UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER THESIS

MEASUREMENT OF SUPPLY CHAIN PERFORMANCE: THE CASE OF DIGITALIZATION OF A SELECTED PHARMACEUTICAL COMPANY

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LIST OF ABBREVIATIONS

ABBREVIATION	
AI	Artificial Intelligence
API	Active Ingredient
AP	Accounting period
BFR	Brand Forecast Review
BOBJ	SAP Business Objects
BSC	Balanced Score Card
BU	Business Units
BUI	Business Units Interface
BVA	Business Value Added
CAPA	Corrective And Preventive Action
CI	Continuous Improvement
COVID19	Coronavirus Disease of 2019
DMAIC	Define, Measure, Analyze, Improve and Control
DOS	Days Of Supply
DT	Digital Transformation
E2E	End to End
EAH	Enterprise Attribute Hub
ECRS	Eliminate, Combine, Rearrange, and Simplify
EDI	Electronic Data Interchange
ELT	Executive Leadership Team
ERP	Enterprise Resource Planning
FB	Forecast Bias
FC	Forecast
FE	Forecast Error
FERCA	Forecast Error Root Cause Analysis Tool
FIP	International Pharmaceutical Federation
FMD	Falsified Medicines Directive
FY	Fiscal Year
GMP	Good Manufacturing Practices
GMX	Global Markup Exchange
GSC	Global Supply Chain
GSCM	Global Supply Chain Management
ICU	Intensive Care Unit
IFPMA	International Federation of Pharmaceutical Manufacturers Associations
INV	Inventory
IOT	Internet Of Things
KPI	Key Performance Indicator
LSS	Lean Six Sigma
MAD	Mean Absolute Deviation

MAPE	Mean Absolute Percentage Error
MOH	Months on Hand
MOQ	Minimum Order Quantities
MS	Microsoft
MSE	Mean Squared Error
NVA	Non-Value Added
O2C	Order to Cash
OpU	Operating Unit
PDCA	Plan, Do, Check, Act
PSC	Pharmaceutical Supply Chain
QMS	Quality Management Systems
R&D	Research and Development
RACI	Responsible, Accountable, Consulted, Informed
RCA	Root Cause Analysis
ROI	Return On Investment
RSC	Regional Supply Chain
S&OP	Sales and Operations
SC	Supply Chain
SCAT	Supply Chain Assessment Tool
SCD	Supply Chain Digitization
SCM	Supply Chain Management
SCPMS	Supply Chain Performance Measurement Systems
SKU	Stock-Keeping Unit
SME	Subject Matter Expert
T1–T6	Tier 1–Tier 6
TIMWOOD	Transport, Inventory, Motion, Waiting, Over-Production, Over-processing, and Defects
TQM	Total Quality Management
VA	Value Added
VM	Visual Management
VMI	Vendor Managed Inventory

INTRODUCTION

There is an old saying that a chain is as strong as its weakest link. Therefore, knowing your links in the chain is crucial for supply chain (SC) performance. If we want to add value to our supply chain and eliminate the waste, it is very important that the measurement of its performance is as standardized as possible.

The pharmaceutical industry's key factors of success are highly specialized business processes, with a strong focus on research and development (R&D) and local market differentiation, which determine whether a company can succeed in a given market (Tripathi, Rangarajan & Talukder, 2019). Supply chains in the pharmaceutical industry have several specific attributes, such as marketing time, R&D productivity, product lifecycle reduction, government regulations, decreasing exclusive patent life, production flexibility, and cost increase. A pharmaceutical supply chain (PSC) also directly influences public health and safety, and therefore anything less than a 100 per cent customer service level seems to be unacceptable (Mehralian, Zarenezhad & Ghatari, 2015, pp. 77–78). The pharmaceutical industry is a complex set of processes, operations, and organizations involved in the discovery, development, and manufacture of drugs and medications. There are many different drivers involved in the success of a supply chain in the pharmaceutical industry, but the single most important one must be how fast it is able to get the product on the market (Shah, 2004, pp. 930–931). Getting the right drug to the right patient at the right time is an art many global pharmaceutical companies are trying to polish to the finest.

The purpose of this master thesis is to analyze the implementation of key performance indicator (KPI) measurement with a focus on the digitalization of the supply chain and its potential capability to help in providing KPIs that are useful for SC analysis. Inventory management is one of the most complex challenges in the supply chain. Many organizations struggle to define and pursue an organized, systematic approach to inventory performance management and reporting. There is often a focus on metrics without any connection to the insights they are intended to provide or the decisions they support (Gartner Inc., 2019, p. 1). Many companies believe that continuous improvement in the organization relies on measurement. Once management decides on the road map for changes, key performance indicators can be set to ensure that the organization will know when it is there and at which point the objectives are met. Measurement is important as it also affects behavior that impacts supply chain performance, and it is the best tool to assess whether the supply chain has improved or degraded (Lapide, 2000, pp. 287–288).

Monitoring and improving the performance of the supply chain is one of the most important assets of each company. An extremely complex task for managers, it is at the same time included in many company management processes. Data integrity and analytics should therefore be at the center of attention across all business functions affected by supply chain management (SCM) (Trkman, McCormack, De Oliveira & Ladeira, 2010, pp. 319–322).

As digitalization today affects everyone and everything around us, it is understandable that it has a great impact on supply chains as well. Many believe that true excellence of the supply chain can only come from a digital business transformation. It is this transformation that provides endless opportunities that technology has to offer. Getting there is definitely a long journey, and leveraging this road in the right way can lead to new levels of supply chain operational excellence (Bowersox, Closs & Drayer, 2005).

Digital transformation (DT) is defined as transformation dealing with the changes that digital technologies can bring to the company and its business model, products, or organizational structures. It has been one of the most universal managerial challenges for many companies over the last decade. This is because digital possibilities need to be combined with skilled employees and executives to fully reveal the potential transformative power of digital technologies. Thus, DT needs both technology and people (Nadkarni, Prügl, Prügl, Nadkarni & Prügl, 2021).

Every organization needs to measure where they are in terms of performance in order to start making any further improvement. In SCM, where there are many stakeholders involved, including suppliers and customers, it is important to have an aligned and comprehensive performance measurement system in place (Oey & Mulianti, 2017). Supply chain performance measurement systems (SCPMSs) are, thanks to the new technologies available, experiencing new expansions in business practices, which allows organizations to collect, integrate, and share valuable information among all supply chain stakeholders. SCPMs also enable the adoption of KPIs and represent a way to improve the SCM by ensuring better and timely decisions, which bring more added-value to the organization (Maestrini, Luzzini, Maccarrone & Caniato, 2017).

My goal will be to show how, by identifying the right KPIs delivered to key stakeholders efficiently, decision making can be improved. The case will be based on the supply chain of a research-based global biopharmaceutical company.

The theoretical part will analyze the background of SCM, its different models and importance. A separate chapter will be dedicated to discussing the importance and theoretical background underlying KPIs and the continuous improvement loop. Theoretical section of the thesis will be focused on the specifics, issues, and future challenges of SCM in the pharmaceutical industry. The business case will demonstrate how the implementation and digitalization of KPIs could improve decision making in SC processes.

1 SUPPLY CHAIN MANAGEMENT

Global supply chain management (GSCM) is the management of supply chains that are physically situated far from each other. End-to-end supply chains typically consist of suppliers, manufacturers, distributors, retailers, and customers (Jayaram, 2016). Supply chain management is based on a couple of basic concepts that haven’t changed over multiple centuries. Napoleon once said that an army marches on its stomach, clearly stating that unless the soldiers are fed, the army cannot move. A quote from this master of strategy is only one among many analogies from the military world, which could easily translate to the importance of supply chain management. In more recent times, there is a familiar saying that goes, "Amateurs talk strategy, professionals talk logistics." Similar to soldiers, every business process needs to have its day-to-day demands met. Without fuel, spare parts, food, shelter, and ammunition, leaders can discuss all sorts of strategies, but none will be possible without meeting the above mentioned demands (Hugos, 2003).

Supply chain management (SCM) addresses the fundamental business problem of meeting demand by supplying a product. Demand is present everywhere in a complex and uncertain world. Business trends in the last decades created the need for SCM, and development in information technology created an opportunity. Product life cycles are becoming shorter while product variety is increasing, which is raising supply chain cost and complexity. Globalization, together with outsourcing and fragmentation, made it vital for the issue to be tackled along the entire supply chain, rather than taking the limited view of an individual company. New information technologies and digitalization have made real-time information sharing possible, for a better coordination and decision making among companies (Kopczak & Johnson, 2003).

Historically, the term "supply chain management" has had a number of definitions and explanations. Literature on SCM often uses complicated terminology and therefore limits managements' understanding of the concept. Mentzer and others believed that the term needed to be better defined and developed a single, all-encompassing definition of SCM. Following an extensive literature review, they define SCM as "[t]he systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole" (Mentzer et al., 2001).

1.1 Importance of supply chain management and its processes

Every business fits into one or more supply chains and has a role to play in each of them. Their business needs typically also highly depend on supply chains to provide them with what they need to survive and thrive. The most crucial aim of any successful supply chain management is to manufacture the right product, for the right customer, in the right amount, at the right time, or in other words, to meet the customer's demand more efficiently (Wang, Samuel, Huang & Dismukes, 2005). The high pace of change in the market and its evolving uncertainty have increased the importance of supply chain awareness among business owners, as they need to understand their role in it. It has become clear that only companies that will learn how to build strong supply chains will have the competitive advantage in their markets (Hugos, 2003).

Companies have acknowledged the advantages of effective SCM. Most supply chains have already identified and rationalized their processes to a certain level of maturity. There is, however, always room for improvement, which calls for the creation of a new model, one that would emphasize a more holistic approach to explaining how companies do their business. Several business models have emerged out of this. The essence of a business model is to define the manner in which a company delivers value to its customers. It should illustrate the content, structure, and governance for a model designed to create value, through identifying business opportunities (Teece, 2010). The literature agrees that multiple business models can co-exist in a single company, which enables them to migrate products between them. Companies and supply chains should design current business models, as well as develop capabilities for future changes. Every company should therefore decide how many business models they can have at the same time, while designing supply chains that take these business models into the account. A constant balance between improving current SC elements and building dynamic capabilities for future change is of great importance for all managers (Trkman, Budler & Groznik, 2015).

The importance of the supply chain is also demonstrated by the fact that effective SCM has become a potentially valuable way of securing a competitive advantage, which can lead to improved organizational performance. Therefore, the competition is no longer between organizations, but among their supply chains. In the scope of their research, Li and others looked into five dimensions of SCM practice (strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement) and tested the relationship between SCM practices and competitive advantage and organizational performance. Their results indicated that higher levels of SCM practices can lead towards an increased competitive advantage and improved organizational performance. Additionally, competitive advantage itself can also have a direct, positive impact on the organization's performance (Li, Ragu-Nathan, Ragu-Nathan & Rao, 2006).

1.2 Importance of KPI measurement in SCM

Key performance indicators are considered an essential element of any organization's ability to monitor its strategic health. Performance measurements, and particularly KPIs, provide managers and decision-makers with a snapshot of their business operations, specifically how well a business is achieving its goals, which helps them achieve the strategic goals of the organization (Hester, Ezell, Collins, Horst & Lawsure, 2017).

In supply chain management, measuring and monitoring performance reveals the gap between planning and execution and helps companies identify potential issues and areas for improvement. It is, however, well known that developing meaningful KPIs for the supply chain is very challenging, and there are no real guidelines that would fit across all industries. One finding showed that based on industry standards and best practices in supply chain performance measurement, "less is better" applies when it comes to developing performance metrics. The study suggests that organizations should focus only on a small list of KPIs, which are critical to operations management, customer service, and financial viability. Potential KPIs should, however, be developed for every component of the supply chain operations model (plan, source, make, and delivery), and should then be hierarchically grouped and prioritized (Chae, 2009).

In today's highly dynamic supply chains, continuously improving performance has become a critical task for most organizations. Therefore, monitoring and improving the performance of a supply chain has also become an increasingly complex task. Many metrics used in supply chain performance evaluation have been designed to measure operational performance, evaluate improved effectiveness, and examine the strategic alignment of the supply chain management as a whole. However, since many measurement systems lacked strategic alignment and a balanced approach, different methods to evaluate supply chain performance have been introduced. To address this issue, one of most commonly used methods is the so-called balanced scorecard (BSC) method (Cai, Liu, Xiao & Liu, 2009). This (BSC) method is also being used in the selected company that is the subject of this thesis.

The balanced scorecard is a concept that was introduced by Kaplan and Norton in 1992. They proposed the balanced scorecard (BSC) method, to evaluate corporate performance from four different perspectives: the financial perspective, the internal business process, the customer perspective, and learning and growth. Their BSC is designed to complement financial measures of past performance with select measures of the drivers of future performance. The name of their concept reflects the intent to keep score of a set of items that maintain a balance between short-term and long-term objectives, between financial and non-financial measures, between lagging and leading indicators, and between internal and external performance perspectives (Bhagwat & Sharma, 2007).

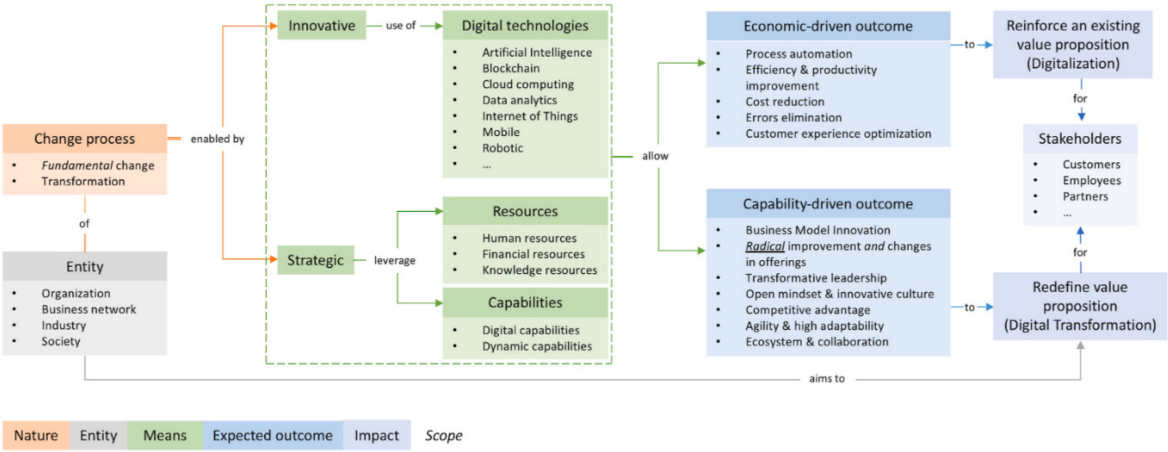
1.3 Digital transformation

Digital transformation is becoming vital for most organizations across all industries. There is a lot that has been said and written about DT in general, but it is noticeable that the published definitions of DT vary a lot. Digital transformation is a buzzword frequently used in both academic and practitioner literature. As with many other buzzwords, there is a fear that the term might be abused and not well understood, which can lead to a misunderstanding of the essence of this phenomenon.

In a flood of different academic definitions of this phenomenon, the one that fits the purpose of this master thesis the most is the following: "Digital transformation is a fundamental change process enabled by digital technologies that aims to bring radical improvement and innovation to an entity (e.g., an organization, a business network, an industry, or society) to create value for its stakeholders by strategically leveraging its key resources and capabilities" (Gong & Ribiere, 2021).

Figure 1 shows a conceptual diagram of DT. It illustrates the logic of six identified primitives with their defining attributes. It also pictures the building blocks of DT and the key elements involved in the process of DT. There can be two types of expected outcomes (i.e., economic-driven and capability-driven outcomes) associated with digitalization and the corresponding DT. This is because some organizations may implement digitalization projects before achieving DT, while others may manage to reach DT directly, depending on the organization's strategy and the industry it is operating in.

Figure 1: Digital transformation conceptual diagram



Source: Gong & Ribiere (2021).

The primitives that represent the main overarching features of DT as identified by Gong and Ribiere are: Nature, which represents the reality of DT; Scope, meaning the extent of changes within the target entity; Target Entity, which is the unit of analysis affected by DT; Means, or the methods involved in creating the change; Expected Outcome, which is basically the consequence of DT that relates to processes; and Impact, which refers to the non-quantifiable long-term effects that the change may have (Gong & Ribiere, 2021).

DT clearly is not only about using new technology in the company. Before this concept, organizations were focused on IT-Enabled Organizational Transformation. This involved using digital technology to support an existing value proposition and reinforce an existing organizational identity. On the other hand, DT involves leveraging digital technology to redefine a value proposition, which can lead to a change of identity for the organization (Wessel, Baiyere abadigi, Ologeanu-Taddei, Cha JCha & Blegind-Jensen blegind, 2021).

