

DOUBLE DEGREE PROGRAM

in partnership with

**POLITECNICO DI
TORINO**

Collegio di Ingegneria Gestionale
Corso di Laurea Magistrale in Ingegneria
Gestionale (LM – 31)



Politecnico
di Torino

**GRENOBLE
INP - UGA**

Génie industriel
Cursus Ingénieur, filière Ingénierie de la chaîne
logistique (ICL)



Thesis

Management consulting in PwC

**Operations as a strategic asset to bridge the gap
between ideas and results**

Supervisors

prof. Franco Lombardi
prof. Giulia Bruno
prof. Michel Tollenaere

Co - supervisors

Team Core Operations PwC

Candidate

Salvatore Musarò



October 2021



Politecnico
di Torino



Abstract

From the idea to the result: it is the classic process that characterizes every project. In this process of transforming inputs into outputs, companies may need help to fill the gap in skills, experience, resources. In this context, the figure of the managerial consultant is of primary importance because he is able to help the client in achieving the set objectives. From a more practical and executive point of view, Operations is a toolbox that contains best practices, methodological and frameworks and they are specific enablers and principles for long-term success.

PwC is a leader in the Operations management consulting industry and in the second part of the paper the e-bike supply chain project in all its phases is analyzed in order to highlight how consulting supports the customer by building trust and solving problems.

To the sacrifices of my family ...
... for their smiles

Acknowledgements

They don't want to be a must, they come from the depths.

These few simple words are for all those with whom I have crossed my gaze in recent years in university, at work, in the squares, in the streets, in the cities.

Firstly, I would like to thank all the people I have interacted with at PwC, especially the entire Operations team for the valuable feedback and discussions and for believing in me and allowing us to have a wonderful experience.

In addition, a special thanks to both my supervisors, Michel Tollenaere and Franco Lombardi and Giulia Bruno, for their availability and support in this final phase of my journey in which I have travelled 2 different but complementary parallel roads. These two paths are my two universities that have enriched my cultural background and allowed me to enter the world of work with great skills.

To moments of weakness

To moments of insecurity

To moments of redemption

To moments of resourcefulness

To missed opportunities

To the evenings with my friends

To our confidences

To my homeland, to my sea

To different traditions and cultures

This life path began as a life bet. The winnings were not redeemed because each time the intention was to invest in myself again, putting myself on the line.

I hope to have matured and grown but maybe I will not stop being weak, insecure, self-critical but I have learned that I will always have my family and their warm love by my side. It is to them that I dedicate these last lines: to their smiles and their sacrifices, to their moral support and understanding, to their affection and love.



Politecnico
di Torino



Index

Introduction	9
1 Management consulting	10
1.1 Role of the consultant	10
1.2 Consulting industry	11
1.3 Porter's five forces analysis of management consulting	14
1.4 Main trends and challenges of the future	16
2 Operations	18
2.1 Historical steps	19
2.2 Production Operations consulting	21
2.3 Operations Excellence	23
3 PwC, an Operations leader	26
3.1 Values and strategy	26
4 E-bike Supply Chain project	27
4.1 Objectives	27
4.2 Risks	28
4.3 An overview of green and sharing mobility	28
5 From ideas to results	31
5.1 The product structure and planning horizons	32
5.2 Assessment phase	36
5.3 Design and implementation phase	39
Conclusion	46
Bibliography	48
Table of figures	50



Politecnico
di Torino



Introduction

“An extreme change in the supply position upstream in a supply chain generated by a small change in demand downstream in the supply chain. Inventory can quickly move from being backordered to being excess. This is caused by the serial nature of communicating orders up the the chain with the inherent transportation delays of moving product down the chain. They don't want to be a must, they come from the depths.” (APIC dictionary)

The unsolved problem of the Bullwip effect is certainly the problem par excellence of the supply chain. All management currents have always had as their main objective to protect the flow of materials and information. Many have clashed with the variability of supply and demand and a small variation in the logistics chain impacts and distorts every forecast and every process. The amplification of the needs that are observed in some links of the supply chain is mainly due to aspects of visibility and transparency between the actors involved so as to prove a distortion of information and materials.

The present paper aims to mitigate the Bullwip effect with the application of concepts and principles in the field of Operations and operational excellence. These skills and best practices are tools and methodologies that consulting companies offer to their clients to help them in the improvement process and to increase the corporate culture.

This thesis can be divided into two parts: a first more theoretical and bibliographic part and a second more practical and executive part. The first chapter analyzes the management consultancy market providing food for thought on the role of the consultant as an expert, doctor and "obstetrician of problems". In addition, market and statistical analyzes are exhibited and the consulting sector is studied through Porter's five forces analysis.

The second chapter focuses on Operations, first providing a quick historical and evolutionary overview and then a focus on operational excellence.

The third chapter briefly presents a leading company in this sector such as PwC and represents the introduction to the following chapters in which the internship experience lived in first person is told. The main objectives of the case study in question are the design of the supply chain processes and the related organizational structure and the re-design of the plant with review and design of the production line (assembly line and warehouse) and the related internal logistic flows. The fifth and last chapter sets out the main activities carried out and are an example of practical actions and enablers at the Operations level that allow you to transform ideas into results.

1 Management consulting

Sometimes it happens that companies, whether small or large, feel the need for change within them, which can be caused by dynamics within the company but also by dynamics of the outside world, the market or the customer.

Thus was born the idea of a particular strategy or activity to be introduced in the company. From here, the top management draws up a strategic plan to transform this idea into an objective and concrete result, achievable in a given period. Every project always starts from an idea but before reaching the final results time passes, problems arise, you realize that you don't have all the skills and competences to transform that idea.

Management consulting bridges this gap between ideas and results. It supports the client in change and provides best practices, methodologies or frameworks that bring this idea to results.

1.1 Role of the consultant

Edgar Schein, one of the most famous and renowned experts in the consulting world, MIT Professor emeritus and the father of organizational development identifies three roles of management consultants. These three roles vary according to the situation and the needs of the client, they are not mutually exclusive but on the contrary they are even more effective if used together from time to time in the various stages of the consultancy. The three roles are respectively (Schein, 1999):

- ❖ Consultant as an expert: the customer is already aware of the problem but does not have the time or skills to solve it. For this reason, he relies on a consultant with more experience in the sector and leaves it to him to find a solution. The consultant operates in total autonomy by providing his services on the basis of his previous experiences, acquired knowledge and selected information.
- ❖ Consultant as a doctor: The problem has not been identified and the consultant can draw on previous experience to be able to recommend a cure and a treatment. It should be borne in mind that the client may not be willing to accept the diagnosis and apply any necessary corrective measures or may not have the skills to implement the proposed changes. Furthermore, the consequences of the intervention are not known with certainty.
- ❖ Consultant as a process consultant: *Client is the one with the problem and the one with a remedy!* The consultant has the task of transmitting the skills necessary to diagnose and intervene in a constructive and non-corrective manner, thus allowing customers to improve their ability to continue independently.

According to Edgar Schein, *“Process consultation is a philosophy about and attitude toward the process of helping individuals, groups, organizations, and communities. It is not merely a set of techniques to be compared to and contrasted with other techniques.”* (Dimitrijević, 2019)

Schein, therefore, provides an innovative idea of the role of consultant. He defines him as the "agent of change", the one who combines research and action, diagnosis and intervention; the one who guides the client to perceive, understand and act on the events that occur in his environment.

What is needed is the ability to involve the client in a self-diagnosis and teach him how to intervene, based on mutual collaboration. The Scheinian consultant is, therefore, the professional who sets as the objective of his work the awareness on the part of his client of his strengths and weaknesses: he is the one who "helps to help himself", who does not design interventions but is sensitive to the surrounding reality, who does not dispense advice but undertakes a relationship with the client, who does not stand in front of those who ask him for help but at his side to accompany him on his path of growth. (Schein, 1999)

Process consulting recalls in many respects the so-called "Socratic or maieutic method", according to which everyone must bring to light (maieutic = "art of midwife" or "obstetrics"), what he already has within himself. The instrument that offers this possibility is constructive dialogue. Socrates did not inculcate "his truth" in the disciples but helped them to "give birth to personal ideas", through questions, answers and critical analysis. Similarly, today, a consultant should act.

Process and helping relationship are the two key words of the consulting method proposed by Schein. By process we mean the way we operate, we refer to the how rather than what we do. Any process allows you to create a relationship. The consultancy process creates a helping relationship between the client and the consultant who must be able to count on a relationship of trust, listening and collaboration in order to achieve the desired results. The content of the project is not important but how the project is carried out, because in this way the customer will be able to operate independently in the future knowing that he can count on the help of the consultant. But the change or rather the transformation of the idea into a result must start from the client and must be carried out by the client himself, the consultant is only the obstetrician of the idea.

1.2 Consulting industry

During a project, the meetings between the management consulting person and the client are many. This is true in the initial phase, but even more so when there is a need to implement the actions that arise from the in-depth analysis carried out. Whether it is therefore a change of strategy to be implemented, a commercial solution to be adopted or which affects the employment levels of the company, especially in this particular historical moment, dealing with management consultancy

cannot ignore the concepts of "Digital Transformation" and "Change Management".

Knowledge is power, as the saying goes. Management consulting is a pool of knowledge in different fields. Indeed, it is a set of knowledge-intensive business services and the real core business is represented by people and their know how.

In recent years, the global consulting market has grown at an incredible rate and has become one of the most developed and diversified segments within the professional services industry. Due to the wide variety of services offered, there is no unequivocal consensus on how to define and measure this market. The development of this sector is closely linked to the economic dynamics of the market: economic downturns lead organizations to budget cuts and therefore also to consulting expenses, unlike periods with favorable economic conditions where organizations pave the way for consulting. The first consulting firms were born at the end of the XIX century in the USA but their greatest success came after the Second World War thanks to the expansion in Europe and new management consulting firms were formed, bringing a rigorous analytical approach to the study of management and strategy. Despite the recession at the beginning of the 70s, the sector recorded a remarkable growth between the 80s and 90s in which it went from 5 consulting companies with more than 1000 consultants to more than 35 companies of the same size (Canback, 1998). The crisis of 2008 has contracted the market that has resumed to grow to the present day even if the Covid pandemic has influenced the growth rate in 2020. ALM Intelligence and Consultancy.uk offer an overview of the global consulting market between 2011 and 2016, differentiating the services in the main fields: Strategy, Operations, Financial Advisory, HR and Technology. This panel highlights a compound annual growth rate between these years of 4.1% and the most prestigious sectors are Operations and Financial Advisory with a market share of about 28%. Regionally, North America is the most mature region and with the EMEA region they are leaders in terms of market size: they

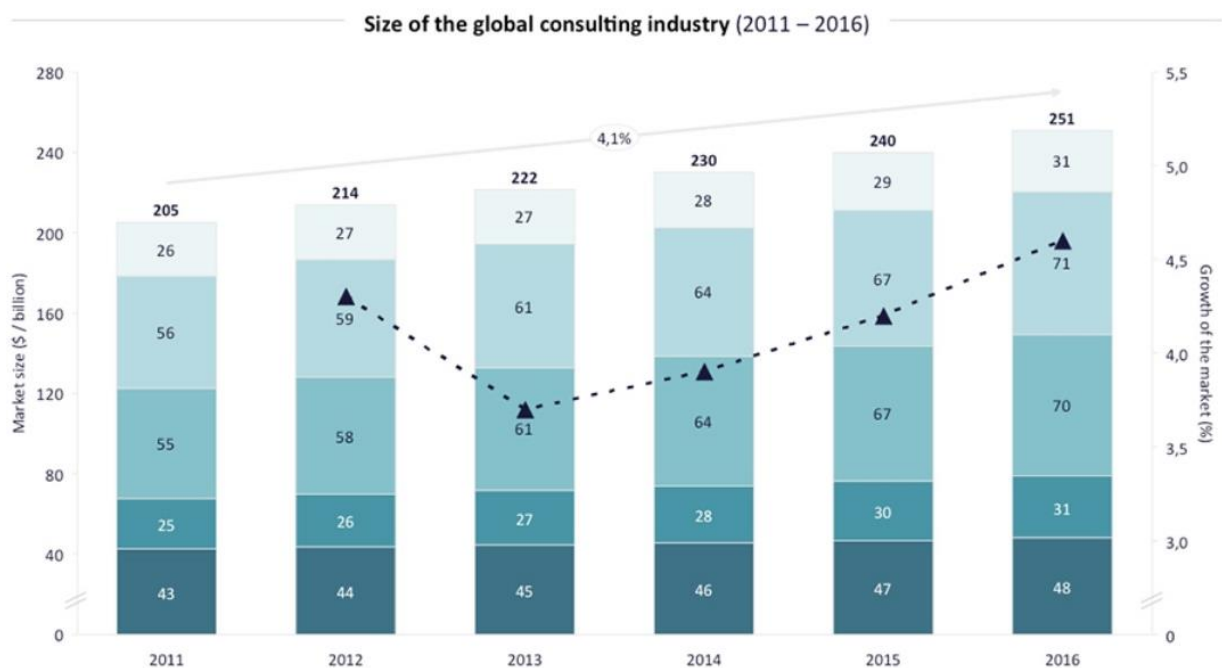


Figure 1: Size of the global consulting industry (2011-2016). Source: Consultancy.uk

represent the 82% of the overall consulting economy. (Consultancy industry, n.d.)

