along the supply chain of Quintiq. Additionally, to support these reports and, consequently, ensure the data validity, other sources, such as video recordings that comprised of interviews with the staff of Quintiq client companies were utilized. These videos contain a lot of useful and credible information for this research, where the speeches of such essential company's staff as resource planning and rostering manager, director of innovation, logistics manager, planning manager are given.

4.1.1 Port Kembla Coal Terminal

Port Kembla Coal Terminal is a coal-exporting enterprise, which serves two of wealthiest coal reserves, the western and southern coalfields of New South Wales. The company exports steaming and coking coal of high quality to clients around the globe, mainly to India, China and other Asian countries. (Quintiq 2010b.)

As is written in the company's report on Port Kembla Coal Terminal, the problems of receipt handling, storage and shipment of such big coal volumes,

involving managing lorry and train unloading, developing optimal loading of ship and controlling local storage, contributed in a complicated planning problem. In addition, changes in demand and resource constraints - are those challenges that must be solved, as well. (Quintiq 2010b.)

The planning solutions PKCT utilized before Quintiq were principally paper-based – unintegrated individual spreadsheets models that did not allow the visibility of the future consequences of planning decisions for any substantial period. Frequently, when there was no ship in the port, loading services were inactive. Moreover, planning was strongly dependant on a small experts' association with the senior and most experienced planner approaching resignation. (Quintiq 2013c.) With an expansion plans that could ultimately increase throughput at PKCT, the company realized that the better planning system was required (Quintiq 2010b).

The solution had to be able to handle the multi-level planning responsibilities related to ship loading, governing local storage and lorry and train unloading. The company was searching for a highly flexible advanced planning system, which could cope with their complicated working environment. The multiple business regulations connected to stockyard utilization, machinery and other essential port assets had to be considered. Finally, the visibility and transparency of solutions on inbound and outbound restrictions were on equivalent significance in the process of selection, as well. (Quintiq 2013c.)

Due to Quintiq's vindicated track record in the industry, the choice fell precisely on their solution planning system. “The specific features that were important in the selection of the Quintiq solution were the degree of integration of both inbound and outbound logistics and in concept with that is the transparency and visibility of those decisions on either inbound constraints or outbound constraints” explained Mark Beale, PKCT planning manager. (Quintiq 2013c.)

With the help of Quintiq, PKCT could obtain exactly what was required: a solid solution with flexibility. Moreover, one of the main characteristics of the system is that it empowers real-time feedback on inbound and outbound logistics limitations and their stockyards as well as optimizes throughput throughout PKCT. The real-time visibility throughout operations of PKCT embraces planning of stockpile and ship loading resources. Based on scheduled arrivals

of vessel and incoming stock, it becomes possible to optimize stockpile planning. Regarding tidal circumstances, hatch plans, and scheduled facilities handling, loading resources are planned. Furthermore, Quintiq's platform embraces tactical planning to solve inventory problems and port scheduling on a weekly basis and operational planning to maximize throughput daily. "What-if" scenario abilities provide full insight of the planning decision outcomes on port operations. Also, the system allows stakeholders to implement practical decisions on the monitored supply chain parts and supports PKCT in enhancing the efficiency and visibility throughout the supply chain. (Quintiq 2010b.)

Cost and schedule were the problems for the realization, however, both the tight budget and tight time frame were met. The integration of data system was the other challenge that demanded both organizations to unite to utilize their intellectual power for result delivery. The problem was successfully solved, as well. As the result, during six months, the organization announced that port terminal throughput was enhanced, stockyard utilization was maximized and visibility of scheduled maintenance was improved, which contributed in capacity, so shorter coal ship lines. Those areas that had restriction challenges, like stockyard, were of best Quintiq's implementation solutions. (Quintiq 2010b.) The utilization of the stockyard increased by 10%, while bottlenecks on the inbound and outbound restrictions were reduced and throughput was increased (Quintiq 2013c).