For many decades, companies have been striving towards an improvement of their processes, and this has resulted in the concept of Lean thinking, which relates to the ideas of standardization and continuous improvement. With the concept of DT, we are witnessing many applications of digital technology to enhance Lean thinking. Supply chain planning is a perfect example, as it aims to improve performance in operations by mitigating uncertainty through managing operations and customer demand, as well as to coordinate supply chain activities with business strategy. The concept of Lean thinking has therefore strongly influenced waste and cost reduction, quality improvements, and increased flexibility. We are, however, living in times of increased market complexity and globalization, where variability and uncertainty are higher. SC planning has therefore become more demand- and event-driven (it takes place in real-time, with increased frequency and a shorter planning horizon, and is cross-functional), and has turned into a process in the supply chain rather than in individual companies. Nowadays, new digital technologies are strongly facilitating planning models by allowing efficient access to information, advanced analytics, and integrating operations between supply chain partners (Ashrafian et al., 2019).

Introducing a new technology is always about either doing more or/and using fewer resources. It is important to realize that this combination is effective only when technology is paired with the right human skills. The creative aspect of innovation is always entirely dependent on people, not technology. Therefore, DT should be more about people than technology. Technology can be bought, but the ability of people and the organization to adapt to an even more digital future is something that depends only on developing the next generation of skills (Frankiewicz & Chamorro-Premuzic, 2020).

Digital technologies are the key enabler of the transformation of supply chains and can be used for a continuous improvement focused on new possibilities introduced by the enormous amounts of data currently available (Buer, Fragapane & Strandhagen, 2018).

1.4 Continuous improvement of SCM

Continuous improvement (CI) reflects a culture of sustained improvement. It is aimed at eliminating waste in all processes, and it involves all the stakeholders of a given organization. There are many CI methodologies, such as total quality management (TQM), Six Sigma, Lean, and Lean Six Sigma. Their definitions are different across the literature, depending on how they achieve their objective, but their overall goal and origin are the same (Toledo, Alliprandini & Lizarelli, 2019). While Six Sigma is used to eliminate defects and reduce variations, Lean is rather used to make a process faster and increase its efficiency by reducing waste and creating a flow in the processes, as well as to drive CI. Due to its focus on process effectiveness, Six Sigma is more appropriate for manufacturing environments, while Lean is better suited for operational processes, as it is focused on process efficiency.

In my selected pharmaceutical company, a combined methodology called Lean Six Sigma (LSS) is being used. Lean is used to improve Six Sigma by reducing waste and solving problems in order to be faster and more efficient. I will further describe the DMAIC methodology, which is used the most and is also the methodology that I applied to my case study.

Define, Measure, Analyze, Improve, and Control (DMAIC) is a data-driven systematic method used strategically to improve processes, and it is often described as an approach for problem solving (De Mast & Lokkerbol, 2012). The DMAIC methodology takes a problem that has been identified in an organization and utilizes a set of tools and techniques in a logical fashion to arrive at a sustainable solution. This solution will minimize or eliminate the identified problem and place the organization in a competitive position (Shankar, 2009).

The Define phase helps us establish a clear problem definition and an understanding of the process. There are three tools that support the Define phase: Problem Definition, Voice of the Customer, and Process Mapping. The problem definition phase helps to highlight the scope of the problem through the 4W method (what, where, when, who) and through the description of its significance and the desired state to be achieved. The Voice of Customer phase is used to describe what the customer needs and how well the product meets those needs from the point of view of the customer (either internal or external). With Process Mapping, it is possible to gain a clear vision of the problem by describing it from four different perspectives: what you think it is, what it really is, what it should be, what it could be. All the above helps us to understand what the problem is and where there is an opportunity for improvement.

The Measure phase starts when the true process is identified and documented. The most common approach to recording the activities is the creation of a process map, and the most common tools to gather and display the data are time series plots and Pareto charts. Time series plots are used to study the variation of a process, its trends, and shifts in a graph that displays data collected in a time sequence from any process. The chart can be used to determine how the data is trending over time and whether the data points are random or exhibit any pattern (Sigma Magic, n.d.). A Pareto chart is typically applied to analyze the frequency of problems or causes, where the 80/20 rule helps to understand what to focus on more. The Pareto principle (also known as the 80/20 rule) states that for many phenomena, about 80% of the consequences are produced by 20% of the causes (Dunford, Su & Tamang, 2014).

The Analyze phase starts with a process analysis that aims to classify each step of the process into 3 main categories: the business value-added, the non-value added, and the value-added steps. The brainstorming method is another technique often used to integrate the Analyze phase. This process is based on group collaboration and aims to gather a wide number of ideas from different points of view. Finally, analyzing the cause and effect and the five whys allows one to determine the root cause of the relevant defects and poor performance. A root cause analysis (RCA) tool (for example, the five whys) is used to uncover these causes the most frequently, in combination with various brainstorming techniques.

Improving process performance means selecting and implementing effective solutions by addressing and eliminating the root causes identified. The Analyze phase show one or more issues and opportunities or other waste in the process. This is followed by the Improve phase, which includes assessing these ideas and implementing them based on priorities. In cases where choosing the correct solution does not seem easy, using a specific matrix may support the decision-making process. It consists of positioning all the possible ideas in the matrix and ranking them to compare the levels of benefits and difficulties for each of the options.

The cycle ends with the Control phase, which is used to control the improved process and future performance. The tools that are typically used in our selected organization are the standardization and documentation of the new process, a control chart, and finally the CI loop. The control chart is a typical time series plot with the addition of control limits. This new feature helps to define the range of possible results that would still be acceptable. Once a process has been improved, a control chart helps to monitor the situation and to avoid any other deterioration. The continuous improvement loop is a process that runs regularly and is an important part of the control phase, making sure that the waste identified before does not recur (ASQ, n.d.).

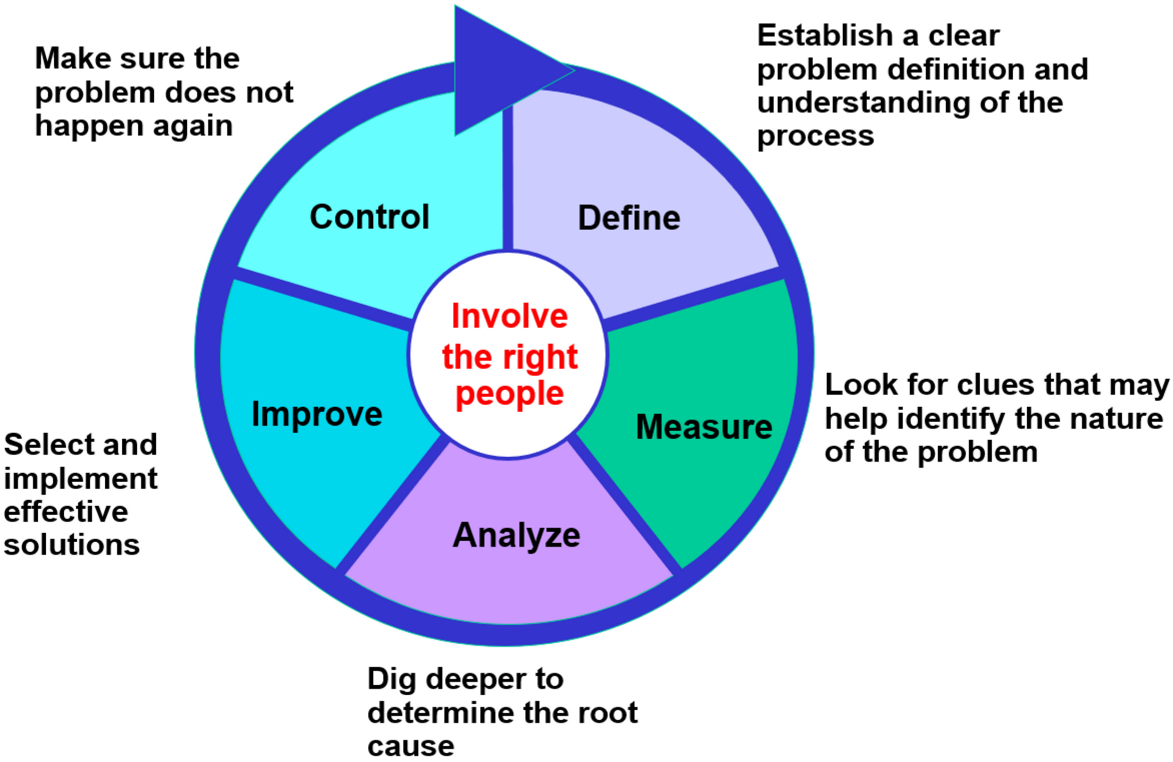
The DMAIC methodology has been effectively implemented across many different applications, such as SCM performance, SC quality management, human and process factors in Six Sigma implementation, the internationalization of higher education, and design process improvements (Rehman, Khan, Kusi-Sarpong & Hassan, 2018).

The above mentioned methodology was used during the implementation of an SC performance measurement in the business case presented in this thesis. I believe it is an important link to how the digitalization of the supply chain was used to continuously improve supply chain processes and decision making.

Figure 2 is a graphic visualization of the DMAIC cycle, emphasizing the key messages for each phase of this method. The circular shape symbolizes that it is a continuous process, which should never end. The message in the middle of the circle focuses attention on the fact that people and their engagement play a crucial part in the success of this methodology.

In a study called “Relationship between continuous improvement and innovative performance,” the authors sought a direct link between continuous improvement and innovative performance. Their findings confirmed that a positive and significant relationship between CI and incremental process innovation does exist. The same study also investigated whether different CI programs adopted by the organization could interfere in this relationship. They found no significant difference between Lean, Six Sigma, and LSS in the case of innovative manufacturing companies (Toledo, Alliprandini & Lizarelli, 2019).

Figure 2: DMAIC methodology



Source: Selected company (2021).

2 SCM IN THE PHARMACEUTICAL INDUSTRY

This chapter provides a review of the supply chain in the pharmaceutical industry with a special focus on quality and regulation, which often influence SCM decision making, and an end-to-end (E2E) overview of SCM, briefly touching on the Falsified Medicines Directive ('FMD') and counterfeit challenges.

2.1 Pharmaceutical supply chain specifics and key issues

Different internal and external factors impact pharmaceutical operations. Product life cycles are short and therefore boost the importance of the introduction of a new product on the market. In the pharmaceutical industry, a product launch is of great importance, as competitors seek the shortest possible time-to-market to exploit patent protection as much as possible. On the one hand, relatively big volumes of the product need to be ready to fill the downstream supply chain at market launch, while on the other hand, high inventory levels are connected to several risks (Hansen & Grunow, 2015).

2.2 End-to-end supply chain management in the pharmaceutical industry

A typical pharmaceutical supply chain will consist of one or more of the following nodes:

- primary manufacturing (possibly including outsourced contractor sites),
- secondary manufacturing (possibly including outsourced contractor sites),
- market warehouses/distribution warehouses,
- wholesalers/distributors,
- pharmacies/hospitals.

The primary manufacturing site is responsible for the production of the active pharmaceutical ingredient (API). The API typically involves several chemical synthesis and separation stages in order to build up complex molecules. Manufacturing is a multistage process, characterized by long processing times with considerable inventories held throughout all stages. On top of that, all stages are subject to strict quality control checks before being approved for use downstream in the process, which can introduce many delays into the process.

Secondary manufacturing deals with taking the API produced at the primary manufacturing site and adding the excipient (an inactive substance, which serves as the vehicle or medium for the drug) along with other processing and packaging. This process results in the final product, usually in stock-keeping unit (SKU) form. Secondary manufacturing locations are often geographically separated from primary ones, as a result of tax and transfer price optimizations within the corporation.

The rest of the supply chain depends on the logistics network design of each organization and diverse go-to-market models, which often differ even within a single organization based on the product portfolio. Although the process varies between organizations, all major pharmaceutical companies operate enterprise resource planning (ERP) systems and follow this supply chain with different management processes. For example, demand management can be spread across the globe and provides forecasts for up to 36 months based on historical data, market data, and artificial intelligence. On the other hand, inventory and logistics management ensure that demand is met globally and that sufficient inventory is available across all warehouses and logistics centers (Shah, 2004).

2.3 Quality control and regulation

The pharmaceutical industry has been one of the most closely regulated industries for more than 60 years. Awareness of the significance of quality has been growing ever since the industry managed to harmonize its practices and guidelines under the so-called good manufacturing practice (GMP) system. The importance of governments has grown since the joint statements of the International Pharmaceutical Federation (FIP) and the International Federation of Pharmaceutical Manufacturers Associations (IFPMA). Ensuring the safety of medical products to protect patients was at the core of this agreement (Woodcock, 2004). GMP tries to make sure that manufacturers have high quality standards built into their organizations and all the processes involved in manufacturing.

The industry is involved in the development, production, and marketing of pharmaceutical products, approved by the relevant regulatory authorities. Quality is a key factor that determines each manufacturing system, including the characteristics of the product, its appearance, maintenance, and duration. Last but not least, it has a big impact on supply and the relevant documentation. Measurements and KPIs are present in quality control as well and represent an important element of the CI concept, which play an important role in modern quality management systems (QMS) (Boltić, Jovanović, Petrović, Božanić & Mihajlović, 2016).

Decisions in pharmaceutical research and development (R&D) often need to be made with a shortage of data and a high degree of uncertainty. Decision makers are furthermore often subject to time pressure and significant economic stakes. All of this happens in a highly competitive market, where companies compete to be the first to launch their product on the market. Among regulators, decision making is driven by various factors, such as a positive impact on public health, while it is at the same time mindful of precedents and adhering to local laws, regulations, and policies. On the other hand, the pharmaceutical industry is motivated by the desire to transparently develop and deliver medicines that will fulfill both patient needs and regulatory requirements. All of this needs to happen while also delivering results to satisfy shareholder expectations (Donelan, Walker & Salek, 2015).

2.4 Demand management in the pharmaceutical industry

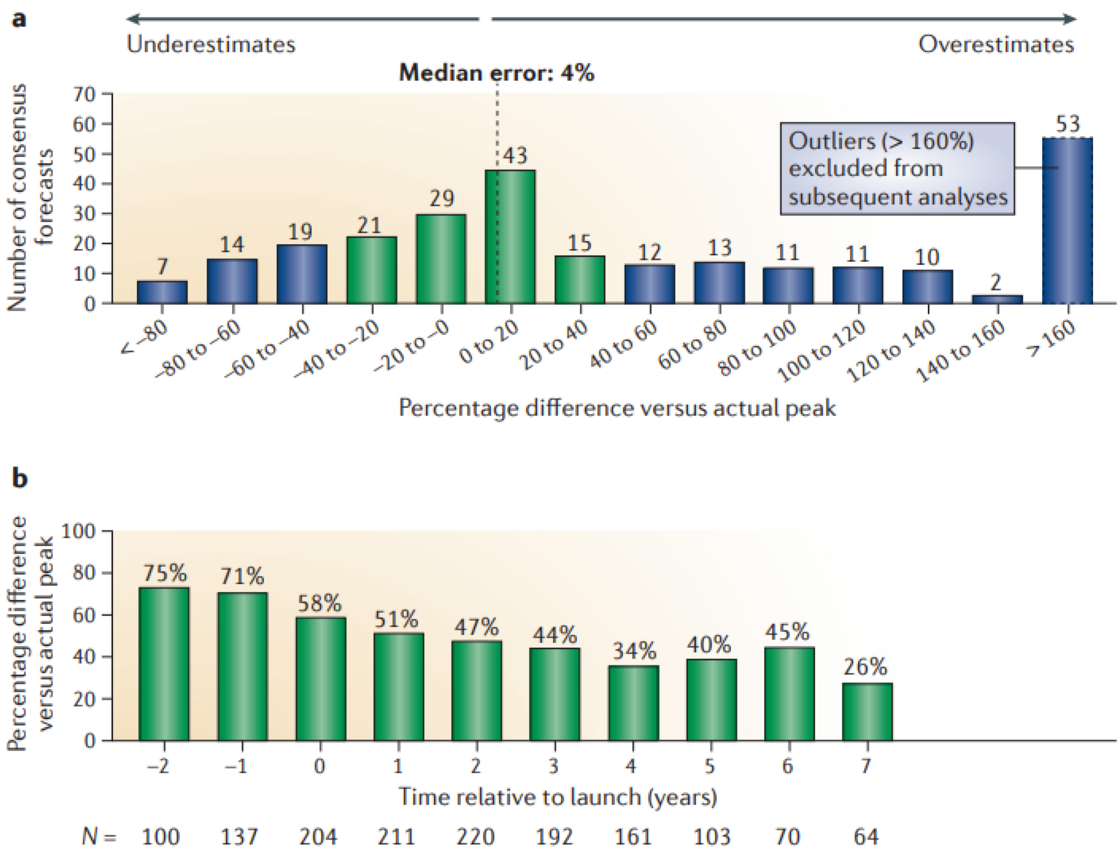
Demand forecasting is an integral part of business process management. Despite its complexity and the differences in execution across different industries, the core purpose stays the same. The purpose is to obtain a fairly accurate estimation of future demand for a product given historical data and the current state of the environment to plan and organize the business accordingly. Forecast accuracy in the pharmaceutical industry is typically considered a big challenge. The supply chain of pharmaceutical products is characterized by high complexity due to limited supply and delivery channels to customers and stringent regulations. Furthermore, demand forecasting for pharmaceutical products is also dependent on the product lifecycle. This complexity is one of the main challenges to performance and efficiency improvements. There is little to no room for error in pharmaceutical industry demand planning, as it might have a great impact on the health of a population. Therefore, stockout costs in this industry cannot be measured only in monetary terms. Avoiding out-of-stock situations and the forecast accuracy of future demand can lead to higher inventory levels in comparison to supply chains in other industries (Merkuryeva, Valberga & Smirnov, 2019).

