POLITECNICO DI TORINO

Logistic Agreement

SUPPORT ACTIVITIES FOR IVECO LOGISTIC SUPPLY-CHAIN & STANDARDISATION

MSc Engineering and Management path 'Innovation Management and Entrepreneurship'

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Summary

1. Introduction

1.1 Background: Introduction to Supply Chain Improvement and Standardization

The automotive industry, which has long been recognized for its complex and globalized supply chains, is in fact one of the sectors where these principles are especially critical. As automotive companies operate in a highly competitive environment with constant pressure to innovate, reduce costs, and improve customer satisfaction, the efficiency of their supply chains has a direct impact on their bottom line. The sector is characterized by a vast network of suppliers, manufacturers, distributors, and service providers, each playing a crucial role in delivering high-quality products in a timely manner. The intricate nature of the automotive supply chain makes it vulnerable to disruptions, inefficiencies, and inconsistencies that can significantly affect production timelines, costs, and product quality.

To be competitive in the market is mandatory maximized efficiency, reduced costs, and meet customer demands in a timely manner. These are the main points on the list of every actor in the automotive industry, in which the supply chain optimal exploitation is crucial for those who want to be a leader in this sector. As highlighted by the Supply Chain Operations Reference (SCOR) Model, developed by the APICS Supply Chain Council, optimizing supply chain operations through standardized processes is essential to achieving efficiency and resilience (Supply Chain Council, 2010).

Characteristics of Automotive Supply Chains the so-called "supplier–manufacturer–customer network" in the automotive industry extends around the entire world, especially for raw materials and for some intermediate products and components. To coordinate this network, OEMs and suppliers have established a supply chain management system to secure and optimize product, information and cash flows in a competitive environment. OEM stands for Original Equipment Manufacturer, which refers to a company that produces parts or equipment that are then marketed and sold by another company under their own brand name as finished product. OEMs play a crucial role in many industries, as they are often able to manufacture products more efficiently and cost-effectively than the companies that rebrand and sell the products. This allows the rebranding companies to focus on marketing and selling the products, while relying on the OEMs to handle the manufacturing. The Global Value Chain (GVC) theory by Gereffi, Humphrey, and Sturgeon (2005) explains how companies like Bosch act as lead firms orchestrating supply chains, ensuring quality and efficiency while managing Tier 1, Tier 2, and Tier 3 suppliers. Tiers, in this context, refer to different levels or categories of suppliers or manufacturers within a supply chain. There are typically three tiers in a supply chain: Tier 1 suppliers are the primary suppliers that provide products directly to original equipment manufacturers (OEMs). Tier 2 suppliers are companies that provide components to Tier 1 suppliers, and Tier 3 suppliers are companies that provide raw materials to Tier 2 suppliers. Some examples are reported in the table below (fig 1.2)

In the automotive industry, for example, Tier 1 suppliers might produce complete systems such as engines or transmissions, while Tier 2 suppliers might produce components that are incorporated into these systems. Tier 3 suppliers might provide raw materials, such as metals or plastics, that are used to make the components produced by Tier 2 suppliers. The distinction between the tiers is important because it helps companies manage their supply chain and identify potential risks or issues.

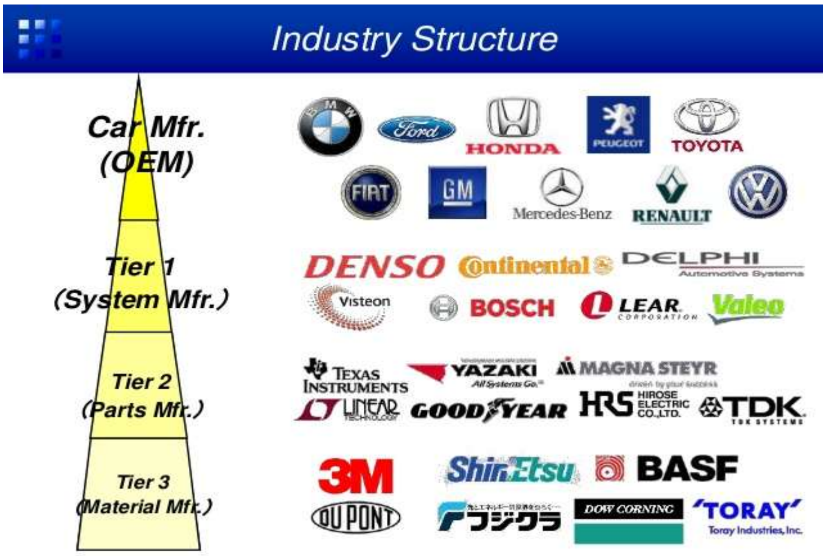

Fig 1.2***: OEM Value System*.