As mentioned before, there is no single and 100% reliable source to give a detailed insight into the management consulting market as statistics vary due to the different definitions for consulting services and the differences in the regions considered. For this reason, we also intend to present the results of an important reference point for this industry: FEACO (Fédération Européenne des Associations de Conseils en Organisation) annual report that is based on the data of 12 European countries and represents 81% of the overall European Gross Domestic Product and 74% of the overall European employment. (FEACO, 2020)

COUNTRY	2017	2018	2019	Yearly CAGR (2017-19)	2020
Austria	12.3%	12.9%	11.3%	12.2%	n.a.
Denmark	7.9%	5.7%	10.8%	8.1%	-10.0%
Finland	4.3%	0.0%	0.0%	1.4%	-10.0%
France	10.2%	12.3%	8.2%	10.2%	-10.0%
Germany	8.6%	7.3%	5.7%	7.2%	-7.5%
Greece	7.1%	9.3%	13.7%	10.0%	3.0%
Hungary	6.3%	8.8%	22.3%	12.2%	-10.0%
Italy	7.8%	8.6%	7.8%	8.1%	-8.9%
Romania**	n.a.	4.2%	12.0%	8.0%	10,0%
Slovenia	1.2%	7.5%	0.0%	2.8%	-12.5%
Spain	8.0%	6.5%	5.9%	6.8%	-11.0%
UK***	8.0%	7.0%	7.0%	7.3%	2.5%
European panel*	8.4%	8.3%	7.3%	8.0%	-6.2%

Figure 2: Management consulting turnover trend (2017 - 2020). Source: FEACO survey

The Covid19 health emergency has created a chiasm in the growth trend of the European Management Consulting: the results of 2019 show a turnover increase of 7.3% while the recent estimates for 2020 show a 6.2% decline. Similarly, in 2019 employment grew by 7.4% while in 2020 there was a decrease of 2.5%. This last percentage is encouraging compared to the decline in turnover in fact it is supported by government incentives to help companies in the lockdown period and also symbolizes the intention to retain skilled resources for the future recovery.

1.3 Porter's five forces analysis of management consulting

The attractiveness of a business area is the higher the lower the degree of competition in the broad sense within the area itself, and vice versa ... in an area with less competition the company is able to maintain a higher level of profitability.

To identify better an industry's structure, the Porter's Five Forces analysis is frequently used to understand the level of competition and to consider how the five forces shape the industry. The management consulting segment is competitive, but it is large enough for various players to enter

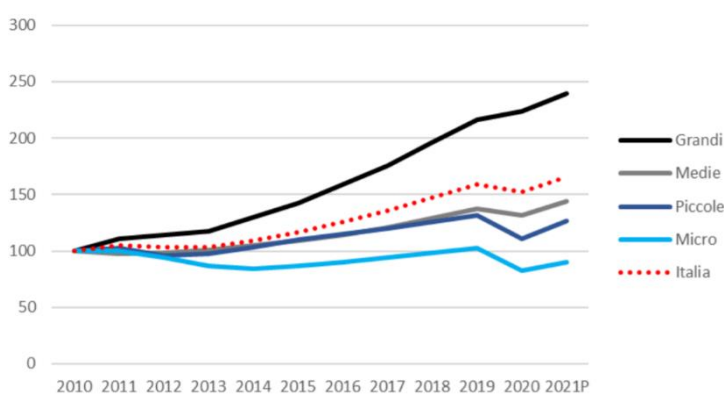


Figure 3: Turnover trend 2010-2021 (by size class). Source: Assoconsult

and compete. However, the ability to do this effectively depends on many factors.

It is far from recognizing market saturation and fragmentation still exists.

Leading companies in the industry are large multinational organizations that tend to diversify their business so as to reduce internal rivalry. The

concentration of this market is constantly

growing. As an example, we report the Italian case that was analyzed as every year by Assoconsult (Association of Management Consulting Companies). (Assoconsult, 2021) Large consulting companies, i.e. with over 50 employees, represent 60.4% of the Italian market and employ 37.6% of consultants. The graph shows the turnover trend from 2010, considered the base year, until the first half of 2021 of consulting companies in the Italian market classify by size. The black line (top companies) presents an impressive acceleration at the difference of the other trend lines that concern smaller companies in size (gray for medium, blue for small and light blue for micro). The red dotted line represents the Italian average. As can be seen from the graph, micro-enterprises composed of no more than 2 employees have faced a decline in turnover in recent years. A descent in the trend is characteristic of all the companies involved between 2019 – 2020, in times of health emergency, but 2021 is a year of economic recovery. Large companies, on the other hand, have not recorded this decline but the growth trend has only stuck compared to past years. In 2021, top companies seem to have more than doubled their revenue compared to a decade ago, however, due to their ability to diversify and work in several profitable sectors such as insurance banking, public administration, telecommunications and industrial. The consulting market is truly heterogeneous and consultants have different knowledge on a wide range of sectors. Given that the economy is

always changing and evolving, the opportunities for potential market entrants are different especially if new companies aim to offer an ad hoc service for the customer by carving out a niche in the market. Management costs are low because no large investments are required, also thanks to the increasingly widespread practice of office hotelling. Despite this, the consulting market has few barriers to entry but several barriers to success. (Gelles, 2011). Leading companies have a distinct advantage in terms of customer loyalty and customer building. Reputation in this area is also of the utmost importance. The first mover in this market gains great competitive advantage. Laggards in order to compete are forced to stand out by offering a lower price, better strategy or more resources available. Although the costs do not have to be high to enter the field of consulting, knowledge of the sector is the most important commodity. Being able to count on a varied and highly specialized pool of skills means having economies of scale and addressing the needs of more customers, as well as winning more profitable contracts. The experience of the consultants and the strength of the brand are essential factors to achieve success.

The costs that a consulting firm usually faces are mainly represented by the costs of recruiting and compensating the best consultants and the costs related to office equipment and use of information technologies. The costs related to staff training are sunk costs but inevitable to keep up with the times. Precisely to alleviate these costs, large consulting firms collaborate with the best universities to train the consultants of tomorrow also funding different courses of study and MBA. In fact, the power of suppliers is closely linked to the behavior of consultants who are the only fundamental asset for management consulting firms. Another factor to consider is the loss of talent. Business consultants gain a certain reputation linked to their company and due to the unhealthy work-life balance they are willing to change companies and perhaps be hired by the customers themselves. This forces consulting firms to continuously hire and develop new talent to counter this trend.

It is increasingly common practice in large organizations to acquire more skills within them, thus building internal consulting departments to reduce costs and create greater cohesion. In-house consultants know the organization better and share the corporate culture by driving change faster and easier. This trend is a significant threat of replacement assets for the business consulting industry. Added to this is the use of business intelligence and Data Analytics that allows them to have timely analysis to support decision-making processes without resorting to external functional analysts. (Marasà, 2019)

The consulting service is B2B and clients, who have a wide choice, have a low bargaining power since a onerous and project-specific contract is usually stipulated between consultants and client. There are high switching costs linked to contract termination fees and long notice times. Of course, the time required to achieve a certain goal is reduced and a new strategy must be established that

involves additional costs.

Nowadays, consulting firms occupy a unique place in the market. During economic crises they tend to fare better than other companies thanks to their experience and diversification of activities. Client companies feel the need for change or to gain a competitive advantage and business consulting is a driving force for projects of this type. On the other hand, the goal of consulting companies is to always be at least one step ahead of all the others.

Consulting is by nature a product of rapid innovation and change and the success of a consulting firm is dependent on disruption. (Mandelbaum, 2020)

1.4 Main trends and challenges of the future

In a digital and interconnected world like ours, disruptions become fundamental resources for consulting companies: anticipating, analyzing and finding an escape from these revolutions is the task of management consulting.

Clayton M. Christensen, an American academic and business consultant, has developed the history of "disruptive innovation" and says that as has happened in other industries, from steel mills to publishing, management consulting itself is on the verge of breaking. No one can know for sure the results. Interruption is not an event but a process and does not necessarily mean total destruction. In an article in Harvard Business Review he writes that "consultancies are shifting from integrated solution shops to modular providers, which specialize in supplying one specific link in the value chain". (Christensen, Wang, & van Bever, 2013) The consulting market has been immune to disruption over the past 100 years because the business model has not changed and has been characterized by opacity and agility. The first factor refers to the fact that clients ask consultants for help because they lack specialized knowledge and it is difficult to judge and evaluate when the project ends. Agility, on the other hand, is the ability to move from one great idea to another and respond flexibly to disruptions in other markets. Nevertheless, opacity and agility are eroding due to a democratization of knowledge, the advent of Big Data and predictive analytics.

There are several challenges that the management consulting market faces and they are closely linked to economic and social dynamics and internal and external disruptions.

These last few years have been shown to us how fragile our systems are: a simple hacker attack can block and destroy entire interconnected information systems, a simple virus that exploded in the region of the world can bring the economy to its knees and make it lose all certainty.

"It almost seems like not a day goes by without reports of another supply chain snafu caused by the pandemic, which dismantled just-in-time inventory systems that could not cope with massive simultaneous disruptions to supply and demand." This is what we read in newspapers and

magazines today. This collapse of indissoluble convictions and principles forces us to question all knowledge. Just-in-time inventory systems, which grew in popularity in the 90s, and the stubborn imitation of the success of Toyota Motor Corp., the gold standard of lean manufacturing, made Lean a religion. "Their orthodoxy became their undoing when the pandemic hit and there was no surplus of stocks to be found." It seems to be facing a paradigm shift in which consulting firms will have to play a supporting role: "The 20th century was about finance. The 21st century should be about supply chains." (Boyle, 2021)

2 Operations

Each company is managed through three main functions: finance, marketing and operations management. In our particular context, the operation is the most critical business function. Today, companies compete in a very different environment and to survive in global competition and technological progress they must focus on lean and agile organizations. This new focus has placed operations management at the forefront of business because it is the function through which companies can achieve this type of competitiveness.

The goal of operations management is to maximize efficiency by producing goods and services and meet customer needs in terms of cost, quality, time and environmental footprint.

What is Operations? They are a set of purposeful activities of a work plan. They are performed with a method and designed to achieve a goal. It also plays a strategic role in any organization because operations decisions have long-term consequences and often involve a great deal of expense and resource commitments. OM is management of a systemic transformation process to convert a set of inputs into outputs. These inputs include labor,

equipment, raw materials, information, and other capital resources, while outputs are goods and services. In this simple transformation process, customers participate by defining the requirements of the final goods and services in terms of cost, quality and variability. Operations management serves as a continuous improvement process to improve

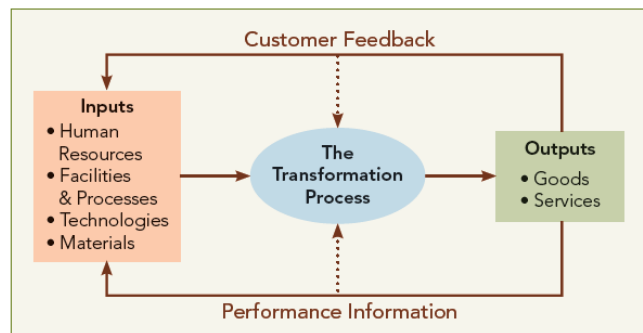


Figure 4: The transformation process. Source: Operations Management

quality, productivity and customer satisfaction thanks to the feedback received and performance information. Operations management is responsible for orchestrating all the resources: companies must forecast what customers want and maintain adequate inventories of goods, manage distribution centers and warehouses, operate fleets of trucks, and schedule deliveries, all while keeping costs low and customers satisfied. To be successful, this process must add value: the higher the added value, the more productive a company is. In addition, operations must be efficient: perform activities well and at the lowest possible cost. Eliminating those that do not add value (waste) and redesigning processes and jobs is a focal point of efforts to increase competitiveness. (Reid & Sanders, 2013)

2.1 Historical steps

Operations management is as old as time and is linked to human life. The most significant historical milestone that shape its development are summarized in the figure below. The ancient system of recording inventory and commercial transactions in the times of the Sumerians around 5000 B.C. are two simple examples that testify how operations have been fundamental in the history of the human being. Another application of operations systema regards of the project of construction of the pyramids in Egypt and the Great Wall in China: these wonderful masterpieces are the result of a planning, organization and control of materials and human resources. The industrial revolution marked a radical change in production systems: from products made by hand by skilled craftspeople to mass production with standard specifications made by machines and workers. The most important innovation was the steam engine, invented by James Watt, that provide a new source of power useful for production and transportation. This revolution was facilitated by the concepts of division of labor and interchangeability of parts.

Concept	Time	Explanation
Industrial Revolution	Late 1700s	Brought in innovations that changed production by using machine power instead of human power.
Scientific management	Early 1900s	Brought the concepts of analysis and measurement of the technical aspects of work design and development of moving assembly lines and mass production.
Human relations movement	1930s to 1960s	Focused on understanding human elements of job design, such as worker motivation and job satisfaction.
Management science	1940s to 1960s	Focused on the development of quantitative techniques to solve operations problems.
Computer age	1960s	Enabled processing of large amounts of data and allowed widespread use of quantitative procedures.
Environmental issues	1970s	Considered waste reduction, the need for recycling, and product reuse.
Just-in-time systems (JIT)	1980s	Designed to achieve high-volume production with minimal inventories.
Total quality management (TQM)	1980s	Sought to eliminate causes of production defects.
Reengineering	1980s	Required redesigning a company's processes in order to provide greater efficiency and cost reduction.
Global competition	1980s	Designed operations to compete in the global market.
Flexibility	1990s	Offered customization on a mass scale.
Time-based competition	1990s	Based on time, such as speed of delivery.
Supply chain management	1990s	Focused on reducing the overall cost of the system that manages the flow of materials and information from suppliers to final customers.
Electronic commerce	2000s	Uses the Internet and World Wide Web for conducting business activity.
Outsourcing and flattening of the world	2000s	Convergence of technology has enabled outsourcing of virtually any job imaginable from anywhere around the globe, therefore "flattening" the world.
Big data analytics	2010s - present	Applies math and statistics to large volumes of structured and unstructured data to gain unprecedented business insights.