The most commonly used forecast accuracy metrics to assess the quality of the demand forecast are a combination of the following basic metrics: forecast bias (FB), mean absolute deviation (MAD), mean squared error (MSE), and mean absolute percentage error (MAPE) (Merkuryeva, Valberga & Smirnov, 2019). Depending on which metric the company chooses, the level of aggregation, and the forecast horizon, forecast accuracy results can be different with the same data sets. When deciding what metric is best for assessing forecast accuracy, there is no universal answer. It is more a question of what the company wants out of it. FB tells you whether you are systematically over- or under-forecasting. MAD will measure the error in units and can be used to compare the results of different forecast models for the same product. MAPE is good for comparisons, as the error is put in relation to sales. An important thing to note is that the forecast accuracy metric should always be selected to reflect the relevant levels of aggregation and the planning horizon. Companies need to be able to react to expectations. The forecasting system needs to be transparent enough for demand planners to understand how the forecast was formed and how it is being measured. By simply reacting and manually overriding inaccurate forecasts, not much will be improved in the forecasting process as such. A deep understanding and control over the forecasting system in the company is therefore crucial to deal with forecasting errors (Relex Solutions, n.d.).

The pharmaceutical industry always looks to the future to address unmet patient needs. The horizon, due to the long life-cycle for drug innovation, is often very far away, counted in years if not decades. For investors, forecasting plays a very important role, as it is one of the main inputs for them to decide whether they should buy or sell the stock. Therefore, pretty much all decisions made inside a pharmaceutical industry, such as designing a clinical program, sales force deployment, geographical resource allocations, mergers and acquisitions, etc., are based on forecasting inputs. Given its importance, it is only fair to ask how accurate the forecasts in this industry are on average (Cha, Rifai & Sarraf, 2013).

Figure 3 shows that the majority of consensus analyst forecasts are off by more than 40% in the upper graph. The graph shows the percentage difference in estimated versus actual peak sales (calculated as the consensus estimate of peak sales minus the actual peak sales divided by the actual peak sales) for 260 drugs forecasted in the year before launch. The bottom figure shows the variance in the consensus estimate versus actual peak sales. Although the forecast error decreases over time, it remains as high as 45% even six years after launch (Cha, Rifai & Sarraf, 2013).

Figure 3: Inaccuracy in pharmaceutical forecasting



Source: Cha, Rifai & Sarraf (2013).

Interestingly, the same study also showed that large pharmaceutical companies, such as the one in my business case, tend to have better results in terms of the forecast bias. This is a consequence of the fact that the bias for these companies averages out the underestimations applied before launch and the more moderate bias after the launch of the product. Variances, however, remain high for both sets of forecasts, and the same also applies to smaller pharmaceutical companies (Cha, Rifai & Sarraf, 2013).

For anyone familiar with this industry, the conclusion that most forecasts are poor might not be surprising. But this also suggests that there is a substantial opportunity for companies and investors capable of developing a competitive advantage in demand forecasting. The authors concluded their article in a manner that reflects the purpose of my master thesis. There is no magic bullet to improving the accuracy of forecasts, but the first step is to start measuring it and recognizing that there may be a capability issue that needs to be addressed (Cha, Rifai & Sarraf, 2013).

2.5 Digitalization in the supply chain and the pharmaceutical industry

The process of digitalization affects almost everything in today's organizations, including supply chain management, and puts a huge pressure on organizations to change (Agrawal & Narain, 2018). An enterprise resource planning system (ERP) is typically used to get real-time information and to forecast results, computed based on the various models available in the ERP. By developing an ERP, using the demand forecasting functionality appropriately, and having precise data, companies can reduce inventory levels. Integrated systems can further enable companies to lower the gap between actual sales and the forecast demand, which can lead to a competitive advantage. These systems allow companies to seamlessly share information among different departments as well as among multiple SC players, resulting in better estimations and less uncertainty. Collecting data from different stakeholders, such as distributors, healthcare providers, pharmacies, and other customers, is also essential. Recent technologies and the development of the Internet of Things (IoT) have made this much more accessible, and the concept of digitalization can help companies to align their SC networks to become more agile. Different technologies can be leveraged for data collection, both internally and externally. Externally, vendor-managed inventory (VMI), electronic data interchange (EDI), and sales data can help in driving more accurate forecasting results. Internally, data collected by demand planners, collaborative information-sharing, sales and operations (S&OP) meetings, and brand forecast review (BFR) meetings can bring a lot of good market-specific intelligence to arrive at a better informed decision about the forecast (Siddiqui, Azmat, Ahmed & Kummer, 2021).

The so-called Industry 4.0 (the fourth Industrial Revolution) is here, and it is responsible for the creation of fully connected ecosystems within organizations. Because of this, organizations are re-shaping their strategies, which includes their supply chain management. The major opportunities in digitalization include increased information availability, optimized inter-company logistics, supply chain visibility, transparent end-to-end real-time information access and control, operations efficiency and maintenance, integration and collaboration, innovation, and more efficient inventory management. More and more companies are therefore applying different features of digitalization, such as big data, cloud computing, the Internet of Things (IoT), artificial intelligence (AI), etc., to start creating integrated and self-optimizing supply chain systems in order to allow for a more proactive response to the fast-changing environment of the markets (Seyedghorban, Tahernejad, Meriton & Graham, 2020).

Supply chain processes were greatly affected by digitalization, and the shift from the traditional supply chain to a digital supply chain can constitute a competitive advantage. "Digital supply chain can be defined as the development of information systems and the adoption of innovative technologies strengthening the integration and the agility of the supply chain and thus improving customer service and sustainable performance of the organization" (Ageron, Bentahar & Gunasekaran, 2020). The digital supply chain consists of three constructs: digitalization, supply chain management, and technology implementation. In a study on the Malaysian manufacturing industry, Lee and others looked for a relationship between the digital supply chain, supply chain performance, and organizational performance. They concluded that the implementation of the digital supply chain could help companies develop their businesses, improve their service levels, and achieve competitive values in the market to stay ahead of the competition. The same study showed that companies could consider adopting the digital supply chain as a business process for them to remain reliable by providing good supply chain performance and the best organizational performance as a whole (Lee et al., 2022).

The pharmaceutical industry has traditionally been slow to adapt to change. Digital maturity varies across different sectors, and the pharma sector is lagging behind the global average when it comes to individual industry scores. Companies in the industry are also often limited not just by their digital and analytical capabilities, but also by the specific elements related to their strategy, culture, and organization. There is no doubt that digitalization is driving and shaping the healthcare industry. Successful companies of the future will have structures, processes, and mind-sets in place that make them agile when responding to this change and endow them with a culture that is eager to win the digital race in the pharmaceutical industry (Fox, Paley, Prevost & Subramanian, 2016).

Industry 4.0 technologies surely have the potential to transform the pharmaceutical industry, in particular the pharmaceutical supply chain. While both the industry and the regulators are developing competences in preparation for smart manufacturing systems, the path to adoption of Industry 4.0 will require advancements and innovations addressing multiple data, computing, and automation risks and challenges. In addition to regulatory and technical challenges, financial investments will be required as well. The initial investments towards capital and operating expenses might not immediately bring returns, yet the long-term value should speak in favor of adopting new technologies. Better control, fewer errors, and more responsive supply chains will lead to fewer drug shortages, meaning that the ultimate winner of Industry 4.0 in the pharmaceutical industry will not be manufacturers or regulators but patients. Eventually, patients should benefit from higher-quality drugs with more reliable supply chains that are less prone to shortage (Arden et al., 2021).

3 SUPPLY CHAIN PERFORMANCE IN THE PHARMACEUTICAL COMPANY PHARMA INC.

The business case of Pharma Inc. will demonstrate how the implementation and digitalization of KPIs can improve decision making in SC processes. I will also try to demonstrate what the other potential benefits of digitizing the SCM are and which factors contribute to their achievement.

3.1 Methodology

The main enterprise resource planning (ERP) system for the supply chain in Pharma Inc. (the name is fictional, but the case presentation and analysis are real) is SAP. The tools used for data analytics are mainly the SAP BusinessObjects intelligence suite (BOBJ) and the Tableau software. The data used for this case have been collected in the scope of a nearly 2-year-long exercise, which consisted of different steps. The initial overview of the master data in SAP was performed by the project team dedicated to the task. The project team consisted of the Regional SC Technology Lead and his team in collaboration with the Regional Continuous Improvement and Operations Manager (the author of this thesis) as the market representative for the entire region. For proper governance, our project needed a project sponsor. The project sponsor played an important role in overseeing the entire project, giving mentorship where needed, and being the final approver in the approval flow that we put in place. After the initial kick-off and introduction of the scope of the project to the project team, the first step for this team was to assure data integrity of the highest possible level for the master data of the markets in scope. To achieve this, the team had regular meetings and aligned on the ways of working on this project.

First, the master data was exported from the ERP for the markets in scope. After that, a comparison was performed with historical sales and with future forecast data for each SKU in the range of 36 months. This enabled the team to get a first look at which SKUs were still active or were planned to be active in the future. Each market colleague completed a series of interviews with the project team to provide detailed information about each SKU and its status from the ERP master data database, as well as a detailed supply chain flow, including market specifics.

The next phase involved the status change of each SKU. Based on market feedback, a so-called KPI Flag for each SKU was set to either Yes or No. This KPI Flag signaled which SKU should be included in the calculation of a dedicated KPI. Following an alignment between the project team and the individual market, all changes in the ERP were performed centrally via the project team with a mass change. The final step was controlling to make sure that the master data reflected the real state of the market and was relevant to be used for KPI calculation. The project team double checked that all the requested changes were performed and that the KPI calculation was based on the data agreed upon with individual markets.

While the majority of global markets at Pharma Inc. rolled out KPI measurements years ago, the selected markets, due to their complexity, officially started measuring their supply chain performance from the beginning of the fiscal year 2020 (in the calendar month of December 2019). Markets within the region onboarded the go-live in two more separate waves later in the year since the first steps for them were prolonged due to the many challenges that were identified during the onboarding process. The challenges were mainly a consequence of the different E2E supply chain designs in various markets.

In this business case, I will focus on the measurement of the performance of the supply chain through 3 leading KPIs: forecast error %, in-stock %, and months on hand (MOH), which are all calculated based on the global corporate logic, to be explained in detail in the "Key Performance Indicators" section. The analysis will compare the performance data on day 1 of the markets going live on automated metrics with the results of the same KPIs 24 months later (at the end of the fiscal year). A comparison between the beginning and the end of the given period will be performed to elaborate whether the enhanced usage of various digital tools to actively follow up on key KPIs and take measurable actions to meet targets has any impact on performance.

The data encompasses 24 markets, spanning a distance of around 7500 km, delivering hundreds of SKUs with a mix of different distribution models, divided across 6 different business units ('BU') with different market dynamics.

A discussion will follow, first by using the interview methodology, after which I will summarize my reflections and key findings from this business case.

3.2 Company overview

The company Pharma Inc. was established in the mid-1800s and is one of the world's leading biopharmaceutical companies. It is one of the major players in the pharmaceutical industry, with headquarters in the USA. The company is driven by scientific excellence and a compelling commercial strategy. Via several mergers and acquisitions, the company has achieved organic growth, allowing it to position itself as a market leader in several key therapeutic areas, such as anti-infective, cardiovascular, inflammation and immunology, internal medicine, oncology, rare diseases, and vaccines. In 2019, the company's revenue exceeded USD 50 billion. The company operates in more than 120 countries, with more than 80.000 employees worldwide. Its manufacturing network is large, spreading over more than 40 manufacturing sites worldwide. The company also dedicates a lot of resources to research and development and had more than 90 projects in Clinical Research and Development in 2019.

3.3 The role of SCM in Pharma Inc.

Global supply chain (GSC) organization is one of the critical elements of the success of Pharma Inc., whose mission it is to become the premier innovative biopharmaceutical global supply organization by delivering recognized value to patients and being recognized as the most trusted organization by both its internal and external stakeholders. More than 9000 suppliers are handling over 13,000 SKUs via 120 logistics centers. More than 23 billion doses are being delivered to patients in more than 125 countries all over the world every year.

Because of the above mentioned approach and the tight industry-related regulatory constraints, the organization is highly focused on guaranteeing top quality medicines and avoiding any risk which might threaten product integrity and, even more importantly, patient safety. Therefore, timely information on the status of shipments, inventory levels, the authenticity of the product throughout the value chain, and other pieces of the puzzle are critical to guaranteeing supply continuity. Moreover, the high level of complexity has led Pharma Inc. to invest in an integrated ERP platform deployed across all markets to increase the level of transparency and improve master data accuracy.

3.4 Key performance indicators

There are several KPIs used within the GSC of Pharma Inc. This work will focus on the ones that are most commonly used in performance review processes. GSC performance in Pharma Inc. is usually reviewed on a monthly basis, with the help of visual management meetings. For better visualization, a so-called balanced scorecard (BSC) is generated for each tier performance review. Tier 1 (T1) represents shifts and work center teams in the markets, hubs, and intercompany operations. Tier 2 (T2) stands for departmental teams, including at the market level. Tier 3 (T3) are site leadership teams and the sub-regional or cluster-level management; these tiers constitute the first tier of the leadership ecosystem, T1 and T2 being on the functional level of the ecosystem. Tier 4 (T4) stands for the regional leadership team and Tier 5 (T5) for the global supply chain management. Tier 6 (T6) would be a performance review at the level of the executive leadership team (ELT) of the company. The lowest tier to be reviewed is the market tier (T2), which then feeds into the regional tier (T3), and the logic continues up to T6, where there is a global review.

Targets are set globally for each tier of KPI and represent the baseline for each review discussion. The BSC is a combination of different KPIs divided in 3 groups: Services, Efficiency, and Finance. I will compare the evolution of KPI results at the aggregated cluster level, where specific targets are set for the three above mentioned KPIs. The customer service metric is measured based on a BU and segment combination, where each SKU is dedicated to a specific segment within the BU. The result gives us information as to what was the percentage of each SKU being in stock and salable in a given period. The forecast error (FE) metric tells the difference between actual sales in a given period and the forecast that the demand planner provided for this period 3 months ago. Targets differ based on the BU and are also followed as such. The months on hand (MOH) metric provides information on how many days of supply (DOS) worth of inventory each SKU has, based on the future consumption forecast and the current unrestricted inventory data. Like FE, this metric's targets differ based on BU expectations. If the metric target is met, the result turns green in the aggregated balanced scorecard (BSC) view and there is no need to dive any deeper into root cause analysis. When the target is not met, markets need to provide a root cause for this result, together with a corrective and preventive action plan (CAPA) to make sure that they follow up with an action. The analysis will show how many KPIs have turned green after months of using this approach.

The company uses various digital tools (i.e., BOBJ, Tableau, MS Office tools) to serve markets with the various data needed. Based on the data provided, local market supply chain professionals make decisions while trying to improve overall supply chain performance. I will therefore present the business case with a qualitative description of what the implementation of KPI measurement has brought to day-to-day operations, and investigate if there has been any noticeable improvement to supply chain processes. The key focus will be on how digital tools can help an organization to bring more value-added activities into SCM and allow employees to focus on more meaningful work (e.g., replacing manual forecasts with statistical/intelligent forecasts).

3.4.1 Services

Services are being measured through the customer service KPI, often also referred to as percentage in-stock. The purpose of this KPI is to measure supply ability to meet customer needs.

Figures 4, 5 and 6 are a snapshot of each KPI, with a more detailed explanation about its respective purposes and key stakeholders. The purpose tab explains what the KPI is measuring. A detailed definition explains how it is being calculated and what each variable in the equation means. Beneath the description of the scope of measurement, there is a RACI (Responsible, Accountable, Consulted, Informed) structure and the name of the source for the data. The right side of each figure provides a bit more clarity on who are the key stakeholders.

The metric owner is an important piece of information, as this owner is responsible for following up on the KPI. This means executing a performance review and the actions related to it, making sure that the CAPA is followed and that there is a CI loop in place. Targets for the majority of KPIs are typically set by global teams, using a top-down approach. This means that the global target is set first, after which individual targets are set for other tiers and regions. The aggregation principle is therefore also important to understand how each KPI is rolled up, from the lowest tiers of markets to global tiers.