The optimization of the planning process was executed through provision of support of expert decision, incorporation of the embedded shared knowledge and automation of planning functions. Due to foresight and visibility possession, planners are able to cope with large forecast requirements and manage outages, while reducing tiredness and working under less stress. Owing to Quintiq solution, PKCT can design the performance-based planning. Managers may evolve data-oriented goals and make justified decisions on the controlled and influenced supply chain parts. (Quintiq 2010b.) The visual ability to depict restrictions was also very important, since after the issue was detected, it was addressed through such powerful tool, as the scenario or what-if" planning (Quintiq 2013c).

4.1.2 Airservices

Airservices is an Australian corporation owned by government, which provides secure, productive and environmentally accountable services to the aircraft industry. The company employs about 4,000 workers, including nearly 1,000 controllers of air traffic, operating in two main centres in Brisbane and Melbourne, 29 towers at regional and international airports and four terminal control blocks. Airservices manages air traffic operations for more than 80 million passengers on over 4 million international and internal flights annually. In addition, the corporation's technicians and engineers deliver over 440 surveillance aids and airways navigation aids, and telecommunications. Moreover, more than 740 support and operational employees provide firefighting services and aviation salvation services. (Quintiq 2009d.)

The Quintiq' report on Airservices states that it is complicated for air navigation service providers (ANSP) to plan air traffic control labour force because, while creating rosters, they must consider such factors, as shift tasks, management of fatigue, qualifications and training. The planning of manual roster includes consideration of personnel preferences, demands for meeting times and training, skills and qualifications. Moreover, while developing the staff roster, it is essential to take into account such factors, as conditions of work agreement, compulsory security requirements, fair shifts, sector assignments, and planned and unplanned leave. (Quintiq 2009d.)

Before Quintiq's implementing, Airservices utilized several systems for every phase of the process of rostering. For system maintenance, multiple manual and time-consuming processes were required, compelling export and import of numerous data, which, in consequence, influenced the integrity of data. Thus, the corporation needed the holistic unification with organization's SAP HR and payroll system. (Quintiq 2013e.)

Firstly, the corporation demanded the new solution to guarantee both an end-to-end planning system for ANSP's processes of rostering and integration with the SAP HR and payroll system and its IT-environment. In order to empower management to guarantee compliance with numerous industrial agreements, rules and licensing components of providing an air traffic control service, the enhanced visibility over every stage of process of rostering had to be provided, as well. Besides, the enhanced visibility would assist in deeper and

thorough analyses and improved reporting to support company's operations. Secondly, the new solution was essential to embrace company's demands for short and medium-term scheduling of air traffic management and other support personnel. Thirdly, to control the risk referring to fatigue, the software had to deliver an increased fatigue risk management system (FRMS). Since Airservices has already possessed set of rules specifically evolved for its operating environment in cooperation with Integrated Safety Support, its external fatigue advisers, the implementation objectives were to integrate an extra FRMS set of rules and its connected processes to forecast and manage possible serious and aggregate influences of fatigue. (Quintiq 2009d.)

As the result of solution for Airservices' air traffic management labour force, firstly, Quintiq managed to adapt to the particular Airservices' requirements and to enhance its rostering process, by reducing time of processing and cost of printing and by enabling about an 80% decrease in number of queries related to payroll. (Quintiq 2013e.) Secondly, the software solution provided the visibility level over the whole process of rostering, which led to enhanced capabilities of management that determined areas where expenses and hidden capacity in the network could be diminished. Thirdly, with the help of Quintiq's solution for increased functionality, which is easy to utilize, Airservices increased their productivity. In addition, the execution of organization's improved fatigue risk management system was facilitated by Quintiq's software support tool. Lastly, Airservices personnel is now able to utilize an only tool across every stage of process of rostering. (Quintiq 2009d.)

Concerning the Fatigue Risk Management System (FRMS) project results, by means of a two-stage process based on an extra set of rules, Quintiq now allows Airservices to control risk related to fatigue (Quintiq 2013e). This extra rule set was specially evolved for operating environment of Airservices in cooperation with its external fatigue advisers - Integrated Safety Support (Quintiq 2009d).