Figure 5: Historical Development. Source: Operations Management

Division of labor was described by Adam Smith in *The Wealth of Nations* and was a disruption idea for those times: the production of a good is broken down into a series of element tasks and each of which is performed by different worker. Interchangeability of parts represented an important leap in manufacturing efficiency because each item in a batch fits equally.

A new paradigm was emerging: assembly line that allowed to fulfil high volumes and more clients. First scientific studies of productivity were conducted by Frederick W. Taylor at the turn of XX century. He focused on the flow and its efficiency. His goal was to standardize and reduce time variances: he introduced a widely used method of work measurement, stopwatch time studies. Observations and recordings of the activities of the workers were made to set a standard time to perform that particular task while ignoring the loss of time. These studies continued thanks to the contribution of the Gilbreth brothers who laid the foundations for the predetermined motion time systems. By filming numerous sequences of movements, Gilbreth determined that human movements can be reduced to 17 elements of movements that combined describe the activities of an assembly line workstation. These elements, called "therbligs" are the precursors of the basic MTM movements that still today are a valid support to evaluate the times of small and repetitive tasks. Henry Ford applied these theoretical considerations to his moving assembly line for the production of black Ford T cars with no room for customization: production increased, average costs decreased and the product was accessible to a wider audience. (Wikipedia, 2021) The scientific and practical approach is joined by a human relations movement that based on the recognition that factors other than money can contribute to worker productivity. Elton Mayo, a psychologist and industrial researcher at Harvard Business School underlined the importance of relationships among people who work for industrial organization. He laid the ground rules for interviewing. His studies have shown that workers' productivity improves when changes are made, and the increase in productivity occurred as a result of the motivational effect of attention and empowerment they are given came. Until World War II, operation management was not considered a formal field of study. When all production systems faced a common set of problems, management science gained importance. Quantitative techniques and tools emerged to solve these operational problems about forecasting, inventory control, scheduling and decision making. The contribution of Mathematics, Statistics and Computer Science has made it possible to use linear programming to optimize resources and manage complex algorithms. (Reid & Sanders, 2013)

While in USA management software architectures such as MRP developed, in Japan Lean management and Toyota Production System spread. Push systems in the USA and pull systems in Japan are different way of operations management: they are diametrically opposed to each other but their integration and contamination in a management system can bring great benefits. The modern world has required companies to shorten their time to market, to be flexible to changes and to be able to reinvent themselves by redesigning internal processes and flows in order to compete with new entrants who have exploited the wave of progress and information to impose themselves. Companies today are a component of a myriad of supply chains, and this means that their core

business is influenced by the trend of supply and demand along the chain: an event that slows down one of our suppliers obviously affects our business. Economic crises and large investments have forced companies to outsource part of their secondary activities. This phenomenon of interconnection and globalization on the one hand has guaranteed a reduction in costs and a flattening of the world that has resulted in competition on a global scale but on the other hand problems of organization, communication and transport have arisen. Competition is synonymous with greater efficiency, quality and innovation but it is about to be undermined by the large organizations that extract data everywhere: data, information is the greatest gold that a company can possess. (Reid & Sanders, 2013)

2.2 Production Operations consulting

Supply chain management is the main ecosystem of Operations consulting that aims to improve the flow through which inputs are transformed into outputs creating value for all stakeholders. The three essential production assets are people, equipment and information. Through consulting engagements, companies want to reach durable capabilities in order to build upon improvements and sustain independently. Skills development is a long-term process, but companies are trying to achieve improvement in the short term. There is a risk of drawing a flow to temporarily solve the problem and the company risks not understanding the results of the project and not metabolizing the new *modus operandi*. In this trade-off, consulting firms must be able to instill small and fast improvement cycles by carrying out rapid analysis in the workshop and at the same time coordinate the change process and obtain approval from senior management for the execution of the proposed changes. Operational consulting projects on a center of excellence (bottom-up approach) not only scalable to the rest of the production network. Top-down approaches, on the other hand, risk remaining too theoretical and not implementable. To overcome passive resistance, it is important to make a case for change by financing operations and quantifying the true level of losses and the impacts on bottom line. In this way, a coaching activity and active involvement of people is carried out. (ALM, 2017) Companies need at least to know and understand the landscape of available technologies and how and where they can add value. The diagnostic phase and the range of methodologies and best practices are the main offers of Operations consulting. They are realizing that the transformations they intend to adopt are failing not because of technologies but because of the lack of change management related to the culture and business processes. Companies believe that it is enough to buy the best technologies. The art of consultant is how they engage plant team to draw out issues before introducing technology. In order to digitize and automate plants, digital

maturity assessments need to be carried out and subsequently impacts and adherence to standard best practices to be monitored.

The report of Production Operations Consulting Providers conducted by ALM Intelligence in 2019 assesses consulting firm and their client impact on the basis of their breath and depth service capabilities. Breath is an index of development of competencies in multiple client scenarios, sectors and regions. Depth is an indicator of resources and proprietary methodologies.

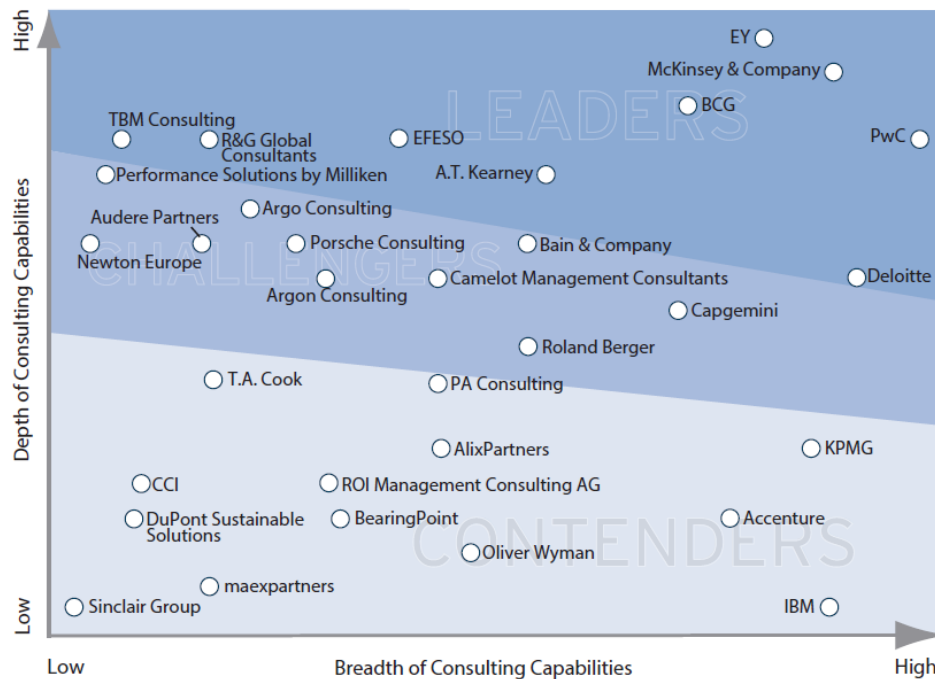


Figure 6: Production Operations Consulting Providers. Source: ALM Intelligence

The graph is divided into three parts by 2 lines with a descending slope that indicate the transition from a model of involvement of different degrees of complexity. The 3 rating levels rank the consulting firms in leaders, challengers and contenders. Leaders have experience and skills that enable them to complete complex end-to-end projects and create value at every stage of the supply chain. Challengers represent all consulting firms that develop models of lower complexity and a lower depth of capabilities than projects conducted by leaders. Contenders, on the other hand, can only execute a part of the projects for their limited knowledge in the Operations and Supply Chain market.

PwC exhibits the broadest capabilities in Operations consulting market: it is able to combine strategy and technology insight with technical discipline to drive improvement initiative on the shop floor and in others business units. According to the report, PwC creates flexible and customer-centric solutions based on lean practices and other new internal methodologies. (Essing, 2019)

PwC has been named “Best in Class” for Operations system and Project management. From strategy through execution and enablement, PwC Operations teams conduct assessments of each

plant's process, labor and equipment condition aided by the application of benchmarks, frameworks and analytic tools. They are able to intercept gaps and start by listening and interviewing all levels of organization. Priority initiatives are then defined and their impacts highlighted. The client is helped in this phase to make informed decisions and the improvement activities are designed, conducted and monitored by the consultants themselves. (Essing, 2019)

2.3 Operations Excellence

At the beginning of a management project, it is essential to know the company and the various stakeholders involved in depth in order to identify the gaps to achieve operations excellence.



Figure 7: Evolution and trends of Operational Excellence. Source: ScienceDirect

Operational excellence (OE) has been the subject of study in the literature for several centuries and scholars have identified 3 interconnected streams that describe the evolution and trends in history. This outline summarizes the key concepts: for each evolution the main exponents of the historical period and the strategic and operational factors to achieve the key objectives are

indicated.

OE 1.0 and OE 2.0 had the task of answering the question "What is excellence?" and until the 20th century the discipline of the value of cost minimization by virtue of maximizing production was established: companies that pursue operational excellence must bear lower costs than their competitors, as a result they can sell their goods and services at lower prices obtaining a considerable competitive advantage. (Jaeger, Matyas, & Sihm, 2014)

"How can excellence be achieved?" is the question of EO 3.0 that stresses tools to encompass world-class operations. New approaches emerge aimed at eliminating waste and non-value-added activities and focusing on total quality management, lean, just in time, continuous improvement. All these practices are often considered to be the main goals of Operational Excellence but they are only tools and activities to achieve it. "Real change is only possible when timeless principles of operational excellence are understood and deeply embedded into culture". (Miller, Raymer, Cook, & Barker, 2013)

OE 4.0 represents the paradigm change in Operations Excellence (OsE) 1.0, that identifies enablers as the answer to "What is needed to manage excellence?". The paradigm shift from Operational

Excellence, which focuses on results-oriented processes, to Operations Excellence, which promotes operations as specific enablers and principles for long-term success. (Jaeger, Matyas, & Sihm, 2014) According to Gleich and Sautter, “OE is the dynamic capability to realize effective and efficient core processes in the value creation chain utilizing technological, cultural and organizational factors in an integrative way and based on the respective strategy”. (Gleich & Sauter, 2008)

Schwientek and Schmidt are among the few who use the term “Operations Excellence” to indicate the 3 levels at the core of excellence in operations: strategy, performing improving and enablers. The first level sets the objectives to be pursued and organizes the resources according to a plan of improvement actions. The second one deals with performance drivers and competitive levers. The third level is represented by tool of support, measurement and control such as enablers. All these levels cover the entire value chain, from R&D, Purchasing, Manufacturing to Supply Chain Management. (Schwientek & A., 2008)

During the first phase of a project, interviews were planned with the various business areas. The Operations Excellence assessment framework is an excellent example for identifying the key relationships between the various business units. This framework is the result of a research project conducted by an institution of the Austrian Federal Economic Chamber and the Institute of Management Science of the University of Vienna. It was used to qualitatively analyse the processes, flows, organization, existing relationships and results. (Jaeger, Matyas, & Sihm, 2014)

Porter's value chain is the starting point and horizontal and vertical correlations with different business areas are added to identify the role, position and interaction of the OsE in organizations. The relationship between results and enablers that create that output is referred to as “fit”: “horizontal fit” indicates the sharing of principles along the value chain, “vertical fit” refers to adherence to the same objectives from high-level functions up to the operational production level.

The implementation of Operations Excellence is not a project but the beginning of never-ending development as a part of corporate culture, where everybody must innovate and follow future improvement. The operational strategy, one of the enablers, allows to align managerial decision, culture, competences and capabilities.

To define the path to excellence, the needs of all stakeholders must become the input for the development and evaluation of a strategy and its respective guidelines, and organizations should strive to continually meet their expectations. In the assessment of operations, the process of engineering and development of new products also becomes important, which has a significant impact on productivity in the long term. It is also important to not underestimate the dependence of operations on technology and innovation which are support levers that can allow you to excel in your sector.