Each below figure uses multiple abbreviations for the sake of simplicity. All abbreviations are explained in the List of Abbreviations, available at the beginning of this thesis.

Figure 4: Customer Service – % in-stock definition

Purpose: Measure supply ability to meet customer needs

Metric Owner: Global BU Interface

Detailed Definition:

- % in-stock = 1 – (Total Stock Out Days / Total Shipping Days)
- Stock Out Day = A SKU gets hit with a stock out day if:
  - Available inventory for SKU < 0 or,
  - Available inventory for SKU < Daily Forecast
  - Where available inventory = on-hand (approved) inventory minus backorders
- Total Shipping Days = # SKU * number of Shipping Days in a month.
- Targets and thresholds at product segment level (e.g., M, S, A, B, C)

Frequency: monthly – available on 1st day after AP close

Target set by: Global BUI and OpU leads (global top-down)

Targets per: Business > Business Unit > BU Segment

Aggregation principle:

- Global target per Business Unit/Segment
- Automatically rolled-up

1 – [Total Days Out of Stock / (Total # SKU's x Total Days in Month)]

% in-stock

Scope of measurement:

- Metric is displayed on Business unit and Segment level

Responsible:	**Accountable:**	**Consulted:**	**Informed:**	**Source:**	**Applied on tier-level:**
Global BUI	OpU leads	OpU, BUI leads System or metric owners	Market Lead / Leadership Team at each level	SAP (automated) to BOBJ/Tableau	At T5 to T2

Source: Selected company (2021).

3.4.2 Efficiency

Efficiency is measured through 3 main KPIs. The first one is the forecast error (FE) percentage, whose purpose is to measure forecast deviations, the second one is the forecast bias percentage, whose main goal is to understand those forecast deviations, and the third one is called months on hand, which measures how many days of inventory the company owns in a given moment.

Figure 5: Forecast Error (in %) definition

Purpose: minimize FC deviations that impact customer satisfaction and demonstrate FC robustness as leading indicator to potential impact on SC effectiveness	**Metric Owner:** GSC
Detailed Definition: ❖ Absolute Error Quantity over the past Accounting Period (AP) divided by FC Quantity over the past Accounting Period ❖ Forecast Error in % = Absolute Error (Lag 3 Forecast - Actual) / Lag 3 Forecast	**Frequency:** monthly – available on 3rd day after AP close **Target set by:** Regional SC **Targets per:** Market, Market Business Units
Scope of measurement: ❖ Market's Forecast by Business/Business Unit (product level) ❖ Measured at T2 (market) to T5 (area)	**Aggregation principle:** ❖ Regional SC calculates Market & Market BU target based on prior year's November FC ❖ RSC applies improvement factor ❖ RSC & Market find consensus ❖ Targets entered into SCAT per Market & Market BU ❖ Aggregated target from market to region to global automatically by system

Responsible:	**Accountable:**	**Consulted:**	**Informed:**	**Source:**	**Applied on tier-level:**
GSC	Market leads	Regional Supply Chain	Market Lead / Leadership Team at each level	SAP (automated) to BOBJ/Tableau	At T5 to T2

Source: Selected company (2021).

It is crucial to understand FC error logic to analyze deviations and perform a root cause analysis that will lead to a continuous improvement of this metric. The two main inputs in this metric are the market sales forecast inserted by the demand manager and the monthly customer sales orders coming from various order-to-cash (O2C) systems. A supply chain digitization (SCD) tool automatically calculates the FE using a lagged –3-month forecast, and outputs are then available in FC error reports. All users can view them globally, or by item, brand, market, region, or business unit. There is a lot of attention dedicated to this KPI in Pharma Inc., as the forecast error is a critical measure of the ability to accurately predict market demand. Similar to FE, the forecast bias is measured in order to understand deviations better.

Figure 6: Forecast Bias (in %) definition

Purpose: understand FC deviations that impact customer satisfaction and demonstrate FC robustness as a leading indicator to potential impact on SC effectiveness

Metric Owner: Regional SC
System Owner: A. Valbuena

Detailed Definition:

- Forecast Bias = (Actual - Lag 3 Forecast) / Lag 3 Forecast

Frequency: monthly – available on 3rd day after AP close

Target set by: Regional SC
Targets per: Market, Market Business Units

Aggregation principle:

- Aggregated target from market to region to global automatically by system

Scope of measurement:

- Market's Forecast Bias by Business/Business Unit (product level)
- Measured at T2 (market) to T5 (area)

Responsible:	Accountable:	Consulted:	Informed:	Source:	Applied on tier-level:
GSC	Market leads	Regional Supply Chain	Market Lead / Leadership Team at each level	SAP (automated) to BOBJ/Tableau	At T5 to T2

Source: Selected company (2021).

The FC bias logic works very similarly to the FC, but with an important difference, as the FC bias represents a consistent FC error in the same direction (overselling or underselling). The difference between both KPIs is easiest to explain on examples (see Table 4-1).

Table 1: FE% Calculation logic

Item	Actual Sales	Forecast (lag – 3)	Absolute Error	FE (%)
A	100	150	50	33%
B	200	200	-	0%
C	100	50	50	100%
Total Market	**400**	**400**	**100**	**25%**

Source: Own work.

As seen above, FE% shows the percentage error based on the absolute error, regardless of whether the market is overselling or underselling. To understand the trend, the company needs to also look at the FE bias.

Table 2: FE bias calculation logic

Item	Actual Sales	Forecast (lag – 3)	Absolute Error	Bias FE
A	100	150	-50	-33%
B	200	200	0	0%
C	100	50	50	100%
Total Market	**400**	**400**	**0**	**0%**

Source: Own work.

In the examples above, FE% would result in 25%, while Bias FE% would result in 0%, meaning that there is no clear overselling or underselling trend.

The last KPI in this section is called months on hand (MOH). The purpose of MOH is to establish a balanced inventory position across the organization and to demonstrate effective inventory to sales management. Inventory MOH includes all inventory, both strategic and operational. The KPI has three inputs. The first is the inventory for each market, the second is the statistical cost provided by manufacturing sites, and the third is the market sales forecast. Based on these 3 inputs, MOH is calculated as follows: MOH = $Inv / $Estimated Monthly Consumption.

Table 3: MOH calculation logic

Item	Inv $	Estimated Daily Consumption $	MOH
A	2,500	150	0.83
B	50,000	800	3.13
C	3,000	50	3.00
Total Market	**55,500**	**1,000**	**2.78**

Source: Own work.

Inventory MOH is a critical measure of the ability to satisfy customer demand while minimizing excessive inventory.

3.4.3 Finance

Finance and working capital KPIs are reviewed as their own set of indicators to track the financial impact of inventory on the organization's profit and loss statements. The purpose of these indicators is to optimize the company's asset utilization and to understand the value of the capital that is deployed for inventory. The two most important KPIs in this category are the GMX inventory value and the write-off value.

The GMX inventory value is a report of the absolute $ value of all inventory owned by the company. It is calculated as: Inventory $ Value = (On Hand + In Transit) * net statistical cost. The report is based on the 5 controller division inventory categories: raw materials, work in progress, packaging, finished goods, and reserves. It is valued as a net statistical valuation, meaning that the intercompany markup is removed.

The second important KPI is called write-off value. Its purpose is to track the $ value of material to scrap and to understand the value of capital losses. It is based on a net balance of all 4 major inventory accounts: obsolescence, slow moving inventory, physical inventory adjustments, and salvage. Both KPIs are tracked on a business unit segment basis and are rolled up together with the defined targets by the commercial finance stakeholders.

4 MEASUREMENT OF SUPPLY CHAIN PERFORMANCE AT PHARMA INC.

This chapter explains how launching the measurement of select KPIs in select markets within Pharma Inc. impacted supply chain performance. I will try to determine whether the implementation and digitalization of KPIs could improve decision making in supply chain management and seek other potential benefits of measuring performance. First, I will address some key challenges of the implementation phase and the preliminary work that needed to be done. Second, I will go through all the elements of the DMAIC cycle, which was the method that was being used with this business case.

4.1 Implementation challenges

First, I want to highlight the importance of the implementation phase in this business case. I believe it is crucial to plan enough time and resources to make sure that the preliminary work is done appropriately, as it will make change management much smoother. Two very important elements, which turned out to be crucial for success in this business case, are data integrity and a cultural mindset shift of the people involved.

4.1.1 Data integrity

Assuring the quality of the data used for performance measurement inputs has been a hard task for myself and the entire project team. We were aware that the quality of decision-making in the markets would highly depend on the quality and integrity of the data used. It is only when data integrity is guaranteed and is effectively monitored that good decision-making support is possible. There are three prerequisites that must be fulfilled to achieve excellent data integrity. The data need to be complete, consistent, and correct. If any of these three requirements is violated, that could lead to false conclusions and wrong decisions (Schuh, Reuter, Prote, Brambring & Ays, 2017). This means that for the project team to prepare complete data sets, existing gaps had to first be identified and then corrected.

The biggest challenge was to identify the gaps, and this is where I relied completely on my colleagues from the respective markets and their insights. As already mentioned in methodology section, the data encompassed 24 different markets, namely: Slovenia, Bosnia and Herzegovina, Croatia, Albania, Kosovo, North Macedonia, Montenegro, Serbia, Belarus, Estonia, Latvia, Lithuania, Bulgaria, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Turkmenistan, Uzbekistan, Slovakia, and Ukraine. For these 24 markets, there were 11 different colleagues responsible, so they were my main point of contact for this task. Identifying the gaps took the most effort and time in this process, because the data was raw, with a lot of history, and this was the first time since the launch of the ERP a couple of years ago that somebody performed a data integrity exercise for these markets.

Our approach was to look at historical sales data and future demand forecasts per SKU and compare them with the list of SKUs that were marked as active for each market. Where there were no sales in the last 36 months, and no forecast for the next 36 months, we considered the SKU not active and removed it from the data scope. The biggest challenge were shared packs, where multiple markets use the same SKU and potentially even the same forecast location, so the data needed to be checked manually. Each scope file was also double checked by two colleagues. Once confirmed by the markets, all changes were gathered in one master file. I then agreed with the ERP support team to perform a mass upload of the changes to the ERP system, so that markets didn’t have to enter all the changes manually.

After the changes were performed centrally, the same exercise was repeated to see if we missed any SKUs. I created the same scope files with new master data and asked the markets to repeat the exercise. The second round demanded only a few minor changes, which were handled manually. After that, we concluded that the data were ready for calculating the KPIs. The last step of the data integrity exercise was to check if the KPIs calculated based on the cleaned-up data and the standardized formulas fit the markets, and if the results can be explained or whether there might be a considerable outlier somewhere. Therefore, another exercise was performed, where markets had to help me by validating the KPIs for themselves.

Since the results of these markets cascade through other tiers and are incorporated in global results (see the aggregation principles for each KPI in Figures 4, 5, and 6), it was important for the entire project team to understand that our work will have an impact on the supply chain performance metrics of the whole company. The team took another month for the validation of results, which were now already calculated automatically, to assess the impact of the aggregation of these results on global results and to re-validate data integrity. After confirmation from myself and the project sponsor, the new KPIs went live in the following month and were already showing up in various BSCs, not only for individual markets but also broader regions.

Data integrity will remain an important challenge for this company in the future. There is no systematic data integrity clean-up exercise in place that would assure strong data integrity in the long run. Different data owners are scattered across the organization, and in theory each of them should assure that data integrity remains high. In practice, the data owners do not put the same amount of effort into this process, so the risk of poor data integrity remains a systematic issue.

4.1.2 Change management

As seen above, the preparation phase before the KPIs went live took a while, meaning that colleagues from individual markets were involved in various actions before realizing what the results for their markets would be. I received questions from market colleagues on how this will impact their processes and individual performance reviews. This triggered a discussion in the core project team on how we should prepare our market colleagues for this change. We already realized that any effort to enact change could face resistance, so we had to organize activities to minimize the level of resistance and promote a smooth transition into change. Leaders and managers have a big role in instituting change, serving as models to effectively manage the change. To implement a successful change, initiatives, managers, and organizations should ensure that any plan for change is aligned with the corporate goals and objectives (Jalagat, 2016), which was the case at Pharma Inc. A study by Oreg showed that employees in many organizations ignore change when such change does not promote their interests (Oreg, 2003), which was true in our case. One of the biggest barriers to change is employees who are comfortable with the current performance, with no plans to improve. Any request to enhance performance can lead to ignorance among employees, and many of them may refuse to learn new things (Jalagat, 2016). Therefore, challenging the status quo became one of my biggest tasks and challenges in all phases of this project.

4.1.3 Digitalization

As already mentioned in previous chapters, digitalization played a crucial role also in this project. To be honest, it played a much bigger role than any of us in the project team anticipated and wished for, mainly because the world entered a pandemic era, which significantly impacted all areas of activity. This includes project management and day-to-day operational meetings, which were traditionally held face to face at least within local teams, but occasionally on the regional level.

Historically, crises and technological advances go hand in hand, changing the ways of working around the globe. The COVID-19 pandemic pushed virtual teams into a completely new era, since for the first time becoming a member of a virtual team was no longer a choice but an obligation, due to the many restrictions regarding physical distancing imposed by governments. The so-called digital era started a change in the processes and routines of business dynamics, to which many organizations have had to adapt in order to compete and survive in globalized markets (Garro-Abarca, Palos-Sanchez & Aguayo-Camacho, 2021). Luckily, our organization was well prepared for this transformation, as it started to invest in digitalization long before the pandemic, leading to a great return on investment during the crisis.

The usage of various Microsoft tools, such as MS Teams, to facilitate collaboration was crucial to transform the ways of working in a completely virtual environment. One of the most important processes that the company copied from manufacturing environments to all functions in the global supply chain were so-called visual management meetings. A visual management (VM) meeting is an essential tool from the Lean Six Sigma toolkit. It is often seen as the link between the data and people and is fundamentally all about communication. To be effective, a company needs to use instinctive visual cues to communicate accurate key information within a workplace and should always be available. This tool is also vital for embedding a continuous improvement mindset in a company (ClarityVM, 2022). Pharma Inc. uses this tool to schedule short meetings on various frequencies, to discuss standard work schedules, key performance indicators, and review open actions. In some markets, these meetings are daily; in others weekly. Different tiers of management discuss different types of topics, with meetings typically used for cascading and delegating different tasks across tiers. Since we were no longer able to meet in person, the adoption of these tools was much faster, in my opinion, than if we worked according to a hybrid model, where information would still circulate in open-space office environments. Colleagues needed to find a manageable way to still share all the information and discuss future tasks, so weekly visual management meetings were adopted rapidly within our region. On top of short weekly meetings, one longer monthly visual management meeting was organized for each market, with the agenda focused on performance reviews and continuous improvement initiatives.

This became very useful right at the time when we were trying to find a way to regularly show our selected KPIs to all our colleagues in the region in a structured way. A supply chain performance review was placed on the monthly agenda, with predefined KPIs that were to be reviewed. The desired outcome of these meetings was to perform a root cause analysis for the major contributors of every KPI and agree on actions, which would then be either cascaded to the upper or lower tier or remain the responsibility of the market team. These actions would then be followed up in regular weekly meetings via the tools mentioned above.

4.2 Implementation of SCM performance measurement using DMAIC methodology

As already mentioned in the theoretical part of this thesis, the DMAIC methodology of the Lean Six Sigma approach to continuously improve supply chain performance was used for this business case. This chapter will explain the approach going through all 5 elements of DMAIC.

4.2.1 Define

The first element of the define phase is the problem or challenge description. In this case, the main challenge was that there was no real visibility in supply chain performance and no KPIs identified for the selected group of markets. Due to the specific market setup, data integrity was very poor, and KPI validation was historically not possible. Therefore, all the automated metrics calculated for those markets in which performance management was already established were suppressed and not visible to GSC colleagues. Due to no visibility of supply chain performance, it was often pointed out by the management that there is no possibility to run a proper assessment on how successful supply chain processes in this market are, as well as that it is hard for GSC colleagues to run a proper root cause analysis on their performance, which would consequently lead to the process of identifying potential CAPA actions and CI projects, which would ultimately improve SC performance in this region.

Another important question to answer in the define phase is, why does this need to be done? So, the goal of the above-mentioned business challenge was to give these GSC colleagues visibility of their SC performance through the main KPIs, which were already available widely across GSC to other colleagues. The aim was to standardize in-market processes, where KPIs would be reviewed regularly. As an outcome of this review, root cause analysis, CAPA actions, and potential CI projects would improve the region's SC performance and maturity level.