The first process stage is completely automated inside the software. It specifies a possible level of fatigue for every shift and notifies planners of feasible raised fatigue-risk scenarios in real time. The second stage of the process includes a decision-support tool that suggests planners to review any extra or environmental factors that can raise fatigue. Additionally, planners are

supported in the application of controls to decrease the fatigue-related risk effect. Finally, the solution with convenient interface aided in the implementation of increased FRMS, which involves all the tactical, strategic and connected risk evaluation processes. (Quintiq 2009d.)

4.1.3 ELVAL Group

ELVAL Group - the aluminium processing and marketing sector of VIOHALCO. ELVAL is one of the world's most significant aluminium rolling industries, situated in Greece. The company's vast production base involves 12 manufacturing factories in Bulgaria, United Kingdom and Greece and produces several various aluminium products that meet the needs of the construction, shipbuilding, automotive, printing and food industries. Above 85% of company's output is exported to more than 80 countries globally. (Quintiq 2009f.)

Daily, ELVAL must decide on a large amount of complicated scheduling and planning activities that influence the bottom line of the company. There are several reasons that cause the complication of planning: challenges in uniting orders on coils in the cold area, numerous machines in the manufacturing process in various manufacturing areas (hot and cold rolling, melt cast, foil and painting), compound product portfolio with a lot of various alloys and measurements, a lot of orders varied in size, and a number of manufacturing regulations and restrictions. Moreover, the thorough reconsideration of planning that was necessary in case of process disruptions, was another substantial problem inducing this complexity of planning. (Quintiq 2009f.)

Earlier, ELVAL was utilizing several applications, however, the problems of production delays, difficulties with manufacturing routes and lead times remained the same. Thus, the company realized the need in an advanced software. ELVAL was looking for a tool that could optimize the company's supply chain by delivery performance improvement, throughput maximization, and inventory levels reduction. (Quintiq 2009f.)

The company chose Quintiq software solution, because it had a substantial experience in managing production planning for aluminium plants and in aluminium industry, in general. Manufacturing, sales and planning sectors' representatives were engaged in the process of selection and evaluated

Quintiq software solution as the highest among three other competitors due to its methodology, implementation plan, better value, comprehension of ELVAL's business and needs, its capability to merge with SAP. (Quintiq 2009f.)

The Routing Generator, followed by the Company Planner was the first Quintiq's solution to be executed. Afterwards, the Melt Cast Scheduler, Cold Mill, Hot Mill and Foil Scheduler were implemented, as well. (Quintiq 2009f.)

Previously, after ERP implementation, producers have faced with losses of 19 million euro inside the industry because of go-live problems. However, after implementing Quintiq, throughout all the interim go-lives for the different projects, there was no loss of machine production time. Moreover, sales also remained without interruptions. Finally, the functionality necessary for costing was also totally covered by Quintiq, which contributed in savings appearance. (Quintiq 2009f.)

Currently, by utilizing advanced optimisation algorithms, the Quintiq's software controls ELVAL's budget verification, material demands planning and final capacity planning. To direct ELVAL's everyday scheduling, the plans are utilized. Throughout the process of manufacturing, the Quintiq system forecasts the awaited end date, which is utilized to inform ELVAL's clients. Likewise, ELVAL's representatives network is informed of the awaited dates of delivery through the corporate SAP ERP system. Thus, now ELVAL can quote accurate dates to consumers and deliver the goods as assured. To control such information as times of production, returns of scrap and standard routes of production, the Quintiq system includes a routing library, which functions as a large database. The information is directed to the SAP system for costing utilization. (Quintiq 2009f.)

The substantial advantages have appeared since Quintiq implementation. Among those benefits are: more practical and logical production requests, the decrease and flattening out of backlog by more than 50%, the enhancement of OTIF (Delivery on Time, In Full), the decrease of manufacturing cycles for some products by about 30%, the reduction of delivery lead time by up to 50%, and the considerable improvement of WIP and inventory. Among the other advantages is the simplicity in making corrections to the plan and the improvement of adherence to the Company Planner plan by scheduling

applications. To diminish delays and maximize efficiency, the planning of capacity allows the opportunity of such interferences, as the production routes modifications, resource changes, etc. Furthermore, the system allows the measurement of decision outcomes and evaluation of alternative scenarios. The production planning decisions quality is determined with the assistance of KPIs. Finally, with the Quintiq system, it is possible to exchange production planning staffs among majority functions. Without the necessity for IT department interference, most of the reports are generated by the users themselves. (Quintiq 2009f.)