It is essential to do scouting, forecasts, research and development to anticipate future trends and scenarios. (Jaeger, Matyas, & Sihm, 2014)

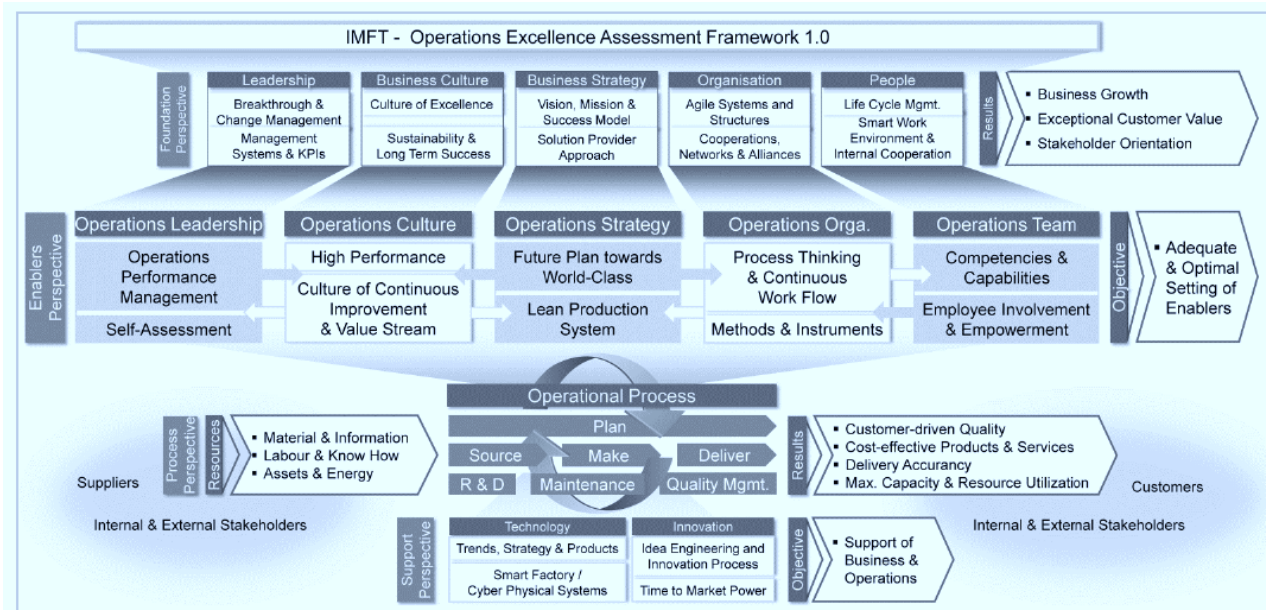


Figure 8: Operations Excellence Assessment Framework. Source: ScienceDirect

3 PwC, an Operations leader

“To build trust in society and solve important problems”: this is the Purpose of PwC, a leading international network in professional business services. Its goal is to create the value that customers and people seek by building solid relationships based on collaboration, quality of service, integrity and mutual respect. The network is present in 155 countries, with over 284 000 professionals committed to providing innovative and quality answers to the complex problems of companies. In Italy it has about 6 400 people in 27 cities. PwC offers a wide range of services thanks to high competencies in different sectors and a multidisciplinary approach: it is able to combine knowledge of local markets with a global organization. PwC is “the business that helps the business” and is divided into different line of services: Assurance, Consulting, Deals, Tax and Legal.

3.1 Values and strategy

PwC's work responds to a need of human beings that has always existed: trust. From the first half of the 800 PwC builds trust on solid and at the same time flexible principles. Only with a great capacity for adaptation can you thrive for so long. Especially in today's world where trust in technology and institutions has been lost.

PwC has its origins in the nineteenth century when Samuel Lowell Price began his profession in London (1849). Its history continues in 1865 the company assumed in the name of Price Waterhouse & Co after the entry of Edwin Waterhouse into the company. Meanwhile, William Cooper in 1854 began to practice his profession in London and in 1898 William Lybrand started his business in the USA. In 1957, Coopers & Lybrand merged. PricewaterhouseCoopers is the result of the historic merger in 1998 between Price Waterhouse and Coopers & Lybrand. (PwC, 2021)

PwC's purpose is based on solid values that define how to behave when the consultants work with their clients or colleagues. The consultant at PwC is invited to respond to change by staying informed and asking continuous questions to make a difference. Taking care of people means recognizing the value of each one, supporting and helping him to bring out the best in himself. To be objective and to operate as if our reputation were at stake is to act with integrity. Collaborating and sharing ideas and knowledge, integrating new perspectives and having an open mind means working together and reimagining the possible. These values are flanked by the corporate strategy, called the New Equation: in addition to build trust in society has been the common thread of PwC's history, today a consulting company must deliver sustain outcomes results. It intends to allocate 12 billion to create 100 000 new jobs to expand capabilities by offering customers excellent solutions.

4 E-bike Supply Chain project

My internship experience took place in the Consulting division, specifically in Operations and now I am continuing to collaborate with the PwC Core Operations team.

The experience lasts about 6 months, it began on March 15th and will end on September 10th, 2021. Given the pandemic situation and company agreements, smart working was guaranteed and travel was limited as much as possible: business trips are organized to monitor the work in progress and to agree on new improvement initiatives.

After an initial phase of onboarding and training of the key skills and methodologies that identify the Italian Operations team, I am working with 3 other professionals on a project commissioned by the ALPHA holding. Anonymized for reasons of data confidentiality, ALPHA is a world-leading group in the transport and aerospace sector made up of synergistic and high-tech companies with over 1000 employees. It has decided to set up a new legal entity, within the Group, dedicated to the development, production and sale of smart mobility vehicles. ALPHA's goal is to land on the sharing mobility market and PwC's task is to support and structure the new business unit by providing all the necessary tools to create value.

4.1 Objectives

The objective of this project is to design and implement the processes of the Supply Chain of the new business unit that will be created in the course of 2021. These processes must support the achievement of strategic objectives (eg type of products, volumes, service level etc ..) that the Group has defined. In order to achieve the goal, ALPHA requested the support of PwC for the following activities:

- Design of Supply Chain processes and related organizational structure.
- Plant Re-Design: review and design of the production line (assembly line and warehouse) and related internal logistic flows.

In the last 2 years, ALPHA has had a partnership with an external supplier BETA to product the first vehicle: the e-bike for the green sharing mobility market. BETA is located in an industrial district with strong expertise in the automotive sector. Due to communication and information exchange problems and to cope with the increase in the volume of e-bikes, the main objective of the project is to involve the supplier and collaborate with it to make communication flows flexible and transparent and to launch initiatives of continuous improvement of production in terms of time, cost and quality.

4.2 Risks

Risk is any unexpected event that can affect the project, for better or for worse and it can affect anything, people, processes, technology and resources. Among the project risks, one cannot fail to mention Covid-19 and the consequences of the health pandemic that we all face today as well as companies and the market. In fact, the scheduled activities could accumulate delays or could not be carried out due to unexpected events. These include the disruption of the entire bike supply chain:

- the shortage of raw materials for the production of basic components,
- the deferred delivery of months of assembly materials,
- the exorbitant costs of purchasing components,
- the explosion of transport costs.

In this perspective, it becomes very complicated to establish and agree on a production plan in the short time, and consequently a manpower plan. Many activities have been reprogrammed and sometimes simulated, when possible, but it is necessary to verify and validate the analyses carried out to implement the initiatives and any changes.

Furthermore, an aspect that should not be underestimated in an innovation project like this is change management. Not all stakeholders are willing to change, some are anchored to the old way of operating, others do not have an open mind. Many are not confident in the project because they have already experienced a failed project, others consider all activities a waste of time. When you need to collaborate with two companies, ALPHA and BETA, you can run the risk of offloading jobs or inefficiencies to the other party and run into a vicious circle with no way out. The task of a consultancy company like PwC is precisely to remedy these situations and be the intermediary able to facilitate communication and find solutions that can involve all stakeholders.

4.3 An overview of green and sharing mobility

Unsurprisingly, the Covid pandemic disrupted the supply chain and lockdowns in several areas have created high uncertainty and long lead times. As a result, each production plan was constantly changed. The ebike market has not been outdone but it is a special market: a disproportionate demand is countered by an unavailability of raw materials, as well as high purchase and transport costs. Maybe, one of the few clear winners of the pandemic is the bicycles, as demonstrated by the Atlas by Heinrich-Böll-Stiftung European Union, a German green political foundation. The surge in bike sales and the terrific forecasts are an encouraging sign from the point of view of green and shared mobility. ALPHA seems to have found a gold mine market but the difficulties in finding materials are holding back the rise.

Nowadays, it is imperative to reduce the levels of fossil fuel consumption and greenhouse gas emissions. The European Green Deal aims to be an excellent point of agreement and the will to tackle a crucial problem for the whole planet. EU's multiannual budget for 2021-2027 and recovery instruments "Next Generation EU" will be the economic sap to sustain the investment into the right infrastructures and mobility segments. Our freedom of movement during the Covid pandemic has been limited and new trends have emerged: air traffic has decreased and the use of bicycles has increased, we have also observed a shift from shared transport to individual transport.

E-bike will play a big role in the near future and has unrecognized potential. It can reduce traffic congestion and foster the vision of bike-friendly city and mobility as a service to unite rural and urban areas with the integration of other types of transport on a single platform.

Sustainable energy and mobility transitions go hand on hand. This trend is evidenced by the tremendous growth rate of the bicycle industry which is mainly driven by e-bike sales: from an annual turnover of around 5 billion euros 20 year ago to almost 14 billion euros in 2019. Unlike many sectors, the bicycle industry and its parts and accessories market involve 23 out of 27 EU Member States with 900 small and medium enterprises and around 200 000 workers. As shown in the figure below, the automotive industry can only dream of the growth rate of the bicycle sector: cars sold in 2018 were 15,2 million while 20 million bikes are sold annually. (Scherer, Becker, Behresen, Weinreich, & Merly, 2021)

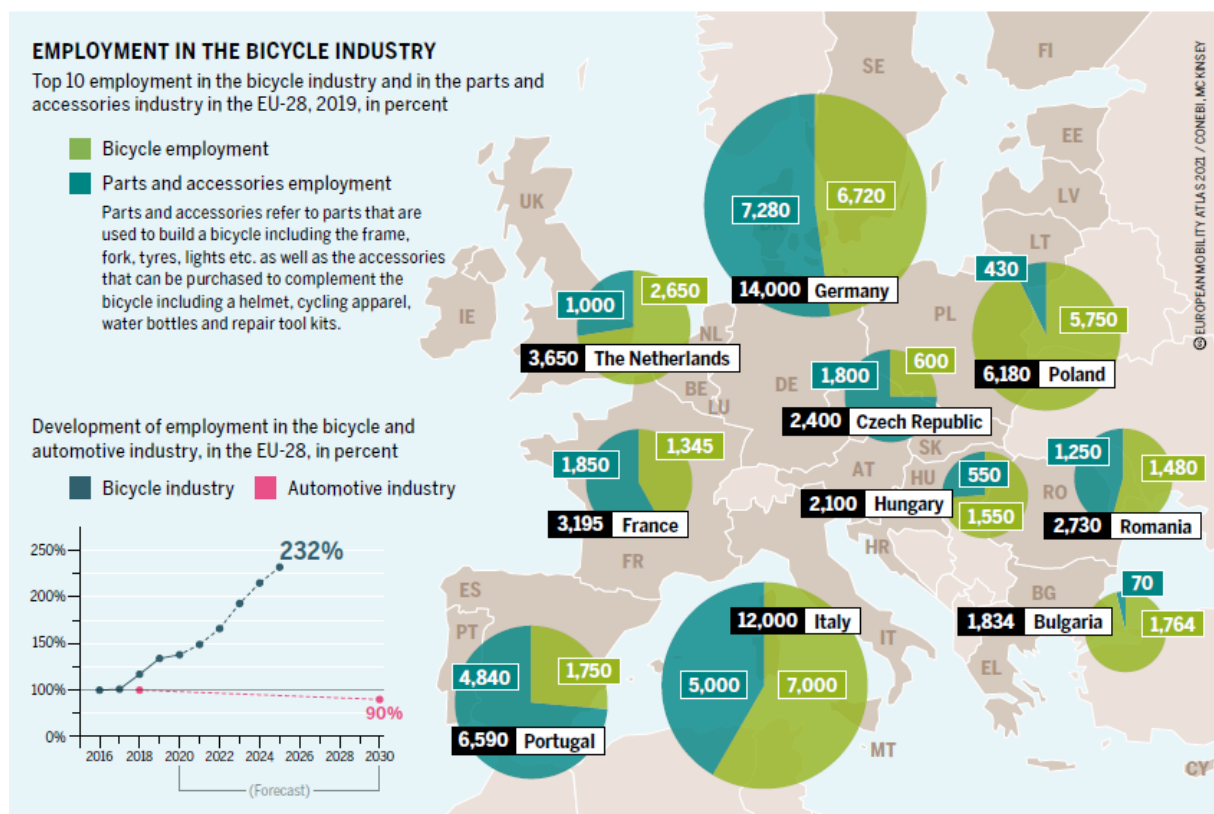


Figure 9: Employment in the bicycle industry. Source: European mobility Atlas

During the lockdown people have reconsidered the bikes and seem to be in love with it because it is the safest and most efficient mode of transport.

Moreover, the ebikes, i.e. electrically power assisted cycles (EPAC), is the actual boost of this sector thanks to possibility to cover longer distances, their low purchase and maintenance costs. EPAC market is expected to reach 13,5 million units sold annually and the comparison with all other alternative-powered vehicles (APV) are remarkable: even if the sales figures of APV are increasing (1,6 million units in 2019), the EPAC sold have been more than double (3,4 million). In addition, around 60 percent of bicycle production takes place in Europe. This guarantees new recruitment of highly skilled personnel, so much so that the “Bicycle Valleys” are emerging. They are industrial districts where component manufacturers and assemblers have established themselves to shorten the supply chain. (Scherer, Becker, Behresen, Weinreich, & Merly, 2021)

This is a goal that has always characterized this market because the key components come from China and their lead times are always high and uncertain.