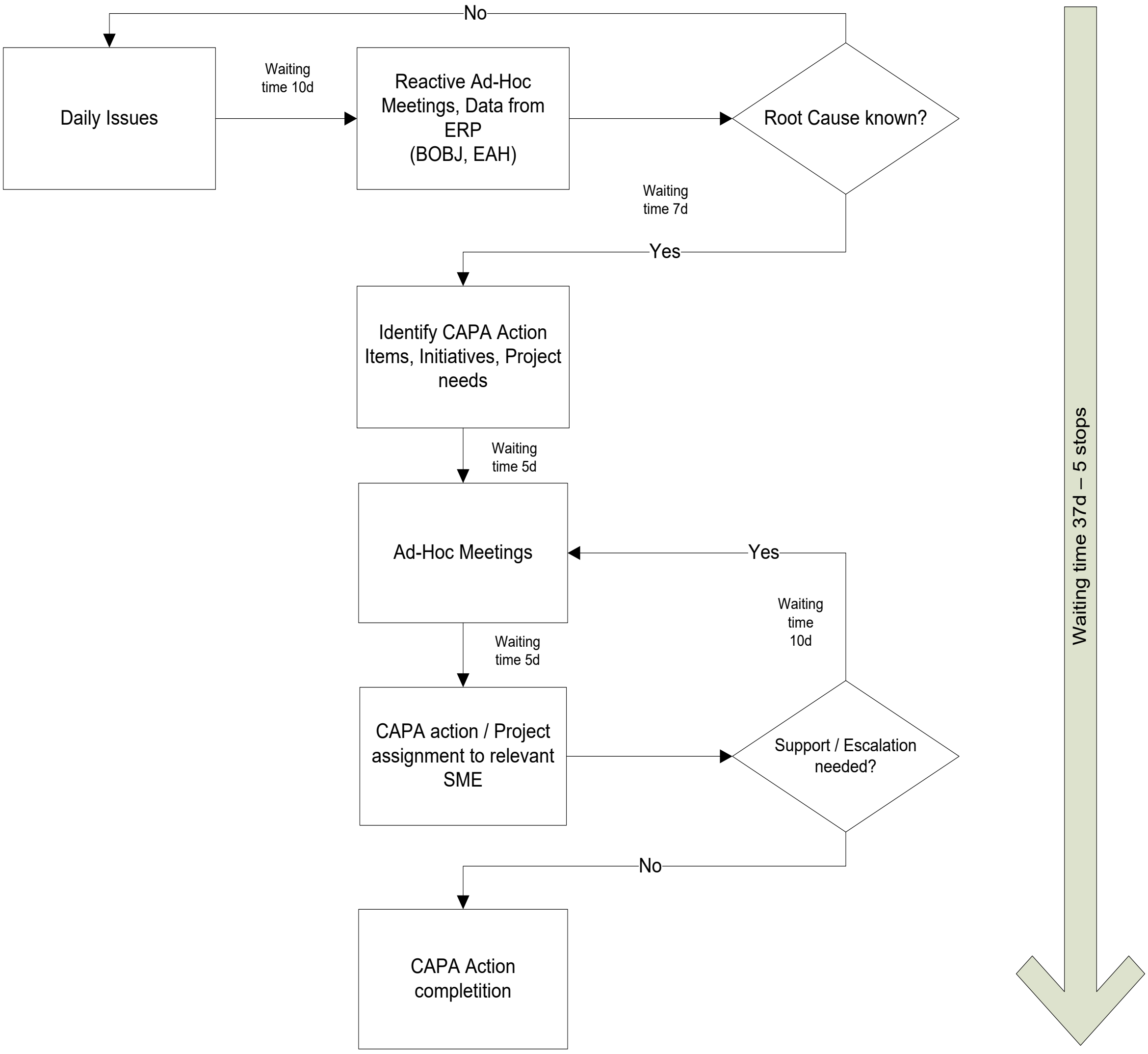
Before moving to the measure phase, we also need to define the specific performance measure that needs to be improved. In this case, the current standard process needed to be improved from non-existing performance measurement to a routine performance measurement, which should lead to a gradual improvement of all selected KPIs. Performance reviews were non-existent before this project, while the desired performance target condition was to assure that performance reviews become a standard, business-as-usual process and drive a continuous improvement process in these markets. As part of the define phase, key stakeholders were identified as well, from local markets to regional and global supply chain teams.

4.2.2 Measure

In the measure phase, a process map was created to show the efforts to improve supply chain processes and solve operational issues—to basically show how the process ran—before any measurement of supply chain performance in the markets. A so-called activity flowchart was used to show, specifically, what happens in a process.

The main observation and conclusion from the process map in Figure 7 was that all actions are identified as a consequence of reactive problem solving, which cannot lead to any proactive continuous improvement loop.

Figure 7: Process map before



Source: Own work.

4.2.3 Analyze

The main purpose of the analyze stage was to identify which steps of the process can be categorized as value added (VA), business value added (BVA), or non-value added (NVA). For the process effectiveness analysis, the so-called TIMWOOD value/waste analysis was used, where TIMWOOD stands for waste in transport, inventory, motion, waiting, over-production, over-processing, and defects. After reviewing the process map, it was clear that the waiting time was one of the biggest issues in the process, so the main focus in the scope of TIMWOOD was on the W. Waste was recognized and categorized as waiting, meaning the amount of time elapsed between processes when no work was being done and there was a waiting time for the next step in the process to occur. The waiting time was 37 days on average between identifying the issue and undertaking CAPA action as the next step in the process.

Based on this analysis, the next step of the analyze phase is the so-called ECRS stage, which is to eliminate steps that add no value, combine steps to improve flow and balance, rearrange steps to achieve a better process flow, and simplify all the remaining tasks, making them as easy as possible to do. In this specific case, this meant eliminating waste (waiting time) and change the process from reactive to proactive problem solving. Five steps in the process were pure waste, and eliminating them would reduce the overall lead time. Rearranging the steps in the process flow would enable our GSC colleagues to identify CI opportunities based on the root cause analysis.

A root cause analysis (RCA) was performed for this business case as well. The main root cause identified was that due to historical reasons (lack of interest in the markets that were not under the GSC umbrella) and a lack of focus due to an absence of regional leadership, there was no prioritization for the required actions. Therefore, based on the analyze phase, the conclusion was that a new standard process flow is needed.

4.2.4 Improve

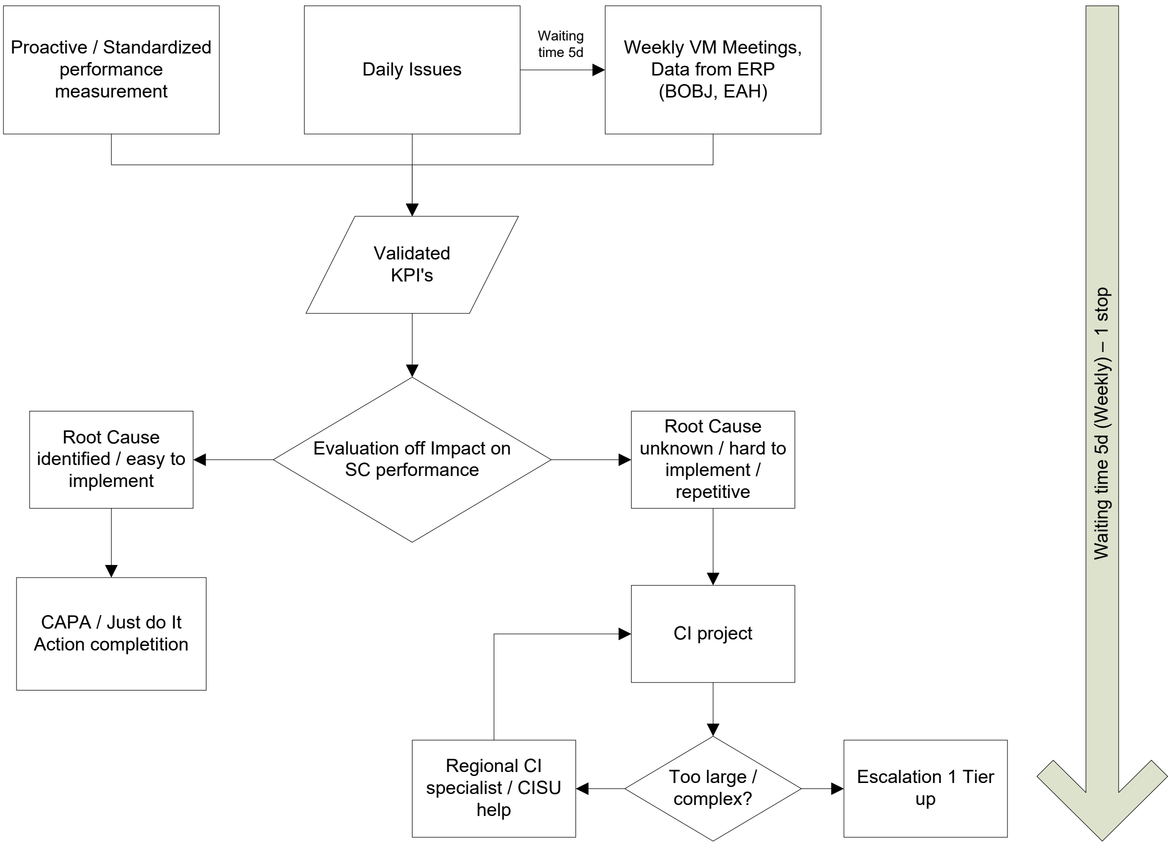
In this phase, ideas for improvement were generated to address the outputs of the analyze phase. These ideas were then prioritized based on the expected benefits and the estimated difficulty of executing the project. To shorten the waiting time, it was important to start looking proactively at supply chain performance. The other important output of the analyze phase was the need for standardization, so the new approach needed to be standardized across selected markets, as well as synchronized with what the rest of the company was doing. We decided to follow these steps:

1. Implement a standardized measurement of supply chain performance, using the validated metrics (KPIs) for the selected markets. This means that the selected markets would start using the same set of KPIs as the rest of the company was already using. This step was only possible after data integrity actions were performed.

2. Introduce select KPIs and performance reviews to all markets in scope. This means training T1 and T2 colleagues (demand planners, customer service managers, logistic managers, etc.) in the selected markets on how performance is being reviewed, how KPIs are being calculated, and how to work on cultural change, especially with demand planners, whose performance is now being measured differently than in the past.
3. Standardize the market approach towards performance reviews. Leverage visual management meetings on both market and regional levels. Include performance reviews on standard work calendars.
4. Identify the main root causes with RCA, follow up on CAPA and CI loop opportunities within the standard performance review cycle.
5. Use digital solutions to perform performance reviews and track actions. The goal here is to make it as simple as possible for everyone to be engaged and visualize the outcome of a review for a better understanding.

The results of the improvement phase and the above-mentioned steps led to a new process within these markets (shown in Figure 8). With the performance review, the shift from reactive to proactive problem solving happened rapidly and reduced the waiting time (waste) to 5 days, eliminating four stops, which is a significant reduction.

Figure 8: Process map after



Source: Own work.

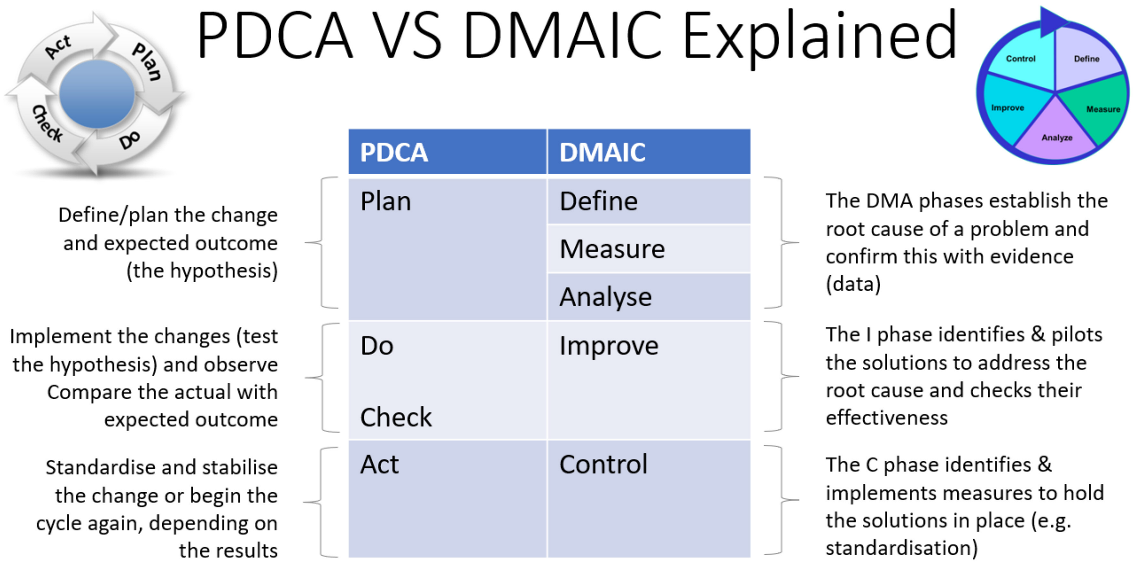
Understanding SC performance had a very positive impact on all markets. Markets shifted the mindset from reactive to proactive thinking through the standardized performance review approach. Understanding the true root cause helped markets to identify what CAPA actions can follow and led them to revisit some of the core processes in the markets in order to eliminate further waste (one example is the MOH reduction project, described later in this work, which led to several initiatives and reduced MOH significantly). A further performance review on the above-market (regional) level helped markets to leverage the regional network and allowed them to share some best practices across different markets.

4.2.5 Control

So, what will ensure that the improvement actions above are put in place? First of all, standardization was established, meaning that standard work calendars and processes were updated and are now aligned with all the other markets globally. KPIs have become a part of regular work objectives, individual goals, and something that is now being discussed daily, weekly, and/or monthly, depending on the reporting line. The process of monitoring performance is therefore ongoing and is embedded in the core processes of supply chain management in these markets. Another important tool for control is the continuous improvement loop (CI loop). The purpose of this loop is to continuously discuss potential improvements to the established market processes based on the results of a root cause analysis performed after the monthly release of KPIs. The CI loop is crucial for making sure that improvements don't end up being merely a discussion, but that they are later translated into tangible actions. The CI loop meeting has many benefits: it focuses on fixing the issues with the biggest impact, it prevents the re-occurrence of problems, it supports teamwork and collaboration, it creates sustainable improvements, and it builds capabilities for problem solving. To execute CI loop meetings, Pharma Inc. uses the so-called PDCA (plan, do, check, act) tool to manage and track improvements. It is important to note that PDCA is not a problem-solving method itself. I explained the DMAIC tool in this thesis, and the control phase is part of its cycle. To further elaborate on the importance of the CI loop and avoid confusion, I will use Figure 9 to visualize the key difference between PDCA and DMAIC.

There are two hybrid models that can be applied using both tools. In the first one, DMAIC is applied to each PDCA step. The second technique is based on the similarity of the principles of PDCA and DMAIC. In other terms, there is an equivalence between every single step of DMAIC and PDCA, as seen in Figure 9. In the scope of this approach, PDCA is the main tool that influences the performance of DMAIC, and not the opposite, as is the case in the first model (Chaabouni, Cheikhrouhou, Abbes & Sejri, 2019). Pharma Inc. chose the second technique and leveraged the PDCA tool to further improve especially the C in DMAIC. Every new efficiency improvement brought to the organization using the DMAIC cycle could be checked against the PDCA cycle, using the latter tool to further improve it. For example, when a new CI project is finished through the DMAIC process, PDCA helps in implementing and standardizing project outcomes.

Figure 9: PDCA vs. DMAIC



Source: Selected company (2021).

The control phase and PDCA are there to ensure that all the efforts in DMAIC are not lost. In my opinion, they are the most critical elements of success in the long term. For me, they were vital when trying to establish the CI mindset and culture in these markets and helped me a lot with change management or when discussing issues with market colleagues. Each CI loop meeting that we held, and each project that was clearly defined and followed the PDCA approach, brought us one step closer to understanding that performance reviews are the enablers of continuous improvement in the long run.

4.3 Impact of KPI measurement on SCM performance

To measure the impact of KPI measurement on SCM performance in the selected markets, I will compare balanced score card (BSC) results before the implementation of the above-mentioned processes and after 24 months of KPI measurement. Before I can compare the results, it is important to clarify the key BSC elements used in this case and to describe how this tool is used in performance measurement.

The GSC balanced scorecard is standardized for all markets, which means that all the selected markets from our business case adopted the same version. This consists of 3 major pillars, which I already elaborated on in chapter 3.4. For the purposes of impact measurement in this business case, I will focus only on some of them, since the ones described below were key for our selected region. This was mainly because market colleagues can have a big impact with their demand forecasting inputs, and we believed that these areas needed improvement first, as enhanced forecasting leads to the improvement of other KPIs as well.

The KPIs that the region which is the subject of this case study focuses on the most are efficiency measurements, namely: forecast error %, forecast error bias, and months on hand, which are already well defined in chapter 3.4.2. The scope of the data (the selected markets) as well as the timeframe for analyzing this business case are explained in the methodology chapter.