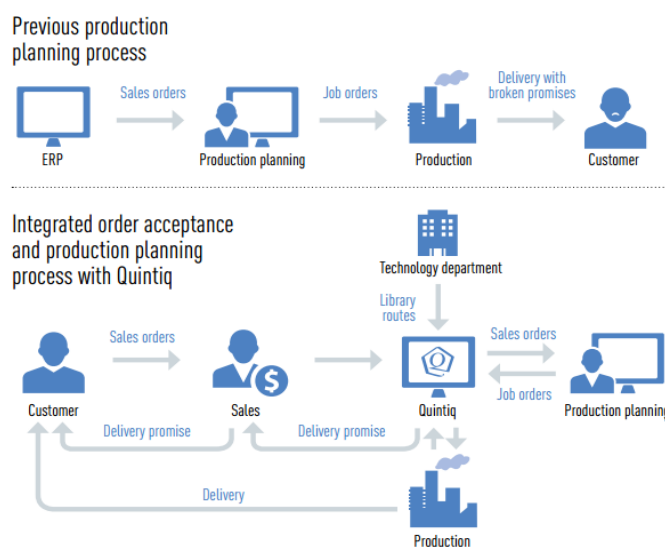


Figure 4 Production planning process transformation (Quintiq 2009).

As shown on figure 4, the Quintiq's introduction of the order combination concept allows one coil to service a lot of order lines or for a few coils matched to service single order line. Quintiq decreased production lead times for some products that were up to twelve weeks, down to approximately four weeks. The decision-support function and improved visibility now allows fast responses to different situations. (Quintiq 2009f.)

In conclusion, the efficient implementation of the Quintiq software is achieved through its implementation process (QPLC) and technology that enables challenges to be managed productively.

ELVAL proceeds the expansion of the Quintiq solution utilization over more of its operations. Now, the blending optimizer for company's operations of melt cast is being developed. Quintiq solution is also implemented in SYMETAL operations. SYMETAL manufactures approximately 50,000 tons of foil and foil

annealing furnaces planning had always been a problem. Nevertheless, Quintiq solution has contributed in instant visible precision in the capacity estimation for the foil annealing furnaces that facilitated the enhancement of OTIF deliveries. (Quintiq 2009f.)

4.1.4 Marquis

Till 2012, Marquis businesses had been functioning in the areas of manufacturing and worldwide transportation of ethanol, as well as agricultural products trading and grain conveyance. In addition, Marquis, had an experience in rail and lorry operations. Afterwards, the company focused their business in logistics of crude oil. To transfer the product to refineries on the lower Mississippi River, the oil and gas manufacturing evolvement from the Bakken formation in North Dakota demanded transport. Marquis defined the optimum destination route for transferring Bakken crude by train to a custody terminal in Missouri and then by barge to refineries near Memphis and New Orleans. (Quintiq 2013g.)

Monthly the company was transferring approximately three unit trains and in the beginning their spreadsheet and whiteboard scheduling solution was enough for assets tracing. Jason Marquis, the president of Marquis organization, believes that “when you manually manipulate a bunch of different information in a variety of spreadsheets, there is an opportunity for things to get overlooked.” He also thinks that “it takes a lot longer for you to react to short-term market situations.” (Quintiq 2014h.) Bakken crude oil manufacturing began to rapidly grow together with Marquis' expansion. Within six months, the terminal in Missouri started to receive 30 trains a month, which is 1000% raise in operations. Consequently, the existing solution's capability to monitor scheduling and long-term business strategy lost its strength and was not able to meet the fast-growing requirements. Moreover, Marquis had only two tanks and two tracks in Missouri and the expansion of their space was not sufficiently quick. This resulted in slowed down decision-making and inability to take an advantage of all the possibilities provided to the company. (Quintiq 2013g.)