An evolution of the simple ebikes is the cargo ebike widely spread in Germany, Austria, Denmark and the Netherlands. Their success is due to the fact that they offer the possibility to transport a capacity between 40 and 250 kg of people or goods and cover long distances. There are numerous subsidy programs for commercial or private cargo ebike as this type of bike seems to be the perfect green substitute for the car. The authors raise a problem: the promotion of new means of transport must be supported by an investment in new infrastructure and digitalization. A clear example is Copenhagen, known as the city of cyclists. But this city is designed and built for cycling and riding a bike is safe, fast and easy. The “last mile” problem can be solved with a planning of intermodal intersections using car/ebike sharing that conduct to public transportation. The use of different means is facilitated by a digital platform (such as an app) which aims to be an aggregation of services. This is the next step in the mobility revolution: Mobility as a Service aims to provide all types of transport via one platform. All means of transport may have an Internet of Thing device that sends and receives data to improve traffic planning, offer numerous services and propose the best solution. (Scherer, Becker, Behresen, Weinreich, & Merly, 2021)

However, there are data privacy and market regulation issues today. But it is undeniable that shared mobility frees up space in cities that can be used to construct new wider and safer cycle paths that connect the city center to suburbs. Redesigning streets and cities are not only a factor of environmental sustainability but above all an aspect that makes the city more liveable, healthy and people-friendly.

5 From ideas to results

ALPHA Group is an Italian holding world leader in Railway, Aerospace and Aeronautics markets. One of its divisions, aerospace, is structured in 2 business units: Space and IoT. La BU IoT t enters the eMobility market thanks to connectivity solution for ebike and international premium bike brands already adopt this device that is able to provide diagnostic and geolocation data. This data is collected via cloud technology and allows you to manage and combine a wealth of data to improve vehicle control, accurate maintenance, customized services or fleet management. Strengthened by this success, ALPHA wants to establish a new legal entity to have more space in the green sharing mobility market. To date, it is open to a start-up with an excellent idea in its hands but with little experience and skills of this new business in continuous growth. The eMobility market is maturing and this is the ideal time to offer not only the device but the complete ebike. At the beginning of this new project, ALPHA decided to transfer some professionals from the other divisions of its group to form a heterogeneous project team. Relying on their design and diagnostic skills but not having the experience and skills, he decided for a buy solution for the production and assembly of the ebike. Obviously, the core business, that is, the IoT solution to be mounted on the bike has not been outsourced because it guarantees a considerable competitive advantage. ALPHA has partnered with BETA, a small company in the Italian production area specialized in the production of motorcycles and cars. The ebike is certainly a product with huge margins for growth but the partnership lacks an organizational and management structure capable of undertaking this challenge so much so that ALPHA has encountered several difficulties and problems.

A winning idea without solid fundamentals cannot stand.

From this arose the need to ask for help and rely on a consulting company, PwC, to be guided in the right direction, establish the steps to follow and accompany ALPHA for a short time. PwC together with the customer defined an initial project roadmap divided by areas of improvement following an evaluation phase of the internal processes that affected the first months of the project.

The roadmap is the result of a work of listening, collaboration and trust between the parties with the natural involvement of the subcontractor (BETA) with regard to production and the production plant. This planning has been repeatedly revised and modified due to delays and unforeseen events. The second phase of the project is the phase of designing the flows, the implementation of best practices and their monitoring for a first period.

5.1 The product structure and planning horizons

When studying a new market and providing management consultancy, it is advisable to make an overview of the context and analyze the different dynamics and actors involved. Among these, the most important is the customer: it becomes fundamental to identify the customer order decoupling point in the value chain because it is the driver of any strategy. The concept of decoupling the customer's order, i.e. "the point in the supply chain where the customer

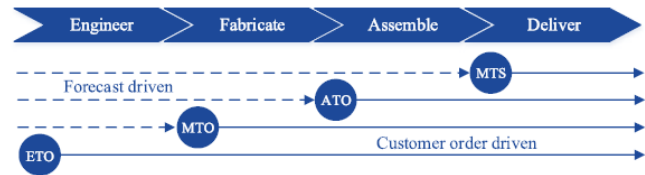


Figure 10: Different customer order penetration points.
Source: ScienceDirect

activates production activities", is the basis for the classification of the main production systems: make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO). The MTS approach follows a pull logic and can cause a demand-supply mismatch in form of shortage or high unsold stock because the systems work on forecasting demand. The other strategies attempt to delay the production of end items to obtain better demand information. (APICS, 2021)

The APICS dictionary defines decoupling as the creation of independence between supply and use of the material, usually through the use of stocks (buffers) that allow variations in the productivity of the upstream operation not to constrain the use of the downstream operation. Ptak and Smith, creators of the DDMRP, explain decoupling through the metaphor of fireproof barriers, which isolate the events that occur on the one hand from what happens on the other. In addition, they clarify how decoupling is a two-way solution, just as the problem that you want to fight is bidirectional, namely the whip effect. In fact, decoupling two operations blocks the propagation of variability both in and out. The size of the buffers will be commensurate with the level of protection you want to ensure. It is important to note that decoupling does not eliminate variability at the local level but stops its spread and amplification along the supply chain. (Ptak & Smith, 2016)

Already in the lean methodology described above there is the concept of decoupling: using the logic of kanban, lean aims to decouple all operations by triggering production only when the directly next phase requires it. This approach is diametrically opposed to that adopted by the MRP, which by synchronizing all the production phases does not present any decoupling point. In constraint theory, the buffer acts as a decoupling point, but with the aim of ensuring a constant supply of the bottleneck and not to block the transmission of variability at the system level. The innovation of DDMRP lies in the union of these 3 approaches: the basic idea is to place decoupling points in

strategic points, making the phases separated by buffers independent of each other but maintaining the logic of the MRP between one buffer and another.

Considering the theoretical concepts just described and the BOM of the ALPHA product schematized in the figure, the product structure was built on the basis of the main components and the lead times declared at the beginning of the project. Below is an example representation to analyse the planning logic to be set in relation to sales orders visibility horizon.

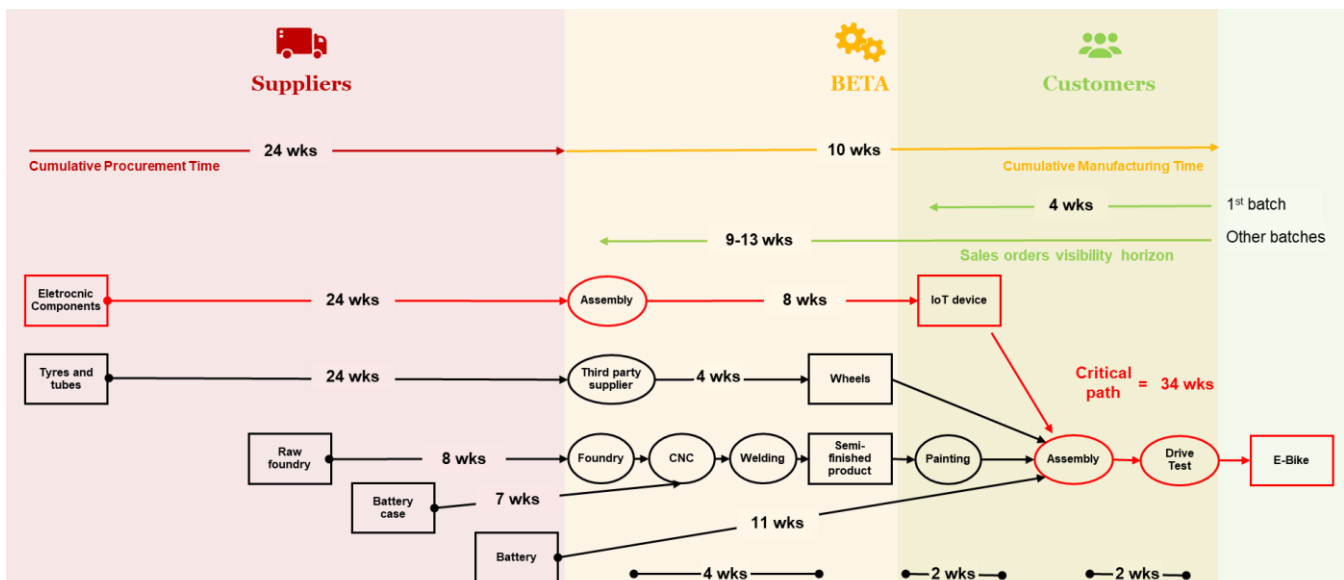


Figure 11: The product structure

In a purchase-to-order (PTO) logic, the procurement of components for the realization of the finished product can begin after receipt of orders from customers. Generally, the purchasing components are very specific and designed to meet customer demands. In this case, the critical path and response time to the order is equal to 34 weeks which is clearly exceeded on the horizon of visibility of sales orders. If, on the other hand, the finished products are made after receipt of orders from customers according to a make-to-order logic, starting from a stock positioned on the purchase components, the decoupling lead time is reduced to about 10 weeks. This strategy can be implemented if the finished product is a combination of standard raw materials and custom items specially designed to meet the specific demands of customers, as in the case of ebikes.

The make-to-stock strategy is quite risky in the ebike market and for an entrant like ALPHA in this industry. Production orders, in this perspective, are planned on the basis of forecasts and historical demand data, which for a somewhat variable market are unreliable and uncertain. In addition, you would risk having high capital costs immobilized because it is essential to have finished and standard ebikes available.

One implication of reducing planning horizons is that if the decoupling point is within the visibility horizon of customer orders, as in the case it will be possible to give only real demand input to the

system. In this way one of the main problems of MRP is eliminated at the root: production planning will no longer take place on the basis of forecasts that, despite being developed with sophisticated software increasingly complex and articulated, are incorrect by definition, but based on the actual demand given by customer orders. This greater accuracy of the demand signal then affects the entire product structure as the oscillations that cause the nervousness of the MRP will be of lower frequency and amplitude, as well as being stopped through the decoupling points.

The implications for market responsiveness are immediate. In fact, based on the positioning of the decoupling points, the lead time seen by the customer will vary. Changing the localization of the buffers will also alter the decoupled lead times, adaptable from time to time to different situations. If the buffers are positioned in such a way that the decoupled lead time of the product sold is equal to or lower than the horizon of visibility that the company has on customer orders, here it will be possible to use only the real demand as an input signal to the system, going to eliminate at the root the problems related to the use of the forecast as a basis for the generation of orders.

During the first assessment phase of my project work, in order to achieve the goal of redefining the entire ALPHA e-bike supply chain and given the increase in sales volumes, a shift in the customer's decoupling point was observed: from a make-to-order logic, originally purely engineer-to-order in which the finished product is unique and its design is done in collaboration with the customer, ALPHA have inevitably moved to an assemble-to-order system.

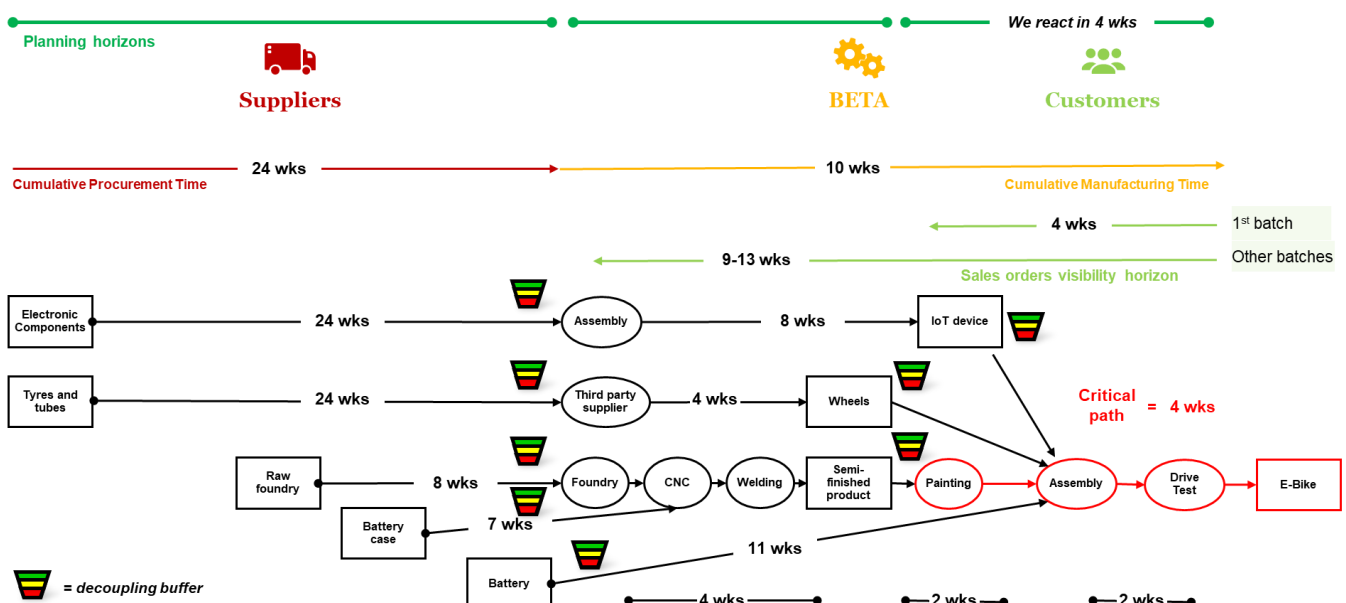


Figure 12: Planning horizons and ATO strategy

In the last few years, there has been a growing interest in the study of assemble to order systems due to the complex policy of material management and lead time. Mass customization and delayed differentiation are two great advantages of ATO systems, but it is essential to find the right balance between demand and supply.