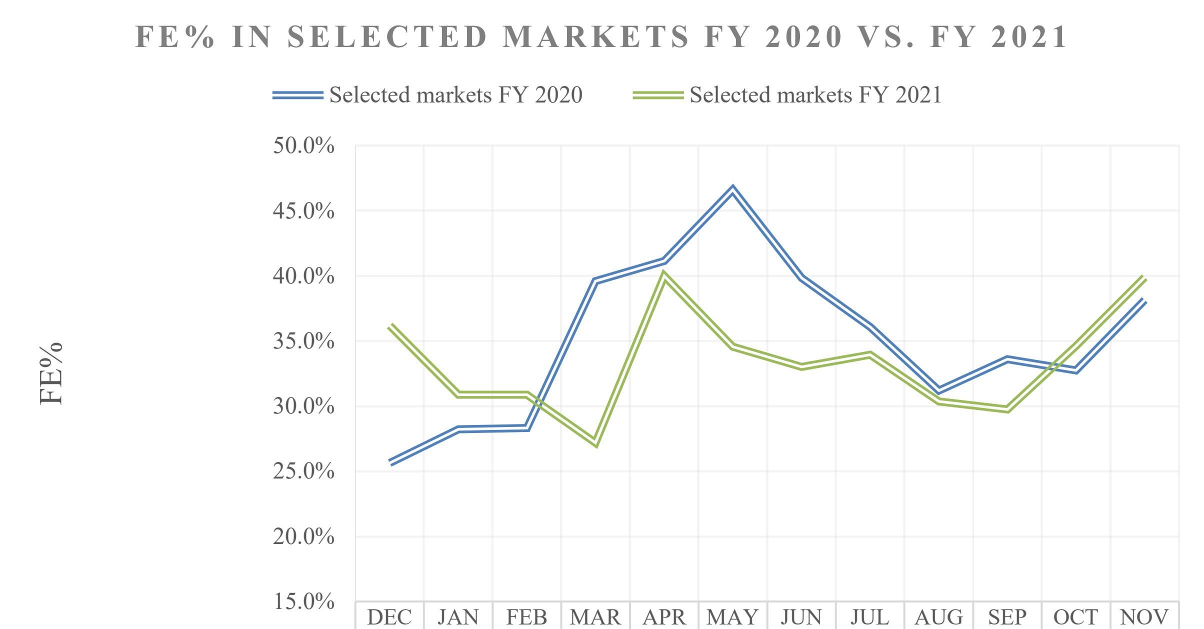
A comparison between the results obtained in the first month of automated metrics and those obtained at the end of the study period (after 24 months) should help us understand whether an enhanced usage of KPIs and various digital tools to actively follow up on key KPIs and take measurable remedial actions to meet the set targets has any impact on supply chain performance in the selected markets.

4.3.1 Forecast error percentage

The forecast error percentage is one of the most important KPIs in this supply chain organization. Its logic and calculation methodology are well defined in the previous chapters, so I will focus on interpreting the results of this case study. To understand all the elements that have an impact on this KPI, the company uses a forecast error root cause analysis tool (FERCA). FERCA is a process in the company's ERP system, in which demand managers inform of the FE root cause for those SKUs that have the most impact (over 1%) in the absolute FE% market metric in every period. It includes a generic reason code and market comments and allows easy analytics to support corrective actions. It also enables the exclusion of only objective exceptional events from the monthly FE% metric when the error does not impact the supply of the product and is therefore caused by certain pre-defined events. I will use FERCA tool analytics to look at the most commonly used reason codes that affected the below FE% results.

The overall (average) result of the FE% KPI for the selected markets in the fiscal year (FY) 2020 was **35.2%**, whereas the FY 2021 result was **33.3%**. This means that there was no significant improvement in this KPI over the course of 24 months.

Figure 10: FE% results comparison



	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Selected markets FY 2020	25.6%	28.2%	28.3%	39.6%	41.2%	46.6%	39.8%	36.1%	31.2%	33.6%	32.7%	38.1%
Selected markets FY 2021	36.2%	30.9%	30.9%	27.2%	40.0%	34.6%	33.0%	33.9%	30.4%	29.7%	34.6%	39.9%

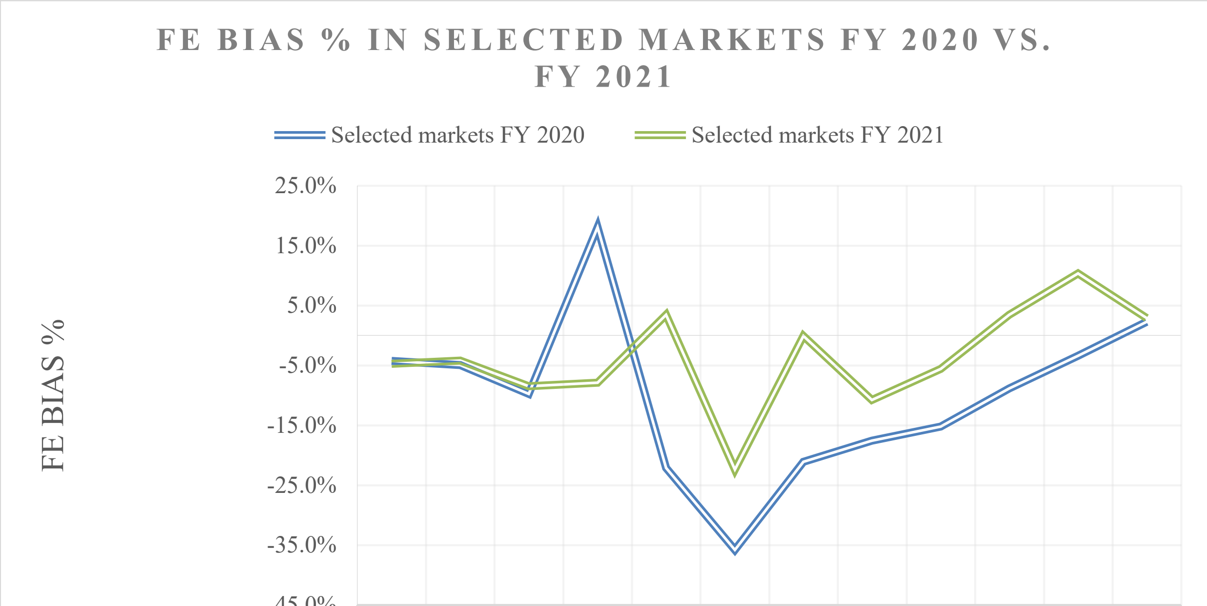
Source: Own work.

A deeper look into FERCA analytics explains why many of the improvement initiatives regarding the FE% KPI were practicality invalidated over the course of this timeframe. The main reason code for outliers was the coronavirus outbreak and the pandemic situation within the market. This means that external environmental factors influenced demand signals, and these are by their nature very unexpected demand outliers, very difficult to predict by market intelligence. The pandemic had a strong impact on the performance of all BUs across all KPIs, which I will address later in the discussion part of this thesis. Unpredictable demand events must be kept in the FE% metric since this is essentially what FE% measures, so the company decided not to suppress these events and allow them to impact the FE% KPI. Taking all this into the account, a small decrease in overall FE% is still considered a good result, with many smaller markets showing significant improvements.

4.3.2 Forecast error bias percentage

To understand the error in the forecast, it is important to look at the bias figures as well (Figure 11). This helps us understand if there is any constant under- or over-selling. Again, the logic and the calculation of this KPI was described above, and very similarly to FE%, the FERCA process has an impact on the result of the FE bias %.

Figure 11: FE bias % results comparison



	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Selected markets FY 2020	-4.3%	-5.0%	-9.8%	18.1%	-22.1%	-35.8%	-21.1%	-17.6%	-15.2%	-8.8%	-3.4%	2.2%
Selected markets FY 2021	-4.7%	-4.2%	-8.5%	-7.9%	3.4%	-22.4%	-0.1%	-10.8%	-5.6%	3.5%	10.3%	2.9%

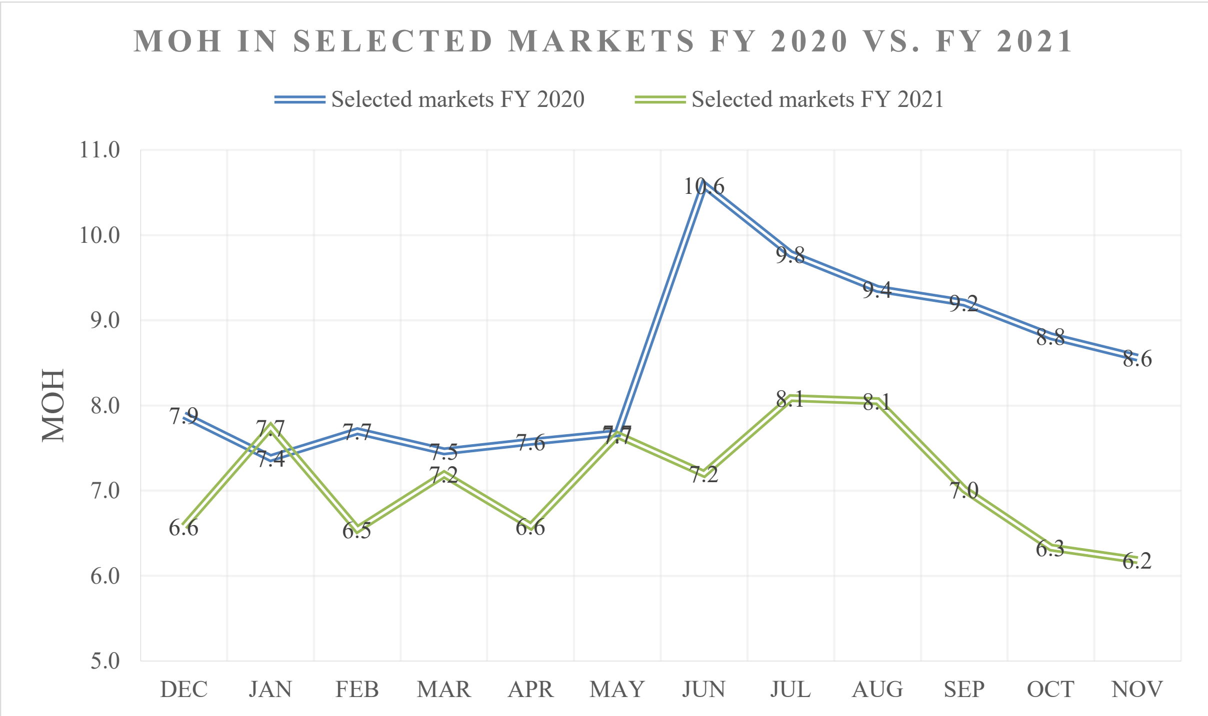
Source: Own work.

The overall (average) result of the FE bias % KPI for the selected markets in the fiscal year (FY) 2020 was **-10.1%**, whereas the FY 2021 result was **-3.5%**. This result shows significant improvement in 2021 versus 2020. Both of these results show that there is underselling when combining all the markets and all the SKUs in total, and that this underselling was reduced by roughly 65%. According to the FERCA tool, similar to the FE%, the pandemic had a great impact on the bias KPI as well. I will further elaborate on this impact later, in the discussion chapter.

4.3.3 Months on hand

Managing inventory earned special attention with the selected markets, as historically these markets had higher than average inventory values, relative to their sizes. The reasons for a high MOH value are external. As already mentioned, we measured a cluster of smaller markets, which are highly volatile due to their political, demographic, and regulatory environments; they are often highly regulated and highly tender-driven, which increases complexity and makes it harder to predict future demand. Other than a high FE%, these markets are also affected by high minimum order quantities (MOQ), that is, quantities that the supplier is willing to supply at a minimum. The demand from these markets is often too small to even reach MOQ, which means that the markets need to order quantities that exceed their desired target, which increases their MOH. They are attempting to solve this issue by combining packs, creating shared packs and common labels, meaning that one supplied batch is destined to multiple markets, making it easier to consume MOQ. While this helps with inventory value, it increases the complexity of logistics and planning processes as well as regulatory affairs and quality oversight. This is why starting to measure MOH was a crucial step for these markets, as some root cause analysis was finally possible and select tangible actions could be introduced based on the first results. Let's look at the comparison of the FY 2020 MOH versus the FY 2021 MOH results for the selected markets (Figure 12).

Figure 12: MOH results comparison



Source: Own work.

MOH dropped from the end of the fiscal year in November 2020 to the end of the fiscal year in November 2021 from 8.6 to 6.2 months on hand, meaning that there was a significant drop of 2.4 months' worth of inventory on hand in these markets. Translating this number to inventory value brings a high reduction of working capital in the company's balance sheet, delivered by a significant improvement of supply chain performance. There are several reasons why MOH dropped so significantly in this case, and I will explain them further on a concise business case in the next chapter.

4.4 Business case: MOH reduction

I will take a deeper dive into the MOH reduction business case to explain how the DMAIC flow worked in practice on this example, and how exploring multiple innovative digital tools helped these markets to reduce MOH.

In my role as Regional CI and Operations Manager, I led a smaller project that started because of newly launched automated metrics in the region. First, let me provide some context as to why this project was selected. Our inventory levels within the region were identified as high immediately after we got our first KPI results. Therefore, we were challenged on this point at the global level, as this is a financial burden for the organization. I was tasked with identifying the ways to reduce this burden. This challenge was specific to our region, which is very tender-driven, and where traditionally inventory levels are higher than elsewhere. The timing to start the project was perfect, since we had just gone live with the metrics and had a given target to reach. There were certain actions that we launched in the region in a couple of selected markets, such as incorporating MOH metrics in our monthly performance review, which led to the first root cause analysis and action planning. Based on that, markets identified a few initiatives, but nothing had yet been started before this project. I identified the key stakeholders in the process, together with the project sponsor, and formed a project team which included the Project Lead (myself), the Project Sponsor, the Lead Innovative Coach (who facilitated workshops), and 15 attendees, who were Subject Matter Experts (SME) for their respective markets and processes. With that, we answered the what, when, where and who questions, and concluded the define phase of the cycle.

The measure phase started already in the scope of the preliminary work being done for this project. Gathering data was easy, as we had fresh data available in SAP, with very high data integrity; the data had just been cleaned-up and double checked before the metrics went live. During the project, the data helped the project team to view the history of the identified problem and allowed a deep dive into the SKU level of details for each market. Using the Tableau analytics tool and MS Excel charts, the visualization helped to start focusing on the biggest contributors to this issue, which we at the same time identified as the biggest opportunities for improvement. The measure phase was also important from the control standpoint of this process, as it is important to monitor process performance through time. Our vision of success for this project was to reach the globally set target for this region within a year.

As part of the analyze phase, the project team took a deep dive into the root cause analysis. As mentioned before, each market has already pre-prepared a RCA for the main contributor SKUs from their markets, using market intelligence. After that, I organized a brainstorming session with all project participants, where we discussed possible solutions to the identified root causes. By this stage, the object of discussion was very well defined, so I encouraged everyone to contribute ideas as they thought of them, regardless of which market they came from.

We wrote ideas without evaluation – we repeated this for 2 more rounds, building on other people's ideas. Afterwards, we grouped similar ideas into different clusters, in order to make further discussion simpler. It is important to note that this was the first time I experienced an intensive brainstorming session virtually, and not in a face-to-face meeting. Facilitating was therefore a special challenge, as it is hard to engage everyone using digital tools only and make sure that the meeting is not dominated by only a few participants. Multitasking during meetings is something that is much harder to control during virtual meetings. It surely has an impact on the colleagues' productivity and their creativity, which was much needed in our case. Virtual meetings were a challenge in their own right, and the fact that all participants worked from home made it even more difficult. It was hard to keep the focus high and block out the noise coming from the external environment, since people dealt with challenging situations at home, as a consequence of the pandemic. Still, given the number of ideas we collected, I concluded that the meetings were successful, because we came out of them with a long list of fresh ideas and very positive feedback from all attendees.

After the brainstorming sessions, the group project work was completed and we proceeded into the improve phase in select smaller working groups. I appointed a working group lead for each group, and each group was given a set of previously clustered ideas. The aim of this phase was to develop and deploy improvements, which would address the outputs of our analysis in the most impactful way. So, the goal of each working group was to identify ideas for improvement to address the key factors from their root cause analysis, asses these ideas, and identify priority improvements. Each working group leader had the important task to select only one of the ideas based on the estimated business value it would add. Then, the project sponsor, myself, and working group leads met to review and approve the selected improvements and agreed on an implementation plan. Five different projects were kicked off in separate workstreams. As the project lead, I was responsible for overseeing them and providing guidelines when needed. I will not elaborate further on how those five projects concluded, as this is not the purpose of this chapter. The purpose here is to demonstrate how the entire process of measuring our supply chain performance led to significant process improvements, and in this case also KPI improvements.