In addition, Marquis encountered with the challenges of costs reduction and turning times optimization for the existent assets. Both the barges from the lower Mississippi and tank cars from the Bakken were cycling and meeting at

the Missouri terminal where the storing was restricted to 550,000 barrels, which is equal to approximately three trains. Barges, however, have more throughput than trains, so matching the optimization of tank levels or the cycling rate was a problem, while considering the variability of the delivery from Bakken. (Quintiq 2013g.)

A logistics solution, which would raise and expand with Marquis had had to be found. The solution had to manage both the rail and barge operations. "I got the sense that Quintiq had been in the puzzle solving business for a while and that they got pretty good at it" said Alex Marquis, logistics manager of Marquis company. "When the Quintiq team gave us a demonstration, it was well rounded in terms of handling both trains and crude oil tows or water movements" Alex Marquis added. (Quintiq 2014h.)

Firstly, Quintiq was able to handle all the new data, which was received daily, convey it across the entire system and inform the managers if it was possible to optimize the terminal. The ability to comprehend and explain all the issues to Marquis was also at Quintiq's disposal. Secondly, in less than two weeks, Quintiq managed to transfer Marquis to the new system and reach working capacity. Afterwards, several months were needed for the software to achieve complete operability. Thirdly, with the Quintiq software, Marquis obtained a detailed overview on all their barges and trains, all the schedules and on how schedules influence tank levels. "A lot of our data which was housed in spreadsheets became visualized in Quintiq solution and it allowed us to quickly point out issues to management or allow us to identify scheduling conflicts for assets that are moving in and out of the terminal" said Bart Pieper, the Marquis director of innovation. (Quintiq 2014h.) Quintiq also focuses on apprehension of such essential factors, as the total spending time of barges or tank cars at the terminal and the time taken for loading and unloading. Marquis reached the most vital objective - cost reduction by planning enhancement and by the abbreviation of the demurrage payments for unused vessels. Additionally, Quintiq's software capability to put into practice "what-if" scenarios and estimate them against business KPIs allows Marquis to bid on contracts that rely on short-term situations of market. The barges and tank cars are now used effectively. Finally, Marquis can evaluate business strategy consequences, like forecasting the bottom line implications of diversification in other types of fuel. (Quintiq 2013g.)

5 CONCLUSION

5.1 Summary of key findings

The major goal of the final chapter of this thesis is to answer the research questions specified in the introduction, thereby, to reach objectives of this research. Additionally, the final chapter is complemented by the credibility assessment of this research paper together with the research limitations and suggestions for future research.

RQ1: What are the factors that influence companies to use Quintiq (software) in planning their supply chains?

According to the findings of this research, there are several vital factors that force organizations to import the software system. Daily, both small and big companies are compelled to decide on a large amount of complicated scheduling and planning activities that influence the bottom line of the company. These activities are highly dependent on organization's industry and the areas it operates in. Companies encounter with such organizational problems, as: optimal loading and unloading, storage control, changes in demand and resource constraints, uniting orders, difference in size orders, manufacturing regulations and restrictions, production delays, difficulties with manufacturing routes and lead times, turning times optimization for the existent assets, planning and controlling of labour force, shift tasks, management of fatigue, etc.

As was indicated earlier in the findings chapter, before the software implementation, companies used to employ paper-based unintegrated individual spreadsheets models and whiteboard scheduling solutions for planning and managing their activities. However, in course of time, organizations realized that with this kind of solution it was hard to manage a lot of different operations and the problems, that had to be solved, remained the same. The solution was not able to provide the visibility and transparency of the future consequences of planning decisions for any substantial period. Moreover, these solutions were time-consuming, were strongly dependant on human factor and exert a bad influence on the data integrity. Additionally, the manual manipulations within different sources of information in a variety of

spreadsheets resulted in an overlook of the important things. Consequently, organizations were not able to meet their requirements and handle the multi-level planning responsibilities, what resulted in slowed down decision-making and inability to take an advantage of all the possibilities provided to the company. Some companies even encountered with the challenges of costs reduction and turning times optimization for the existent assets.