In general, ATO systems are characterized by multiple components, which are sub assembled and stored until the order is received which starts the assembly line producing a variety of finished products. In these cases, the overall production can be divided into two phases: procurement/production of components and assembly. By following this strategy, companies can pursue high customer response times and react to customer demand by offering a variety of products by delaying final assembly, but inventory management remains crucial. Other problems facing ATO systems are the correlation of component demands, the asymmetry of component procurement/production times, and the dependence of demand fulfilment on the availability of multiple components. These systems can be seen as a combination of an assembly system and a distribution system. In the first phase the key challenge is the coordination of components, the last phase the key challenge is the allocation of components among multiple end products. The inventory policy is affected by available shipment modes, lead time and assembly capacity. Since even an imperceptible change in the lead time or cost structure of a single component can be responsible for an increase in the cost or lead time of the finished product, it is advisable to use multiple supply channels. (Atan, Ahmadi, Stegehuis, de Kok, & Adan, 2017)

The authors are aware that managing systems of this type is quite difficult and there is no optimal policy due to possible disruptions in the supply chain, technological changes, uncertainty of lead time and volatility of demand. However, it is popular opinion that the component commonality, i.e. the availability of common components for different end products, is able to mitigate these problems and to find a good compromise for the ATO system management. The focus shifts to building a good Bill of Material to increase the degree of component commonality, that it is one of the fundamental conditions for mass customization. It is a differentiating factor and enables product diversity at low cost. In this perspective, the BOMs play a fundamental role so the main configurations have been studied in the literature, which are shown in the figure below:

1. N-system: there is 2 end products. The first one is only manufactured from one component, the second one is assembled from both 2 components.
2. M-system: in this case the end products are 3. Two of them is only manufactured from each initial component and the third final product is assembled from both components.
3. W-system: now, the end products are 2 and the components are 3. Each end product consists of one common component and another specific component.
4. Nested system: there are multiple components and multiple end products. This system is more complex. The set of components used in manufacturing a product becomes one of the components of the set of components needed to assemble a larger final product. (Atan, Ahmadi, Stegehuis, de Kok, & Adan, 2017)

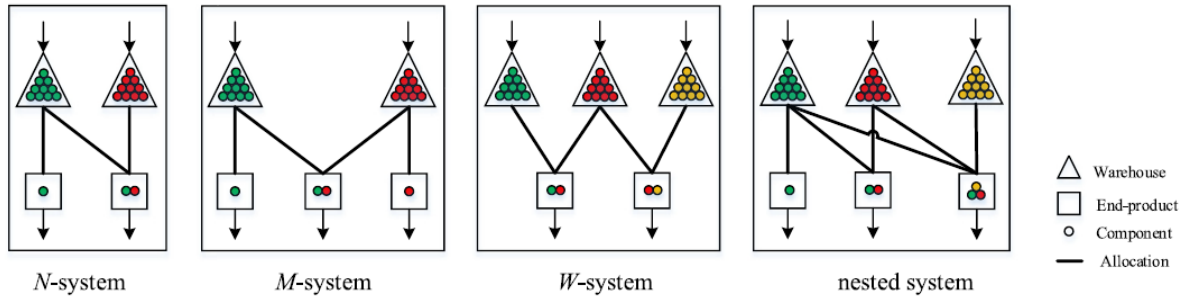


Figure 13: Configurations of assemble-to-order systems

Studying the ATO systems, Song and Zhao argue that FIFO logic is the appropriate component allocation policy but also propose a change: if a component stockout occurs, product demand is assigned to the last position in back orders. (Song & Zhao, 2009)

Furthermore, they show that the commonality of components with a modified FIFO allocation policy allows to reduce the inventory value even depending on the cost and lead time of the components. In a similar study, Shi and Zhao prove that as the degree of component commonality increases and under any no-holdback rule, according to the product demand is backordered as soon as there is a stockout of one of its sub-components, the level of inventory and backorders decrease. The authors state that the service level in business-to-business context for assemble-to-order systems is about 80%. One last aspect not to be overlooked is the continuous technological-engineering change that is seen as disruption in ATO systems: a premature technical modification can be quite expensive as it could make stocks obsolete. (Shi & Zhao, 2014)

5.2 Assessment phase

The objective of this initial phase of the project is the understanding of current processes and the identification of points of improvement in terms of supply chain planning processes and plant organization taking into account the increase in volumes expected in the coming periods.

The project team was divided into two workstreams and each of them had pre-established tasks:

❖ Workstream A:

- Assessment of processes in scope through interviews and analysis of available documentation
- Preliminary definition of improvement points and enabling elements

❖ Workstream B:

- Collect data on flows, materials and processing times (VSM)
- Identify key bottlenecks and constraints
- High-level definition of possible layout alternatives and labor needs based on expected sales volumes for e-bikes.



Figure 13: Main elements of operating model

To support companies in their transformation journeys, PwC addresses in an integrated way the different elements that characterize the operating models. The frameworks followed for the management of business processes, the digitization of information flows, the level of outsourcing have been identified. It was also necessary to evaluate the production structure (warehouses, plants), the logistics structure and the processing flow. At the organizational level, decision-making flows, critical skills and resources, organizational sizing and integration with

platforms or software were considered.

The methodological approach used is the classic one related to Supply Chain Planning in which the planning components are related to the execution processes according to the scheme below.

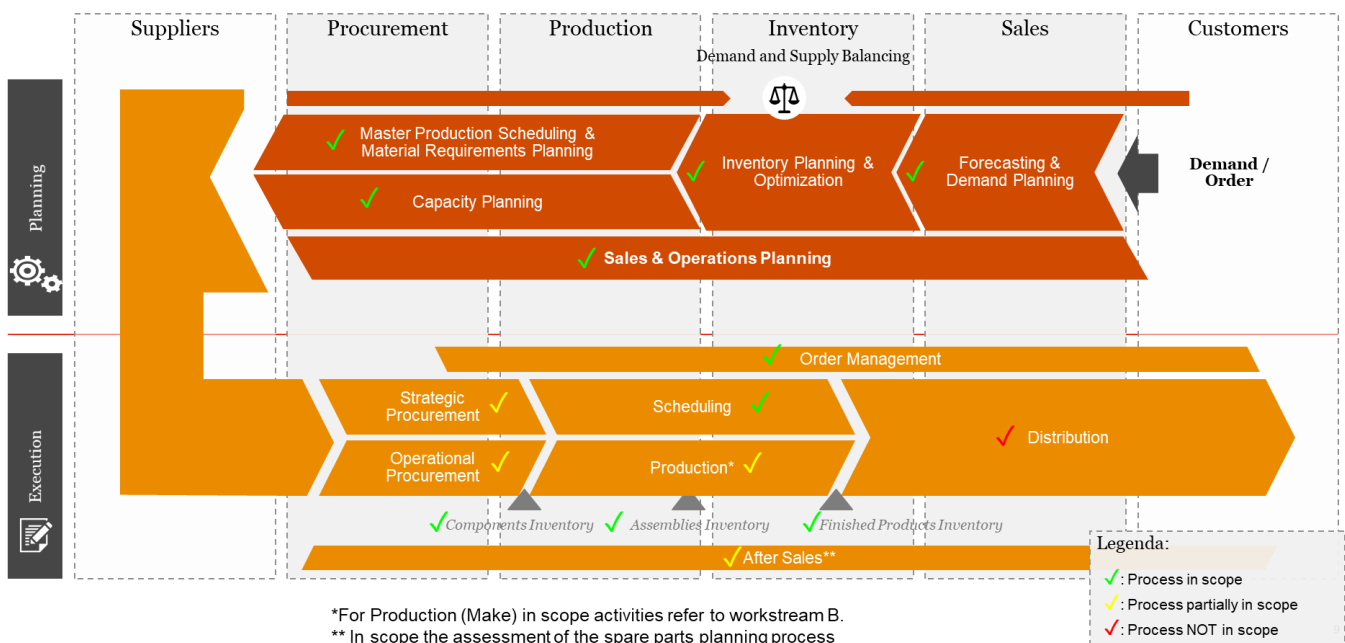


Figure 14: Example of Supply Chain Planning Framework

The first workstream through interviews with the main areas of the previous scheme and the analysis of the available documentation defined in a first draft the pain points and the main areas of improvement, classifying with respect to severity and area of intervention (process, organizational, systems). Once the improved actions have been registered for each of the processes analyzed (short and long term), an effort/benefit assessment was carried out and from here a high-level roadmap and implementation plan was defined.

The final deliverable consists of a detailed report of the analysis carried out in which the recommended improvement interventions and the related implementation plan have been illustrated.

Similarly, the workstream focused on the production part and the participation of the main beta supplier was necessary as the production plant is owned by this subcontractor.

Below, the initiatives proposed to reorganize the production area and warehouses in view of the increase in volumes with an indispensable rebalancing of the activities in the assembly line to ensure flexibility and reduction of takt time are outlined.

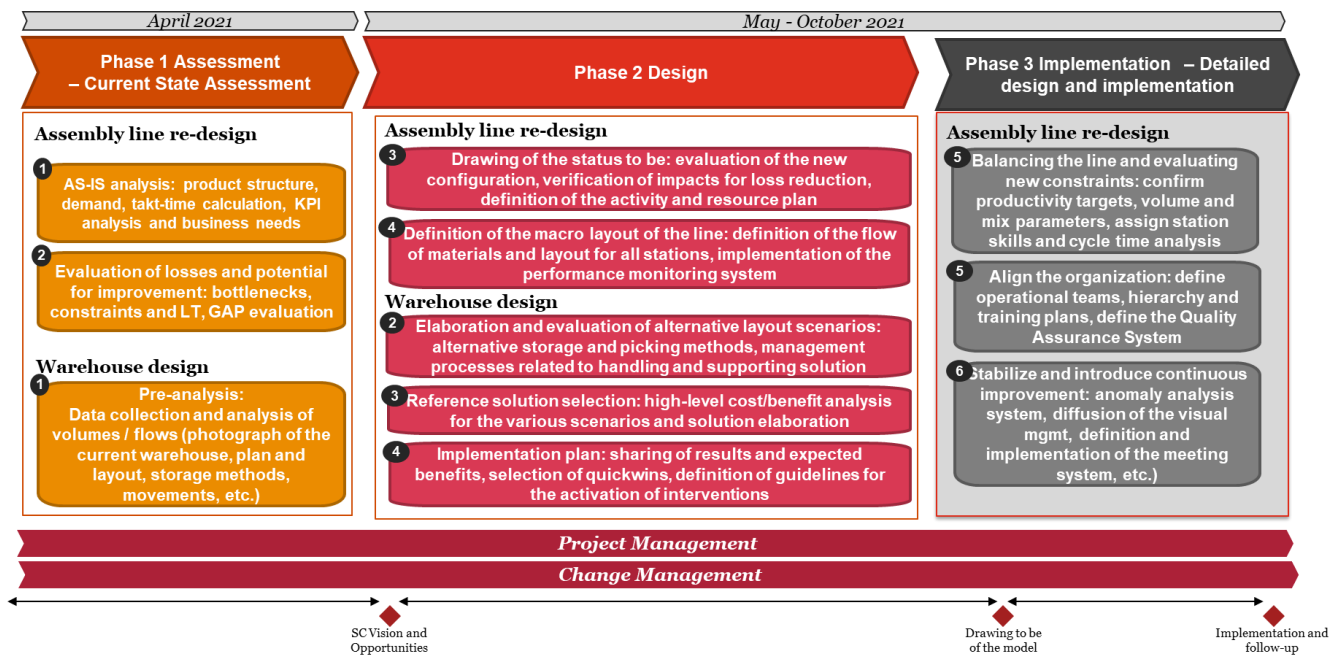


Figure 15: Example of roadmap and main initiatives

The main information that emerged from this first phase was the following:

- ❖ The current BETA production site has a covered area of about 8000 square meters of which just over half is currently used.
- ❖ The Inbound and finished product warehouses were underused and there is no management system shared with ALPHA that keeps track of the stock levels of raw materials purchased by ALPHA and granted on labor account to BETA or semi-finished or finished products.
- ❖ All machining centers are not completely saturated and there is available capacity
- ❖ It is important to reserve supplier capacity in advance in anticipation of peak demand because there were stock out problems.
- ❖ Functional testing and quality controls are not effective and fail to fill and intercept any quality and functionality defects found by customers
- ❖ Given that in the medium term a dizzying increase in demand increases is expected, it is necessary to redistribute sales orders on installed capacity in a more balanced way.
- ❖ The design and industrialization of the new models could have big impacts on productivity because the line is still in a ramp-up phase. In the case of the production of new models it is

necessary to take into account a Learning effect and the need to work on an alternative assembly line.

5.3 Design and implementation phase

The crucial phase of the project is represented by the design phase of the flows for the management of material and information.

The main driver of supply chain performance is the speed of flow according to which materials and information are transmitted between the various nodes of the supply chain. The information flow flows from the customer to the producer of raw materials, while the flow of materials has the opposite direction. George Plossl, one of the founding fathers of the MRP and author of the second edition of Orlicky's Material Requirements Planning, asserts that the true essence of manufacturing activities and supply chain management in general is the flow of materials and information. Such materials and information must be relevant, which means that they must align the company's assets with the real needs of the market. It is therefore evident that the ultimate objective of any planning system, and in a more general sense of all business functions and the tools adopted by them, should be to promote and protect the flow of materials and information. (Ptak & Smith, 2016)

Following the meetings, PwC, together with the ALPHA Group, agreed to focus its improvement proposals on the management of the flow of materials and the redesign of the assembly line. By virtue of these requests, the team began to design a merchandise entry process to be shared with beta and alpha logistics staff.