Lastly, a sustainable control process was established, which is still running today. The MOH metric is still being reviewed monthly in every market, and new RCA topics are now simply compared to the actions that we agreed upon in our MOH reduction exercise. By making sure that all markets are implementing the new standardized solutions to avoid high MOH, it is now much easier to identify new outliers and decide when new actions need to be taken by any of the markets. The number of new CI projects on inventory management is growing; for me, this is a good sign that the continuous improvement culture is well established. Furthermore, it shows that markets have recognized that MOH is an important KPI for the organization and are turning the newly gained knowledge on their high inventory SKUs into opportunities. Since the initial value of MOH was relatively high, the first improvements were easy to measure and the results were seen quickly. Consequently, this gained positive traction across other regions in Europe, and some of the actions we took were identified as replicable in markets outside our region. Replication is another factor involved in how we can measure the success of continuous improvement initiatives such as this one.

4.5 Interview

The GSC Cluster Lead played an important role in establishing the supply chain performance metrics in his cluster. He acted as a sponsor for the projects mentioned in this thesis and supported me as my mentor to help me lead them. His strong influence in the cluster helped a lot with setting up the continuous improvement mindset. Our mentor-mentee relationship expanded, affecting this master thesis as well, so he was the perfect candidate to conduct this interview with. The intention of this interview is to expand the analysis of the case and incorporate his reflections on the business case and the thesis itself.

I conducted the interview after completing my business case analysis and before concluding the thesis. The interview included 7 semi-structured questions. He has read and agreed with the transcript.

The first question was where he sees the biggest value added in measuring supply chain performance in his cluster.

He emphasized that establishing a baseline is the foundation of any continuous improvement effort, as well as its sustainability over time. With so many areas requiring to be addressed, having a quantitative measure of performance helps to maintain an objective judgement as to where resources should be allocated: not just to the area that screams the most, but rather to the one with the highest potential to yield relevant returns on the investment.

The second question was which were the main challenges of change management during this project.

He thinks that one of the hardest bits in the change management process was to get colleagues on board from a mindset perspective. The risk when introducing quantitative elements and more structured revision processes is always that people will feel controlled or, in worst case scenarios, mistrusted. The key effort here went into reassuring everyone involved that the project wasn't aimed at penalizing them or their performance, but rather at helping them harvest the immediate benefits that would translate into better results with lesser mid- and long-term efforts.

The third question was about the investment of his resources and whether they brought him sufficient ROI, based on his initial expectations. I was also interested in how he defines and measures ROI.

He pointed out that one of the main issues with this type of initiatives is related precisely to the quantification of benefits. Defining the implementation cost is relatively easy by considering the system implementation cost and the man-hours involved. But the benefit of improving the forecast error by 10% seems to be much harder to quantify in economic terms. While there might have been some intimation that it had a direct impact on inventory levels (lower carrying cost) and stock-out reduction, isolating the actual impact is extremely complicated unless working under very strong assumptions. The missing element is essentially a relevant control sample. For this reason, these investments are largely based on the strategic vision held by top management, the belief that what is required is a leap of faith knowing that "it is the right thing to do," even though they might struggle to define to which exact extent.

Question number four was about the role of digitalization, and how important it was while establishing performance measurement.

He emphasized that digitalization was absolutely paramount. Implementing such an initiative is already quite challenging on its own. All of a sudden, you fall into hundreds of discussions about exact definitions, exceptions, and market specificities – yet the process needs to be standardized. Unless you can automate the relevant measurements, the chances of survival for the process are extremely low, essentially because the risk for the effort to outweigh the benefit becomes way too high. He also emphasized that digitalization was instrumental to ensuring standardization and, consequently, sustainability.

Question five was about how important KPI results are for him and the main benefit of measuring them for his region.

He doesn't think that KPI results are the outcome of the element of measurement alone. One can safely infer that when results become apparent, people naturally start to feel an intrinsic pressure to improve performance to avoid being perceived as the ones who are "in the red." At the same time, the key aspect of measuring KPIs was the opportunity to effectively address efforts and derive process improvements right where we needed them the most. The results of such interventions were, in turn, further KPI improvements, in a virtuous cycle which is the very essence of process improvement itself.

Question six was on how COVID-19 and other external factors affected their KPI results and how they managed them.

He stressed that, again, we are talking about something that is extremely complicated to isolate. What the world saw during COVID-19 was an immediate rush to hoard inventory across the board, driven by the uncertainty resulting from the pandemic, which blew up standard forecasting. Driven by the new course of COVID treatments in ICUs, they saw a surge in demand for molecules that traditionally saw stable demand and relatively low consumption rates. Therapies and vaccinations that were considered no longer urgent or time-sensitive were postponed, which led to over-forecasting and an increase in inventory levels. The reality is that a number of unprecedented measures had to be taken to tackle an unprecedented emergency both on the supply and the demand side, as well as logistics. For example, they started to work closely with their Medical Function and combined the intelligence on therapies adopted locally in the markets with real-world evidence. Simulation models on the possible evolution of the infection curve, to derive a new consumption-based forecast was introduced for the first time as well. In the pharmaceutical industry, it is unfortunately not possible to access real-time consumption information because of data confidentiality. They had to invest heavily to convert production lines rapidly, in order to satisfy the most burning patient needs. They had to centralize the sales forecast process for specific molecules under substantial strain. They were forced to develop new models and tools, which they ultimately decided to retain. And the list could be much longer. The result, though, is that in the *annus horribilis* characterized by the worst pandemic in modern times, they achieved the greatest service levels in years.

Finally, I asked him if he could summarize his reflections after reading my thesis and how much it reflects his view on our journey.

He thought the thesis reflects much of what he had witnessed himself. We had been through the ups and downs of this journey together, so he was not surprised to find such a high level of alignment. If he was to summarize it all in a single take-away, it would be that starting to measure our supply chain performance in quantitative terms was instrumental for them to sharpen their efforts, drive continuous improvement, and ignite the necessary process changes. KPIs are nothing but numbers if they are not supported by focused actions, so, ultimately, the scales tip in the favor of people as the deciding element. That is why, irrespective of any technical or technological challenges, the hardest nut to crack in change management remains getting colleagues on board, which requires a deep-rooted and infectious leadership vision. He thought that my contribution to this journey was critical, with this thesis reflecting the years of purposeful effort that I have put into it.

5 DISCUSSION

For the purposes of this thesis, I investigated both the KPI results and numbers, but also other operational changes that were happening in our day-to-day work. I was going through the writing process with two different hats on. One as an employee in the organization that is the subject of the case I am writing about, and the other as an author of this master's thesis. In hindsight, I must admit that my views on all the topics discussed in this work were not completely realistic when looking only through the eyes of an employee in the organization. I am therefore very pleased that I had the chance to review the whole process that represented a part of my contribution to the company in the past months also with my academic hat on. This work led me to several new findings and I believe several of them apply to other supply chains and are useful for managers in supply chain management professional positions.

One important question, which never struck me before I started this project, is: Are the extra effort and time put into the previously discussed improvements worth the cost? Simply looking at the KPI results before and after, the answer is not straightforward and could even be misleading if one is not familiar with the details. I was hoping for a much better-looking picture, one that would show significant improvement in all KPI results after a year of measuring supply chain performance and continuous improvement projects. The reality is, however, that not all KPIs improved and only one of them (MOH) improved significantly.

Only with a really deep dive into the root cause analysis of each KPI did I learn that external environmental factors had a much greater impact on KPI results than internal process changes. It was an extraordinary year with the ongoing pandemic and irregular demand trends, which shocked supply chains globally. The overselling of some hospital treatments, due to the huge increase in hospitalization, and the underselling of other treatments, because patients could not reach their physicians, are two extremes that showed up in our root cause analysis throughout the year. In chapter 2.1, I mentioned the importance of balance between improving current SC elements and building dynamic capabilities for future change. This business case is a good example of how a company can do everything in its power to enhance internal CS processes, but these can then still be offset by external events, which are changing the future business models of the company. This is the reality of supply chain professionals, and it is important they embrace the fact that continuous improvement is something they can have control over, whereas the external environment is not. I believe that the answer to question no. 6 from the interview summarizes nicely how managers react to extraordinary external events as well.

Historical data and trends were all of a sudden something that demand managers were not able to rely on, and unpredictable behavior from key customers and unexpected governmental decisions became the new normal in the life of a demand planner. All of the above nullified the efforts that the markets were undertaking on a path towards better forecast error % and forecast bias results. The question is: What would the actual performance have been in the year of the COVID-19 pandemic in the absence of such sustained efforts?

Besides, there are still many positive impacts that measuring supply chain performance alone brought to the region in question. First of all, it showed the markets where their supply chain was less effective and where their focus should be. Second, the amount of work spent on various projects led the markets to many internal process changes, which brought significant simplifications and laid the groundwork for a continuous improvement loop in the future. Third, it sped up the digitalization of the company and the processes that will surely be beneficial for future ways of working. The supply chain organization in the selected markets is, in my opinion, much more resilient to future external shocks now than it was before we began our journey. To sum up, the answer to my first question is yes. I believe that all of the above-mentioned benefits definitely overcome the fact that KPI results did not significantly improve over time. I am confident that the lessons learned on the way are much more valuable to all colleagues and the company than the results themselves, because they are paving the way to many future improvements, which in time will lead to better KPIs. The interview with the Cluster Lead manager showed that he shares this belief.

Before the pandemic, most companies, including the company in the scope of this thesis, had been focusing on implementing a lean supply chain, which meant minimizing costs and decreasing inventory levels while trying to deliver just-in-time. The pandemic exposed the drawbacks of these supply chain actions brutally. It forced companies to refocus on inventory building and creating a buffer to combat disruptions in the end-to-end supply chain, while also dealing with bigger obsolescence due to a sudden drop of demand. Because of that, organizations today are more motivated to deploy digital supply networks since they are more dynamic, integrated, and provide a fast and continuous flow of information, which can empower organizations to stay connected with the entire supply network and to deal with potential future challenges (like that of the pandemic) much more efficiently (Iyengar, Vaishya, Bahl & Vaish, 2020). So, despite the fact that it is difficult, I believe that companies can still be prepared for big environmental changes. The COVID-19 pandemic led many of them to create better recovery plans, leaving them better prepared for next events.

The aforementioned external factors and the example of the pandemic led me to think about the next question. If supply chains in different organizations cannot predict certain events and external factors play such a big role in carving their KPI results, does it still make sense to measure KPIs such as the forecast error? The company in this study decreased the importance of KPI figures in these unprecedented times, not allowing them to impact the performance review of individual colleagues significantly. A 100% uptime on all production lines, adapting to working from home, and delivering some key medicines to combat the global pandemic played a much bigger role when discussing how successful supply chain performance was that year. Having said that, I do not believe that organizations should stop measuring the forecast error. It is the root cause analysis and the lessons learned by the markets after exploring why the error is high that count the most – even if there is nothing that they can realistically do about it in the short term.

My three biggest findings from writing this master thesis and what I think the reader's key takeaways should be:

First, when all the forces of nature are against you, external factors can beat your internal efforts when only reading the numbers. I believe that it is important to look at KPIs not only as numbers, but as guidance to spur process improvements and the CI loop mentality in the organization. Or, to put it in line with the Goodhart's law: "When a measure becomes a target, it ceases to be a good measure" (Libellio & Goodhart, 2013).

Second, people are afraid of the red colour. I found it very difficult to convince people that I am not doing the work of KPI police and that KPIs don't mainly exist to monitor their individual performance. It is crucial to change the mentality of people, reassuring them that KPIs are here to help and guide us toward future improvements. It should be emphasized that root cause analysis is a very useful tool that will help them grow individually, and not a tool to show them what they did wrong. Changing the mindset of colleagues, i.e., convincing them that the color red in their KPIs is not something to be afraid of, but rather an opportunity for continuous improvement, is a very long journey, and one deserving further study. Furthermore, Manfreda and others have argued that while changing business processes, companies should not only focus on the development of methodologically correct models, or in my case KPIs, but should also use the opportunity to increase the absorptive capacity of the company, i.e., change the above mentioned mentality (Manfreda, Kovacic, Štemberger & Trkman, 2014).

Third, the continuous improvement mentality should not be taken for granted. It is a value that needs to be learned and the journey is not easy. As the CI Manager for the region, I was probably biased, so the negative response I received from some colleagues when approaching them with the above discussion was even more frustrating. Nevertheless, I learned that a continuous improvement mindset could go a long way. Even if the results are not always as expected, it is the journey that counts, and the improvements done along the way typically justify the extra effort. Therefore, I believe that each organization should have people, projects, and processes in place that deal exclusively with the CI loop if they want to be competitive in long run.

These findings led me to think about the very basics of any change management. This business case is a very good example showing that sustainable change can only be achieved by working on the three crucial, inseparable elements that are people, processes, and systems.

6 CONCLUSION

Digitalization is here to stay, and the recent global pandemic only increased the speed of its adoption to unprecedented levels. As I pointed out in this thesis, global corporations working in a fast-changing environment with worldwide end-to-end supply chain setups are no exception. The first impression regarding supply chain digitalization is probably that digitalization makes the supply chain better. Digitalization is a strong enabler of continuous improvement in an organization. At the same time, I would argue that digitalization alone is far from enough if we want to see performance improvements in the long run. There are many tools out there, e.g. for measurement, control, visualization, collaboration, etc., that are needed to support decision making, but it is how companies use those tools that matters the most. Whether companies are using digital tools to improve their processes is not a question anymore in 2022: how they manage their usage, and what they make out of them, will remain a big topic for the future instead.

The case analysed in the thesis showed that measuring supply chain performance in an organization is not a guarantee for future improvement of key performance indicators, and the same applies to the digitalization of supply chain processes. It is the culture of continuous improvement in a company that counts the most when it comes to driving future improvements in supply chain processes. What we are able to do with bad KPI results, how successful we are in identifying the true root causes that caused these results, and how resilient our supply chain is to external environmental factors: those are the factors that make a difference.

Obviously, the claims and findings within this thesis are solely the author's own and do not necessarily reflect the opinions and beliefs of the company. Further limitations to my research must be acknowledged as well. First, given the time and resource constraints, only one interview could be conducted. Because of the strong history and connection to the topic itself, some views might be biased. Furthermore, there was no survey conducted among employees before and after the implementation of performance measurement, which does not allow a more quantitative analysis.

On another note, some avenues for deepening this topic through future investments are also possible for the company. Further analysis of a wider range of KPIs, close follow-up on CAPA actions, and a well-structured CI loop could open the gate for many further improvements. An important lesson learned by the company from this business case is also to make sure that external environmental events are well documented and that their impact on KPIs is understood by all stakeholders. The pandemic situation changed the perspective on the importance of KPIs amid unprecedented global events, which could be useful for any other big events that might occur in the future.

Unfortunately, this already proved to be valuable, as the Ukraine-Russia war started in March 2022. During the writing of this thesis, Pharma Inc. has already used some of its takeaways from the pandemic to better understand how new external environmental changes are impacting the KPIs. The company immediately started to categorize the impact of the war on supply and demand and is able to take better informed decisions because KPI outputs are clearer now than they were at the beginning of the pandemic.

The external environment in which organizations are working, regardless of whether it is local, regional, or global, and the impact it has on supply chain performance, is a great topic to continue exploring digitalization and the measurement of supply chain performance. In the last two years, the pandemic has been a great example supporting the above statement. It brought us opportunities in terms of speeding up digitalization and forced many companies to redesign their supply chains and ways of working. On the other hand, it brought serious limitations to measuring the performance of KPIs. It made it hard to distinguish between the benefits of internal supply chain process improvement and the external environmental factors that had an impact on both supply and demand across the globe.