To sum up, the case companies realized the need of an advanced software and, thus, were looking for a tool that could optimize their supply chain.

RQ2: How does Quintiq software help companies in improving their Supply Chain Management (SCM) Key Performance Indicators (KPIs)?

To answer the main research question, it is important to revise and pay special attention to the information obtained from:

- Literature review, where the major part was assigned to identification and a thorough explanation of planning solutions along the supply chain of the case company;
- Quintiq project lifecycle (QPLC) document, which is the working methodology of Quintiq that gives the best understanding of how the software company implements their projects;
- Reports and videos, provided by the case organization.

Firstly, summarizing the information from the literature review and the QPLC document, it was indicated that one of the most vital and initial stages of every company's operation is analysis, where the company strives to see what the problems are, what are the goals and how they can be solved. And to answer these essential questions, Quintiq focuses on KPI-based planning. KPIs are those factors that help the company to find out if the clients that imported their software, achieved a required and desired result. KPI-based performance is one of the key aspects in the business world, as it allows to not only clearly understand the development of a particular indicator, but helps in evaluation of benefits of use of Quintiq's SCP solutions. It was revealed by Stadtler & Kilger (2000), that KPI cover various supply chain areas and can be grouped into three various classifications: supply chain responsiveness and flexibility, delivery performance, costs and efficiency. While comparing this information with the results gathered by the researcher, there are same KPIs in Quintiq

company, however, some supplementary indicators, like, for example, OTIF are included, as well.

Applying this theoretical information to the results collected from the reports and videos, four client companies revealed several substantial enhancements that their businesses have reached by implementing Quintiq software solutions. The results of the first PKCT company are as following:

- Enhanced port terminal throughput;
- Maximization of stockyard utilization;
- Improved scheduled maintenance visibility;
- Shorter coal ship lines;
- Increased stockyard utilization by 10%;
- Reduced bottlenecks on the inbound and outbound restrictions;
- Increase in overall throughput;
- an ability to cope with large forecast requirements and manage outages
- a capability to design the performance-based planning
- Reduced tiredness and stress levels of employees

The evaluation of satisfaction level of employees can be based on their hourly work schedule and the level of adherence to all rules of these work shifts (for example, there is a rule of two working days after 1 free day). In Quintiq company, it is important to not assess how much happier the employee became from emotional point of view, but from operating point of view. In other words, Quintiq strives to answer such questions, as: How much do employees rest? Is every employee considered? Does every employee have a work schedule, which does not exceed 8 hours a day? What is the idle time for employees? The performance of all these factors can be checked by KPI.

As the result of solution for Airservices' air traffic management labour force, Quintiq managed to:

- Enhance its rostering process, by reducing time of processing and cost of printing;
- Enable about an 80% decrease in number of queries related to payroll;
- Provide the visibility level over the whole rostering process;
- Enhance capabilities of management

- Increase productivity
- Facilitate the execution of fatigue risk management system
- Allow the company to control risk related to fatigue

After implantation of Quintiq solution in ELVAL, the company obtained such progresses, as:

- More practical and logical production requests;
- the decrease and flattening out of backlog by more than 50%;
- the enhancement of OTIF (Delivery on Time, In Full);
- the decrease of manufacturing cycles for some products by about 30%;
- the reduction of delivery lead time by up to 50%;
- decreased production lead times;
- the considerable improvement of WIP and inventory;
- the simplicity in making corrections to the plan;
- the possibility to exchange production planning staffs among majority functions;
- improved visibility, which allows fast responses to different situations;

The last but not the least, by planning enhancement and the abbreviation of the demurrage payments for unused vessels, Marquis organization reached its most vital objective - cost reduction. Moreover, it achieved an improvement in the efficiency of barges and tank cars usage. Finally, the development in forecasting the bottom line implications of diversification in other types of fuel allowed the company an evaluation of business strategy consequences.