The physical inventory of contractual work components was the first step in establishing the zero point from which to start with the goods entry flows so that the ALPHA and BETA management systems are aligned. The design of the goods entry processes together with the monitoring and assistance activities guarantee to have the stocks at the same level and to avoid unexpected stockouts.

A structured and shared goods entry process allows you to:

- ✓ Give visibility to the supplier of orders arriving at the supplier's plant and allow him to equip himself for the entry of goods and for production avoiding errors during the loading of goods;
- ✓ Have real-time visibility of incoming orders and related cargo load data avoiding manual data entry work
- ✓ Keep the stocks present in the management systems aligned both on the customer side and on the supplier side

Below are the flowcharts that guide the process of merchandise entry, inventory alignment and the process of material consumption and transformation.

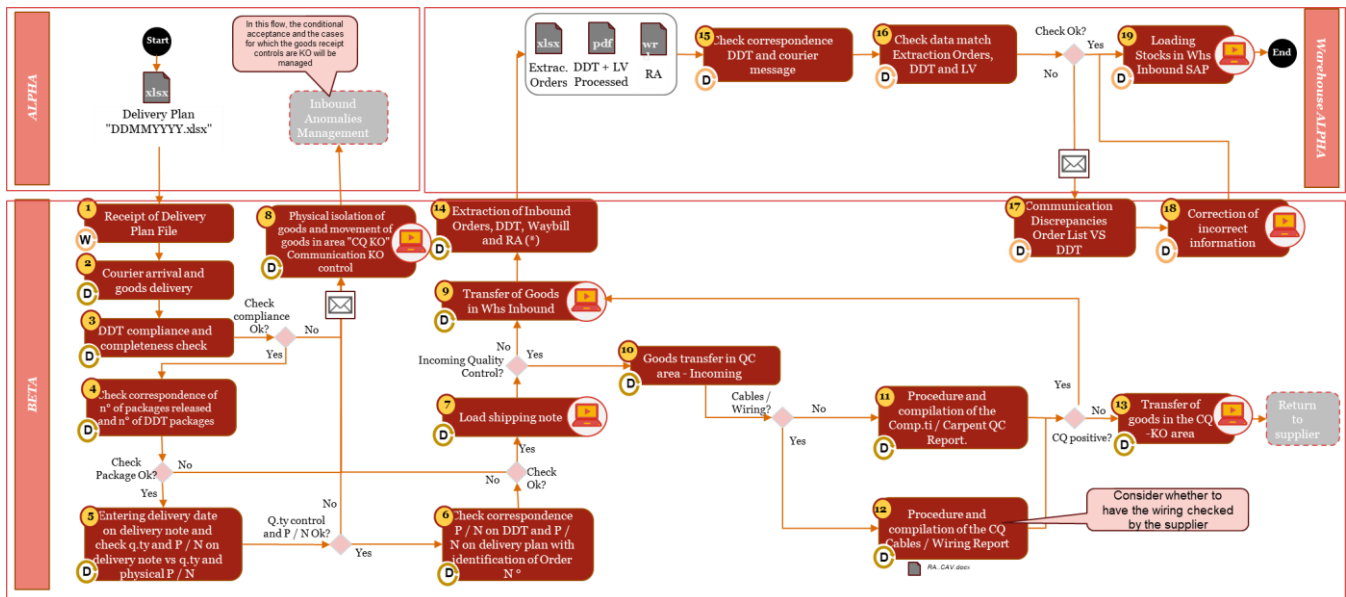


Figure 16: Goods entry process

A "Delivery Plan" file has been prepared which, starting from the orders registered on SAP not yet delivered, allows BETA to have visibility of the material arriving at the plant and to be able to record the entry of goods with the correct information by carrying out the usual incoming quality control procedures in addition to the addition of extra controls for electronic components or components of high value. The flow allows the separate recording of information on both systems that remain independent of each other: this was a fundamental requirement required by ALPHA.

To support this flow of information, a process of inventory alignment has also been devised through periodic inventory operations and sharing it with BETA and ALPHA logistics personnel. At the beginning of the project the two management systems were completely misaligned due to undeclared goods entry, undeclared defective components, quantities not yet delivered, unjustified material consumption, un-registered sales.

Another problem of primary importance was the misalignment related to the management of material codes. In order to have an insight into ongoing production and finished products in stock at BETA, ALPHA required to monitor the flow of information and material so as not to encounter these problems again that created entropy and problems of an economic nature. Below are the flowchart that should guide the process of consuming and transforming materials whether they are attributable to spare parts, prototype production or finished ebikes production.

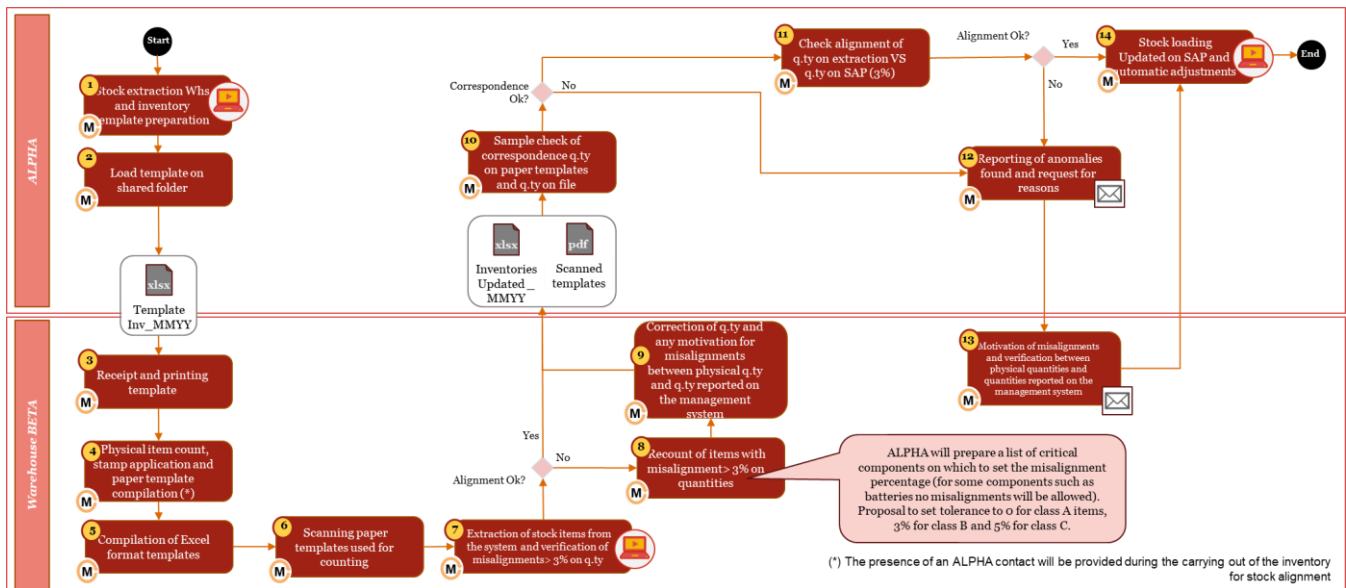


Figure 18: Inventory alignment process

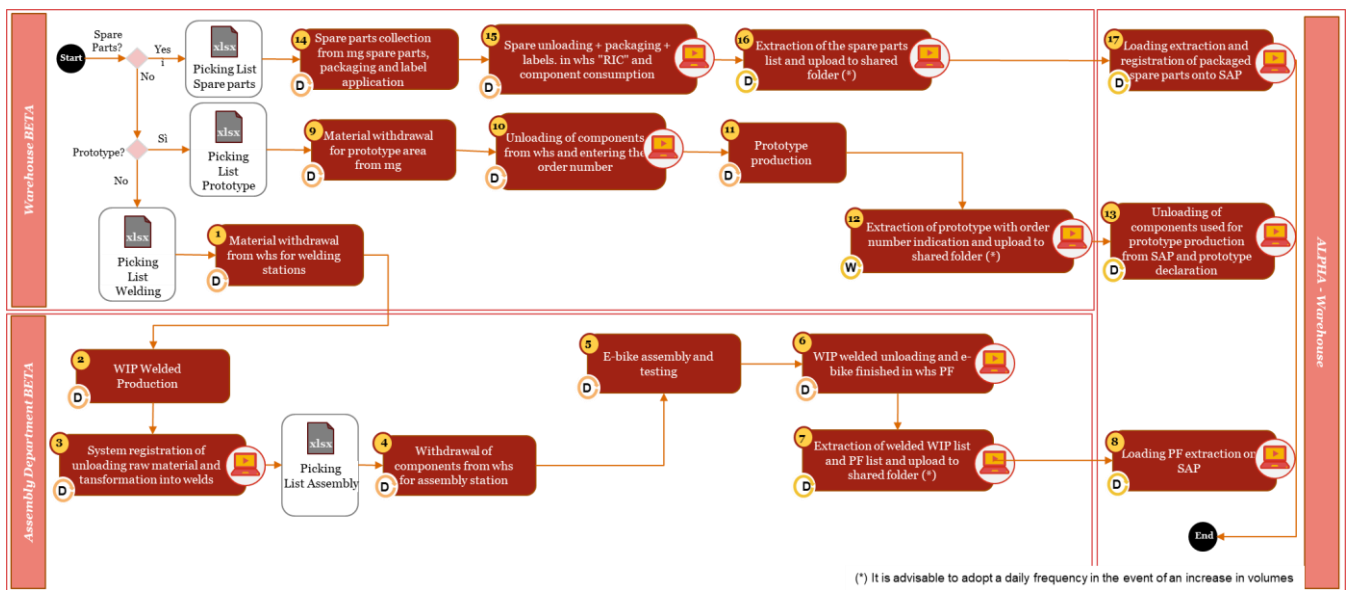


Figure 17: Consumption and transformation process

These flows were first shared with the parties involved and adapted to the needs and requirements of ALPHA and BETA. For a short time, they were monitored to verify the feasibility and their functionality and subsequently a junior figure of ALPHA was trained to continue this monitoring process so as not to prevent any delay or lack.

About the flow of materials and their transformation from raw materials to finished products, the focus was on the assembly line due to the fault feedback found by the customer. Given the expected increase in demand, the bottleneck was the assembly line which was a source of losses and non-value-added assets. This certainly would not have allowed ALPHA to reach the monthly target of finished ebikes.

(Forecast data is not provided for reasons of confidentiality. Even the subsequent data in the graphs do not reflect reality and want to represent a plausible and realistic example).

The graphs below represent the actual working times observed at the beginning of the project compared with the assembly line times at the end of the project.



Figure 19: Balancing the assembly line

There are obvious differences that concern in the first substance the structure and composition of the line: BETA aware of the expected increase in demand and in order not to deprive itself of its main customer, considered PwC's proposal to invest in the production line valid, going from 6 initial stations to 10 workstations.

In our specific case, the two scenarios refer to two different objectives: at the beginning of the project the production volumes were averages and ALPHA was able to meet the demand by leveling and anticipating production. The theoretical target was 40 ebikes/day with a real throughput of 25ebikes/day: the efficiency of the line was 63% due to a disbalance of operations between stations, the availability of materials, the learning effect given that the operators have a temporary contract.

Balancing an assembly line consists of assigning Activities to the right stations on the line in order to meet all the constraints present while maximizing the use of operators. Balancing can be carried out with fixed takt (minimizing the number of operators on the line) or fixed number of operators (minimizing takt time).

To meet the monthly demand expected by the market, ALPHA and BETA have decided to carry out the balancing by setting a theoretical takt time at 6 minutes and to strengthen the quality controls. The work content was not divisible between the initial 6 operators and therefore it was necessary to balance the line on a greater number of stations to obtain a daily throughput of 65 ebikes (efficiency 87%). The actual total work content has increased because quality controls have been introduced

entrusted to each individual work on the line. In addition, the final test has been improved by establishing an external circuit in which there are steps to follow and the tightness, stability and functionality of the ebike is actually evaluated.

To carry out the correct balancing of a production line, it is necessary to ensure that each station and each person works at the same pace, avoiding intermediate stocks and generating fluidity from the entry of raw materials to the finished product. It is easy to understand that if one station works twice as fast as the others, for half the time it will wait for the work of the previous phase while producing stock for the next phase generating waste in both cases. Balancing production and assembly lines is the first step in reducing costs and increasing revenues. One of the tools used to measure workloads and balance production lines is the Yamazumi chart. It is a bar diagram that is used in companies to visualize the cycle time of the machine and the workload of the operators, in order to evaluate its performance.

The constraints to be considered in a balance are typically:

- Priority between tasks due to the need to respect an object mount sequence
- Availability of materials or tools or machines in the station
- Assembly position (top, bottom, left, right, forward, back, etc.)
- Need to refer control activities or quality verification to downstream operators (not to the same operator who performs the action)

As a result, the line has been equipped with enablers that have made it possible to achieve greater throughput and fill losses related above all to defects and non-value-added movements and activities. In addition to line balancing, other enablers attributable to Operations have been introduced:

- ✓ The list of tasks along the line has been revised based on post-balance changes
- ✓ The checklist of controls on the line has been updated and the card travels on the line
- ✓ The picking list has been planned to facilitate line refueling
- ✓ The production warehouse has been organized with tags and indications to quickly find the necessary materials
- ✓ The Drive has been revisited to provide objective and repeatable references to the tester. The new standard procedure is supported by the identification of the circuit on the floor.