REFERENCE LIST

1. Ageron, B., Bentahar, O. & Gunasekaran, A. (2020). Digital supply chain: challenges and future directions. *Supply Chain Forum: An International Journal*, *21*(3), 133–138.
2. Agrawal, P. & Narain, R. (2018). Digital supply chain management: An Overview. *IOP Conference Series: Materials Science and Engineering*, 1–6.
3. Arden, N. S., Fisher, A. C., Tyner, K., Yu, L. X., Lee, S. L. & Kopcha, M. (2021). Industry 4.0 for pharmaceutical manufacturing: Preparing for the smart factories of the future. *International Journal of Pharmaceutics*, *602*(120554), 1–8.
4. Ashrafian, A., Powell, D., Ingvaldsen, J., Dreyer, H., Holtskog, H., Schütz, P., Lodgaard, E. (2019). Sketching the Landscape for Lean Digital Transformation. *IFIP International Conference on Advances in Production Management Systems (APMS)*, 29–36.
5. ASQ. (n.d.). *Define, measure, analyze, improve, and control (DMAIC) process*. Retrieved October 17, 2021, from https://asq.org/quality-resources/dmaic
6. Bhagwat, R. & Sharma, M. K. (2007). Performance measurement of supply chain management: A balanced scorecard approach. *Computers and Industrial Engineering*, *53*(1), 43–62.
7. Boltić, Z., Jovanović, M., Petrović, S., Božanić, V. & Mihajlović, M. (2016). Continuous improvement concepts as a link between quality assurance and implementation of cleaner production-case study in the generic pharmaceutical industry. *Chemical Industry & Chemical Engineering Quarterly*, *22*(1), 55–64.
8. Bowersox, D. J., Closs, D. J. & Drayer, R. (2005). The digital transformation: technology and beyond. *Supply Chain Management Review, 9*(1), 22–29.
9. Buer, S.-V., Fragapane, G. I. & Strandhagen, J. O. (2018). The Data-Driven Process Improvement Cycle: Using Digitalization for Continuous Improvement. *IFAC PapersOnLine*, *51*(11), 1035–1040.
10. Cai, J., Liu, X., Xiao, Z. & Liu, J. (2009). Improving supply chain performance management: A systematic approach to analyzing iterative KPI accomplishment. *Decision Support Systems*, *46*(2), 512–521.
11. Cha, M., Rifai, B. & Sarraf, P. (2013). Pharmaceutical forecasting: throwing darts? *Nature Reviews Drug Discovery*, *12*, 737–738.
12. Chaabouni Y., Cheikhrouhou M., Abbes N. & Sejri N. (2019). A new lean Six Sigma hybrid method based on the combination of PDCA and the DMAIC to improve process performance: Application to clothing SME. *Industria Textila*, *70*(3), 447–456.
13. Chae, B. (2009). Developing key performance indicators for supply chain: an industry perspective. *Supply Chain Management: An International Journal*, *14*(6), 422–428.
14. ClarityVM. (2022). *What is Visual Management*. Retrieved March 20, 2022, from https://www.clarityvisualmanagement.com/technique/vm-visual-management/
15. De Mast, J. & Lokkerbol, J. (2012). An analysis of the Six Sigma DMAIC method from the perspective of problem solving. *Intern. Journal of Production Economics*, *139*, 604–614.

16. Donelan, R., Walker, S. & Salek, S. (2015). Factors influencing quality decision-making: Regulatory and pharmaceutical industry perspectives. *Pharmacoepidemiology and Drug Safety*, *24*(3), 319–328.
17. Dunford, R., Su, Q. & Tamang, E. (2014). The Pareto Principle. *The Plymouth Student Scientist*, *07*(1), 140–148.
18. Fox, B., Paley, A., Prevost, M. & Subramanian, N. (2016). Closing the digital gap in pharma. *Pharmaceuticals & Medical Products*, 1–6.
19. Frankiewicz, B. & Chamorro-Premuzic, T. (2020). Digital Transformation Is About Talent, Not Technology. *Harvard Business Review*, 2–6.
20. Garro-Abarca, V., Palos-Sanchez, P. & Aguayo-Camacho, M. (2021). Virtual Teams in Times of Pandemic: Factors That Influence Performance. *Frontiers in Psychology*, *12*, 232.
21. Gartner Inc. (2019). *Gartner for Supply Chain Leaders Toolkit*. Stamford, CT.
22. Gong, C. & Ribiere, V. (2021). Developing a unified definition of digital transformation. *Technovation*, *102*, 102217.
23. Hansen, K. R. N. & Grunow, M. (2015). Planning operations before market launch for balancing time-to-market and risks in pharmaceutical supply chains. *International Journal of Production Economics*, *161*, 129–139.
24. Hester, P., Ezell, B., Collins, A., Horst, J. & Lawsure, K. (2017). A Method for Key Performance Indicator Assessment in Manufacturing Organizations. *International Journal of Operations Research*, *14*(4), 157–167.
25. Hugos, M. H. (2003). *Essentials of Supply Chain Management*. (1st edition) Hoboken, New Jersey: John Wiley and Sons, Inc.
26. Iyengar, K. P., Vaishya, R., Bahl, S. & Vaish, A. (2020). Impact of the coronavirus pandemic on the supply chain in healthcare. *British Journal of Health Care Management*, *26*(6), 1–4.
27. Jalagat, R. (2016). The Impact of Change and Change Management in Achieving Corporate Goals and Objectives: Organizational Perspective. *International Journal of Science and Research (IJSR)*, *5*(11), 1233–1239.
28. Jayaram, A. (2016). Lean Six Sigma Approach for Global Supply Chain Management using Industry 4.0 and IIoT. *2nd International Conference on Contemporary Computing and Informatics, 89–94.*
29. Kopczak, L. R. & Johnson, M. E. (2003). *The Supply-Chain Management Effect*. Massachusetts.
30. Lapide, L. (2000). What About Measuring Supply Chain Performance? *Achieving Supply Chain Excellence Through Technology,* 287-297.
31. Lee, K. L., Ain, N., Azmi, N., Hanaysha, J. R., Alzoubi, H. M. & Alshurideh, M. T. (2022). The effect of digital supply chain on organizational performance: An empirical study in Malaysia manufacturing industry. *Uncertain Supply Chain Management*, *10*, 495–510.

32. Li, S., Ragu-Nathan, B., Ragu-Nathan, T. S. & Rao, S. S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. *Omega*, *34*, 107–124.
33. Libellio, L. & Goodhart, C. (2013). Goodhart's Law. *London School of Economics and Political Science*, *9*(4), 29–33.
34. Maestrini, V., Luzzini, D., Maccarrone, P. & Caniato, F. (2017). Supply chain performance measurement systems: A systematic review and research agenda. *International Journal of Production Economics*, *183*, 299–315.
35. Manfreda, A., Kovacic, A., Štemberger, M. I. & Trkman, P. (2014). Absorptive Capacity as a Precondition for Business Process Improvement. *Journal of Computer Information Systems*, *54*(2), 35–43.
36. Mehralian, G., Zarenezhad, F. & Ghatari, A. R. (2015). Developing a model for an agile supply chain in pharmaceutical industry. *International Journal of Pharmaceutical and Healthcare Marketing*, *9*(1), 74–91.
37. Mentzer, J. T., Dewitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D. & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business Logistics*, *22*(2), 1–25.
38. Merkuryeva, G., Valberga, A. & Smirnov, A. (2019). Demand forecasting in pharmaceutical supply chains: A case study. *Procedia Computer Science*, *149*, 3–10.
39. Nadkarni, S., Prügl, · Reinhard, Prügl, R., Nadkarni, S. & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly*, *71*, 233–341.
40. Oey, E. & Mulianti, N. (2017). Performance measurement system using balanced score card and tracking tool - A case study in a pharmaceutical company. *International Journal of Logistics Systems and Management*, *26*(4), 497–514.
41. Oreg, S. (2003). Resistance to change: Developing an individual differences measure. *Journal of Applied Psychology*, *88*(4), 680–693.
42. Rehman, S. T., Khan, S. A., Kusi-Sarpong, S. & Hassan, S. M. (2018). Supply chain performance measurement and improvement system: A MCDA-DMAIC methodology. *Journal of Modelling in Management*, *13*(3), 522–549.
43. Relex Solutions. (n.d.). *Measuring Forecast Accuracy: The Complete Guide*. Retrieved March 6, 2022, from https://www.relexsolutions.com/resources/measuring-forecast-accuracy/
44. Schuh, G., Reuter, C., Prote, J. P., Brambring, F. & Ays, J. (2017). Increasing data integrity for improving decision making in production planning and control. *CIRP Annals*, *66*(1), 425–428.
45. Selected Company. (2021). *DMAIC methodology.* Ljubljana.
46. Selected Company. (2021). *Metrics Definitions.* Ljubljana.
47. Seyedghorban, Z., Tahernejad, H., Meriton, R. & Graham, G. (2020). The Architecture of Supply Chain Digitalisation Research. *Supply Chain Digitalization: Past, Present and Future. Production Planning and Control*, *31*(2–3), 96–114.

48. Shah, N. (2004). Pharmaceutical supply chains: Key issues and strategies for optimisation. *Computers and Chemical Engineering*, *28*(6–7), 929–941. Pergamon.
49. Shankar, R. (2009). *Process Improvement Using Six Sigma: A DMAIC Guide*. Milwaukee, Wisconsin. American society for quality, Quality Press
50. Siddiqui, R., Azmat, M., Ahmed, S. & Kummer, S. (2021). A hybrid demand forecasting model for greater forecasting accuracy: the case of the pharmaceutical industry. *Supply Chain Forum: An International Journal ISSN:*, 1–11.
51. Sigma Magic. (n.d.). *Timeseries Plot [published on blog]*. Retrieved April 10, 2022, from https://www.sigmamagic.com/blogs/time-series-plot/
52. Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2–3), 172–194.
53. Toledo, J. C., Alliprandini, D. & Lizarelli, F. L. (2019). Total Quality Management & Business Excellence Relationship between continuous improvement and innovation performance: an empirical study in Brazilian manufacturing companies. *Total Quality Management and Business Excellence*, *32*(9–10), 981–1004.
54. Tripathi, S., Rangarajan, K. & Talukder, B. (2019). Segmental differences in pharmaceutical industry and its impact on supply chain performance. *International Journal of Pharmaceutical and Healthcare Marketing*, *13*(4), 516–540.
55. Trkman, P., Budler, M. & Groznik, A. (2015). A business model approach to supply chain management. *Supply Chain Management: An International Journal*, *20*(6), 587–602.
56. Trkman, P., McCormack, K., De Oliveira, M. P. V. & Ladeira, M. B. (2010). The impact of business analytics on supply chain performance. *Decision Support Systems*, *49*(3), 318–327.
57. Wang, G., Samuel, ·, Huang, H. & Dismukes, J. P. (2005). Manufacturing supply chain design and evaluation. *Int J Adv Manuf Technol*, *25*, 93–100.
58. Wessel, L., Baiyere abadigi, A., Ologeanu-Taddei, R., Cha JCha, J. & Blegind-Jensen blegind, T. (2021). Unpacking the difference between digital transformation and IT-enabled organizational transformation. *Journal of the Association for Information Systems*, *22*(1), 102–129.
59. Woodcock, J. (2004). The concept of pharmaceutical quality. *American Pharmaceutical Review*, *7*(6), 10–15.

APPENDIX

Appendix 1: Povzetek (Summary in Slovene language)

Oskrbovalna veriga je lahko ena najpomembnejših konkurenčnih prednosti vsakega podjetja. Njeno merjenje in nenehno izboljševanje pa je izjemno kompleksna naloga vsakega vodje. Če želijo podjetja obvladovati oskrbovalno verigo, je zelo pomembno, da tudi merijo njeno uspešnost. Ključni kazalniki uspešnosti veljajo za pomemben element sposobnosti podjetja, da spremlja svoje strateške cilje. Pomembno pa je poudariti, da je razvoj smiselnih kazalnikov za oskrbovalno verigo zahteven proces in da pravih smernic, ki bi ustrezale vsem panogam, ni.

Farmacevtska industrija ima zapleten sklop procesov, ki se ukvarjajo z odkrivanjem, razvojem in proizvodnjo zdravil. Ker ima neposreden vpliv na javno zdravje, so pričakovanja, da mora njena oskrbovalna veriga delovati brezhibno, visoka. Dostaviti pravo zdravilo pravemu pacientu ob pravem času je umetnost, ki jo mnoga svetovna farmacevtska podjetja skušajo izpopolniti.

Digitalizacija se je zakoreninila, v praktično vse poslovne procese in je zagotovo tu, da ostane, kar je epidemija samo še bolj utrdila. Je pomemben dejavnik, ki omogoča nenehne izboljšave organizacije in lahko na več načinov prispeva k boljši oskrbovalni verigi. Hkrati pa se mora bralec zavedati, da samo digitalizacija še zdaleč ni dovolj, če želimo nenehne izboljšave na dolgi rok. Obstaja veliko digitalnih orodij, ki jih podjetja uporabljajo na primer za merjenje kazalnikov, nadzor ali vizualizacijo in ki igrajo zelo pomembno vlogo pri podpori za odločanje vodstev. Vendar je v današnjem digitalnem svetu še pomembnejše kot to, da organizacija z njimi razpolaga, vprašanje, kako jih uporablja, kar bo zagotovo ostala pomembna raziskovalna tema za prihodnost.

Namen mojega magistrskega dela je analizirati, kako implementacija ključnih kazalnikov uspešnosti vpliva na uspešnost oskrbovalne verige, s posebnim poudarkom na tem, kakšno vlogo pri tem igra digitalizacija. S pomočjo primera iz prakse sem ugotavljal, kako je mogoče s pravim izborom ključnih kazalnikov uspešnosti izboljšati sprejemanje poslovnih odločitev. Poleg implementacije in digitalizacije kazalnikov uspešnosti sem raziskoval tudi ostale potencialne koristi digitalizacije poslovnih procesov v oskrbovalni verigi.

Na primeru izbranega farmacevtskega podjetja, sem se osredotočil na merjenje treh ključnih kazalnikov uspešnosti. To so odstotek napake v napovedi in njena pristranskost (*forecast error % and forecast bias*) ter zaloga v mesecih (*months on hand*). Analiza primerja rezultate teh kazalnikov pred začetkom implementacije z rezultati 24 mesecev kasneje. Podatki zajemajo agregacijo 24 trgov in na stotine produktov z mešanico različnih distribucijskih modelov, ki delujejo v različnih lokalnih tržnih dinamikah. Analizi sledi diskusija, kjer tudi s pomočjo intervjuja povzemam ključne ugotovitve iz tega poslovnega primera.

Rezultati analize so me pripeljali do treh temeljnih ugotovitev. Prva se nanaša na zunanje dejavnike, ki vplivajo na uspešnost oskrbovalne verige. Epidemija Covid-19 je pokazala, da zunanje sile lahko premagajo notranja prizadevanja organizacije, če razumemo ključne kazalnike zgolj kot gole številke. Zato je pomembno, da na te kazalnike ne gledamo le kot na številke, ampak bolj kot na smernice za spodbujanje izboljšav procesov in orodje, ki spodbuja miselnost nenehnih izboljšav poslovnih procesov in ljudi.

Prav ljudje so ključni dejavnik moje naslednje ugotovitve. Ugotavljam namreč, da slabe vrednosti kazalnikov pripelje do negativnih reakcij ljudi. Zato je ključnega pomena, da v podjetju ustvarimo kulturo, ki spodbuja miselnost ljudi, da ključni kazalniki ne obstajajo zato, da bi ugotavljali njihovo individualno uspešnost, ampak zato, da nam pomagajo. Pripomorejo namreč k temu, da tako zaposlene kot celotno organizacijo vodijo k izboljšavam v prihodnosti. Miselnost nenehnega izboljševanja v organizaciji pa je vrednota, ki se jo je vredno priučiti, navaja tretja temeljna ugotovitev mojega dela. V svoji poslovni karieri sem se naučil, da tudi takrat, kadar so rezultati slabši od pričakovanj, največ šteje prehojena pot in izboljšave procesov, ki so bile medtem opravljene. Enako ugotovitev potrjuje tudi celotno magistrsko delo, svoje strinjanje z navedenim pa je v intervjuju izrazil tudi eden izmed vodij v obravnavanem podjetju, ki je bil pokrovitelj projektov, obravnavanih v tem magistrskem delu. Na osnovi teh ugotovitev primer iz prakse nazorno pokaže, da je trajnostne spremembe poslovnih procesov mogoče doseči le z delom na treh ključnih in neločljivih elementih znotraj organizacije. Ti elementi so ljudje, procesi in sistemi.

Na mojo analizo so vplivale tudi nekatere omejitve. Največji vpliv je zagotovo imela epidemija Covid-19, saj je bila zaradi mnogih zunanjih dejavnikov primerjava med leti zelo otežena. Imela je velik vpliv na ponudbo in povpraševanje trga ter tudi na izvajanje poslovnih procesov znotraj podjetja. Okolje, v katerem podjetja delujejo, in njegov vpliv, ki ga ima na uspešnost oskrbovalne verige, je dobra tema za nadaljnje raziskovanje digitalizacije in merjenja uspešnosti oskrbovalne verige. V zadnjih dveh letih je bila epidemija odličen primer, ki podpira zgornjo trditev. Prinesla je priložnosti v smislu pospeševanja digitalizacije in mnoga podjetja prisililo, da so preoblikovala svoje oskrbovalne verige in načine dela. Na drugi strani je prinesla tudi resne omejitve pri merjenju uspešnosti ključnih kazalnikov. Zaradi tega je bilo v mojem delu težko razlikovati med prednostmi izboljšanja procesa notranje oskrbovalne verige in zunanjimi okolijskimi dejavniki, ki so vplivali na ponudbo in povpraševanje po vsem svetu.

Kljub vsemu sem skozi delo pokazal, da je merjenje ključnih kazalnikov uspešnosti dobra investicija v prihodnost podjetja, saj lahko pripelje do nenehnih izboljšav procesov ne glede na dejstvo, ali se sami kazalniki izboljšujejo ali ne.