To conclude, the study disclosed a number of improvements that businesses have achieved by implementing Quintiq software solutions and it determined that the software can support various planning processes. Nevertheless, it is important to understand that this research focuses on and investigates exceptionally one software company and studies the results of four Quintiq client organizations that imported the software solution. Therefore, this research is not considered to be generalizable to another APS.

5.2 Evaluation of own research

5.2.1 Research credibility

It is essential to pay attention to the reliability and validity of the research design in order to reduce the probability of obtaining wrong answers to

research questions. When the demands of reliability and validity are satisfied, the research is credible. Reliability relates to the degree to which methods of data collection or procedures of analysis will bring consistent results. Validity indicates if “the findings are really about what they appear to be about”. (Saunders et al. 2009.) When using the data from various sources, it is essential to assure that the data is reliable, comprehensive and suitable for the research aims (Walliman 2011).

While collecting data for this research, the researcher paid special attention to the date of data publishing and utilized mostly only up-to-date data. Additionally, the data for the literature review were gathered from reliable sources, such as books, articles and online sources.

As stated above, in the data acquisition section, this research utilized archived primary data, consisted of written and non-written materials. To ensure the data validity, the organizational reports were supported by video recordings consisted of interviews with the staff of Quintiq client companies. These videos contain a lot of useful and credible information for this research, where the speeches of such essential company’s staff as resource planning and rostering manager, director of innovation, logistics manager, planning manager are given. The material provision was arranged by the researcher’s mentor within the case company and which was further used specifically for this research project. The data provided by the employee of a large and well-known organization are believed to be authoritative, because the company’s continued existence strongly depends on maintaining credibility, as well.

Last but not least, the research utilized four Quintiq client companies to better present real-life business information and, consequently, to increase validity of the study and to obtain a rich comprehension of the research context.

5.2.2 Limitations and suggestions for further research

The utilized in this research case study method empowers the researcher to completely comprehend the behaviour pattern of the corresponding unit, contributes in intense study of the social unit and improves the researcher's experience, and, consequently, her analysing capacities and skills. However, despite all these advantages, the case study has some obligatory limitations to mention particularly applicable for this research project.

The first limitation is that the case study method can be utilized merely in a limited area, therefore, it is not practical to use it in case of a bigger society. Moreover, there is always the risk of incorrect generalization due to the fact that no established principles are followed in the information obtainment and just few units are studied. The research is limited to only four Quintiq client organizations that imported the company's software solution and investigates exceptionally this software. Therefore, this research is not considered to be generalizable to another APS.

In addition to mentioned above, due to resource and time constraints, there were a limited number of methods to collect the data. Correspondingly, only archived types of data were collected. Moreover, as was explained by the mentor within the chosen company, the organization was not able to provide the researcher with other types of information for this research project, since the information is sensitive to the business owners, due to the commercial advantages received ones known. Additionally, majority of the company's results are a subject of non-disclosure agreement (NDA). The researcher understands that the utilization of higher number of methods would have enabled an enhancement of the validity and reliability of the research.

Last but not least, since the chosen method for the particular research is qualitative, it highly depends on the researcher's individual skills and more easily affected by the peculiarities and personal prejudices of the researcher. Moreover, it was time consuming for the researcher to analyse and interpret big volumes of data.

To conclude, the researcher revealed several limitations of this thesis and would like to make suggestions for the further research. Firstly, this research aimed to investigate how software solutions improve an efficiency of supply chain planning and, in consequence, supply chain activities in different industries of one particular company. Thus, various other organizations that are focusing on the supply chain planning through software systems can be examined. Moreover, the research concentrates only on client companies that imported Quintiq software system and obtained efficient outcomes. Therefore, the second suggestion would be to investigate the software enterprises for supply chain planning that have insufficient or unsuccessful results of their clients and to find out the ways for the enhancement. Lastly, the future

researchers on the related topic can select various research methods to verify the conclusions. Among other methods suitable for related research can be: observations, in-depth personal interviews and questionnaires.

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