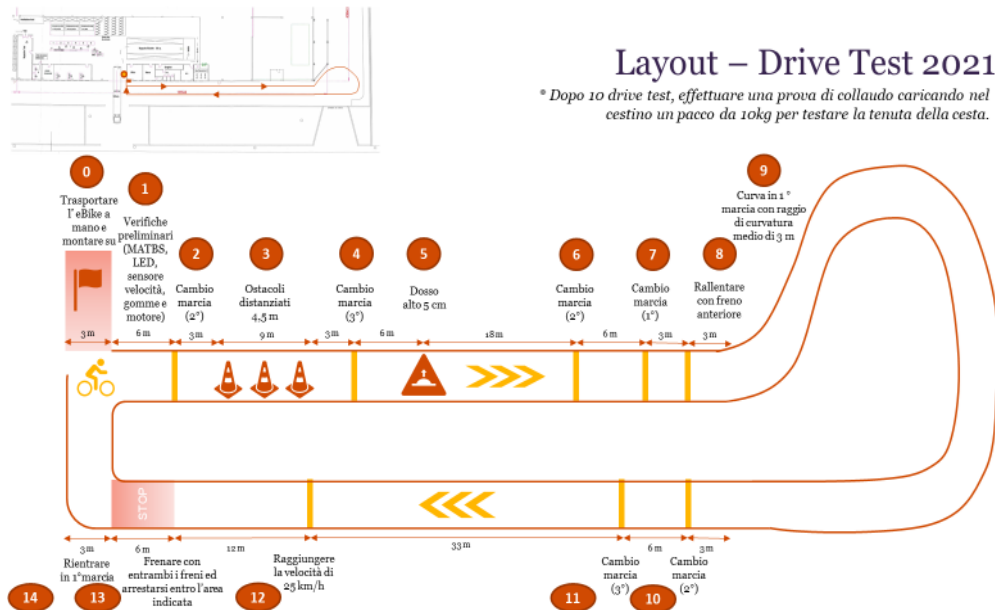


Figure 20: Drive test layout

Purely productive side, the plant has undergone layout changes that are certainly an enabler to achieve operational excellence. The improvement activities concerned the areas listed in the figure.

Improvement area	AS IS – 04/2021	TO BE – 07/2021
Semi-finished warehouse	Unforeseen area	Semi-finished warehouse area created with a view to Assemble-to-order. It is planned to store painted and welded semi-finished products for all mechanical components
Inbound Warehouse	In another area, not organized and unsized warehouse	Created Inbound Warehouse area, and organized with control area and component identification system
Battery Warehouse	Not expected	Made suitable shelving separated from the rest of the warehouse and fenced
Pre-assembly area	Not organized	Created area for pre-assembly of components to be fed directly on the line
Assembly line	6 workstations	10 workstations
Finished product warehouse	Packed E-Bikes Warehouse	Created area for loading and storage e-bikes finished without packaging. Packaging and storage area is available by necessity.
Drive test	Circuit inside the finished product warehouse	The external circuit has been designed to test the E-Bike from a mechanical point of view and test it with a road test characterized by several steps to follow

Figure 21: Layout changes

Production plans have been repeatedly changed, modified and updated because they are tied to an not confirmed delivery plan: several containers have been blocked at customs due to compatibility problems and companies had to face the consequences of supply chain disruption and the high transport cost. ALPHA had not foreseen it and cannot sustain it for long.

The logistics chain that governs the ebike market is largely linked to raw materials from China and the East. However, the low costs of purchasing raw materials are contrasted by a huge transport cost and long lead times that are bringing many economic sectors to their knees. This increase in freight rates is mostly due to disruptions to the global supply chain caused by the Covid-19 pandemic, resulting in port congestions and container shortages.

Drewry, the leading international provider of research and consulting services for the maritime and maritime industry, has unparalleled experience and expertise in all market sectors, from containers to ports. Its supply chain consultants provide reliable spot cost estimates and support for sourcing goods by sea to retailers and manufacturers. This frightening trend linked to the cost of transporting containers is illustrated by the images below and highlights for some routes an increase equal to double, quadruple or even more. This is certainly daunting for many markets. An alternative is to try to scout between suppliers close to your production site, shorten supply chains or think about vertically integrating the design and production of critical components, obviously this requires large investments and facing risks.

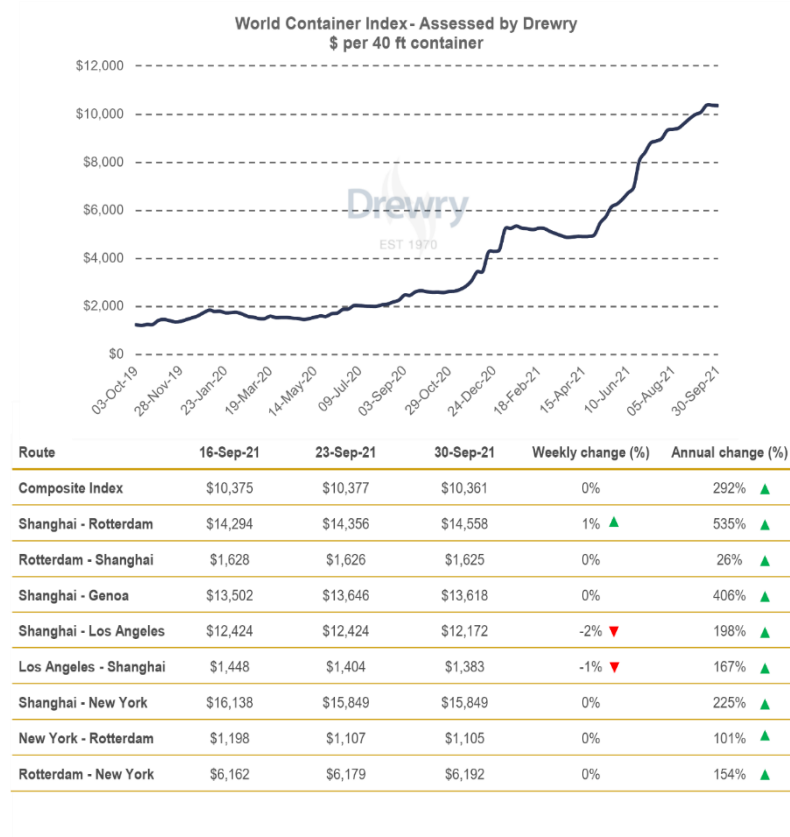


Figure 22: Spot freight rates. Source: Drewry

Conclusion

This project carried out in a market in its growth phase has certainly been an excellent gym to give substance to the theoretical topics studied on university desks. The internship experience is a necessary step in a path of maturation and professional growth. This thesis work does not want to be the closure of the course of study but the beginning of my working career.

The bibliographic research and the statistics depicted were a fundamental starting point to face with the right spirit and enthusiasm this work experience that saw me participate in every phase. Listening, investigating and helping companies to achieve their goals are challenging activities. Knowing new business contexts and finding innovative and customized solutions allows me to continuously improve. The success of the client represents a success and a huge satisfaction for the consultant. Management consulting is undoubtedly a heterogeneous market that allows me to grow rapidly.

My main goal was to take advantage of this experience to continue my professional growth path. It was a great growth opportunity for my future because PwC is a multinational reality that will allow me to participate in the ambitious commercial transformation projects of the main players. In PwC, I'm able to give space to my ideas and give the innovative contribution that I have always wanted. Similarly, one of the challenges of this internship is to train a managerial consultant able to bring added value in the projects that will be entrusted in the future: the initial stages of onboarding and training is aimed at becoming an integral part of the group and learning new skills. For both parties it is an investment that has great growth prospects. In the first training phase I followed internal courses about MTM (Methods-Time-Measurement) and DDMRP (Demand Driven MRP): they are the main skills that represent a competitive advantage in the Operations consulting market.

The group project work for ALPHA Group is not yet finished and has several open points concerning the revision and modification of the Bill of Material to favor the assembly-to-order strategy and the commonality of the main components of the final products. During the current production phase, it is essential to monitor the outputs and information of time, cost and quality in order to optimize the processing and assembly cycles. At a tactical and strategic level, on the other hand, it is necessary to evaluate the dynamics of the market and take decisions that can allow to satisfy the expected volumes and make production and organizational processes flexible.

Continuous improvement is a must not only for small or large companies but it is a philosophy of life. This is the great lesson that I have learned in these years of study: growing by 1% every day (a small and simple effort), in less than four months you will achieve a result equal to double that starting level, in a year you will reach a level of 37 times greater. (Even Mathematics proves it!)



Bibliography

- ALM, I. (2017). The ALM Vanguard: Production & Operations Management Consulting. *ALM Intelligence*.
- APICS. (2021). *APICS dictionary*.
- Assoconsult. (2021, Luglio 8). Observatory report 2021.
- Atan, Z., Ahmadi, T., Stegehuis, C., de Kok, T., & Adan, I. (2017, Volume 261, Issue 3, 2017, Pages 866-879, ISSN 0377-2217). Assemble-to-order systems: A review. *European Journal of Operational Research*, 866-879.
- Boyle, M. (2021, September 3). Forget Finance. Supply-Chain Management is the pandemic era's must have MBA Degree. *Bloomberg Business week*.
- Canback, S. (1998). Transaction Cost Theory and Management Consulting: Why do Management Consultants Exist? *Henley Management College*.
- Christensen, C. M., Wang, D., & van Bever, D. (2013, October). Consulting on the Cusp of Disruption. *Harvard Business Review*.
- Consultancy industry*. (n.d.). Retrieved from Consultancy.uk: <https://www.consultancy.uk/consulting-industry/global>
- Dimitrijević, J. (2019, December 26th). *The Role of Process Consultant*. Retrieved from Jelena Consult: <https://jelenacconsult.com/the-role-of-process-consultant/>
- Essing, N. H. (2019). The ALM Vanguard: Production Operations Consulting 2019. *ALM Intelligence*.
- FEACO. (2020, December). Survey of European Management Consultancy . *FEACO*.
- Gelles, J. (2011, February 20). Porter's Five Forces - management consulting.
- Gleich, R., & Sauter, R. (2008). Operational Excellence: Innovative approaches and Best Practices in the production industry. *Rudolf Haufe Verlag GmbH & Co. KG*.
- Jaeger, A., Matyas, K., & Sihm, W. (2014). Development of an Assessment Framework for Operations Excellence (OsE), based on the Paradigm Change in Operational Excellence (OE). *Procedia CIRP*, Volume 17, ISSN 2212-8271, pp. 487-492.
- Mandelbaum, A. (2020, April 2). *4 Business consulting industry trend to look out for in 2020*. Retrieved from Paradox Marketing: <https://paradoxmarketing.io/capabilities/digital-brand-development/insights/4-business-consulting-industry-trends-to-look-out-for-in-2020/>
- Marasà, E. G. (2019). *La consulenza aziendale: analisi di settore, trend e focus sulle Big 4*. Tesi di Laurea. Politecnico di Torino.
- Miller, R., Raymer, J., Cook, R., & Barker, S. (2013). The Shingo Model for Operational Excellence. Logan: Utah State University.
- Ptak, C., & Smith, C. (2016). *Demand Driven Material Requirements Planning*. Industrial Press.
- PwC. (2021). *Purpose and values*. Retrieved from pwc.com: <https://www.pwc.com/gx/en/about/purpose->

and-values.html

- Reid, R. D., & Sanders, N. R. (2013). *Operations Management: An Integrated Approach, 5th edition*. Wiley Custom Learning Solutions.
- Schein, E. H. (1999). *Process Consultation Revisited: Building the Helping Relationship*. Addison-Welsey.
- Scherer, A.-L., Becker, S., Behresen, A., Weinreich, M., & Merly, G. (2021). European mobility Atlas. Facts and figures about transport and mobility in Europe. *Heinrich-Böll-Stiftung European Union*, 26-47.
- Schwientek, R., & A., S. (2008). *Operations excellence: Smart solutions for business success*. Palgrave Macmillan.
- Shi, J. J., & Zhao, Y. (2014). Component commonality under no-holdback allocation rules. *Operations Research Letters*, 409-413.
- Song, J.-S., & Zhao, Y. (2009). The value of component commonality in a dynamic inventory system with lead times. *Manufacturing & Service Operations Management*, 493-508.
- Wikipedia. (2021, August 14). *Operations management*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Operations_management

Table of figures

Figure 1: Size of the global consulting industry (2011-2016). Source: Consultancy.uk	12
Figure 2: Management consulting turnover trend (2017 - 2020). Source: FEACO survey	13
Figure 3: Turnover trend 2010-2021 (by size class). Source: Assoconsult	14
Figure 4: The transformation process. Source: Operations Management	18
Figure 5: Historical Development. Source: Operations Management	19
Figure 6: Production Operations Consulting Providers. Source: ALM Intelligence	22
Figure 7: Evolution and trends of Operational Excellence. Source: ScienceDirect	23
Figure 8: Operations Excellence Assessment Framework. Source: ScienceDirect	25
Figure 9: Employment in the bicycle industry. Source: European mobility Atlas	29
Figure 10: Different customer order penetration points.	32
Figure 11: The product structure	33
Figure 12: Planning horizons and ATO strategy	34
Figure 13: Main elements of operating model	37
Figure 14: Example of Supply Chain Planning Framework	37
Figure 15: Example of roadmap and main initiatives	38
Figure 16: Goods entry process	40
Figure 17: Consumption and transformation process	41
Figure 18: Inventory alignment process	41
Figure 19: Balancing the assembly line	42
Figure 20: Drive test layout	44
Figure 21: Layout changes	44
Figure 22: Spot freight rates. Source: Drewry	45