In the automotive industry, Bosch is a major OEM that provides a wide range of products and systems, including fuel injection systems, powertrain components, braking systems, electronic stability control systems, and more. These products are incorporated into the vehicles produced by various automobile manufacturers such as Stellantis and sold under their own brand names. Bosch also serves as an OEM in other industries, such as consumer goods, where it provides products such as power tools, home appliances, and security systems. The company's extensive portfolio of products and systems, combined with its reputation for quality and innovation, makes Bosch a highly sought-after OEM in many industries.

In the automotive sector, supply chain management is particularly challenging due to several factors:

- **Globalization of Supply Chains:** Automotive manufacturers source components from all over the world. This global reach, while providing cost advantages, also exposes companies to risks related to geopolitical issues, transportation disruptions, and changes in regulatory environments.

- **Demand Variability:** The automotive market experiences fluctuating demand patterns, influenced by economic cycles, consumer preferences, and regulatory changes. As such, it is essential for manufacturers to maintain flexibility and agility in their supply chain processes to respond to shifting demands.

- **Just-in-Time (JIT) Manufacturing:** The automotive industry relies heavily on JIT manufacturing practices, which minimize inventory levels by ensuring that materials arrive just before they are needed in the production process. While JIT reduces costs associated with excess inventory, it also increases the risk of disruptions, making supply chain efficiency and standardization even more critical. The Lean Manufacturing philosophy, pioneered by Toyota and discussed by Womack, Jones, and Roos (1990), emphasizes reducing waste and ensuring efficiency in production, principles that Bosch integrates into its operations to maintain competitiveness.

- **Technological Advancements:** Emerging technologies such as artificial intelligence, machine learning, and the Internet of Things (IoT) are reshaping the automotive supply chain. These technologies offer opportunities to enhance operational visibility, automate processes, and optimize logistics, making supply chain standardization and continuous improvement essential to staying competitive.

- **Sustainability and Environmental Factors:** With increasing pressure from regulators, consumers, and stakeholders for automotive companies to adopt sustainable practices, supply chain improvements and standardization are necessary to achieve environmentally friendly production processes, reduce waste, and lower carbon footprints.

This thesis explores the critical role that supply chain improvement and standardization play in the automotive sector, specifically focusing on how these practices can be applied to enhance operational efficiency, reduce costs, and ensure quality consistency across the entire production process.

1.2. Thesis Objectives

IVECO has put forth a comprehensive proposal to its customers aimed at enhancing the efficiency of its supply chain operations and achieving standardization. This initiative was driven by the need to reduce the significant operational costs that have been incurred over recent years.

The objective of this thesis is to provide an in-depth account of the BOSCH's response to the proposal, including the strategies adopted, challenges encountered, and the analytical framework employed during the internship period to evaluate the proposal's implications. Furthermore, the thesis also examines the ongoing monitoring and assessment of recent performance outcomes to ensure the alignment of the proposed measures with the organization's overarching objectives.

This thesis is structured to provide a comprehensive analysis of supply chain improvement and standardization, it then delves into the company history, offering an overview of its core business areas, evolution, and economic approach, particularly focusing on Bosch's philosophy.

Following this, the automotive sector is explored, emphasizing supply chain challenges. The study proceeds with an examination of the company's current logistics systems, including connected supply chains and warehouse logistics.

A detailed focus on workspace logistics within Bosch Italy (Perbit Division) follows, covering supply chain control, workplace environment, and order management in SAP, highlighting its key benefits. The thesis then transitions to specific tasks undertaken, followed by an overview of the current situation and the identification of potential solutions.

Risk analysis plays a crucial role in understanding the vulnerabilities within the supply chain, starting with identifying potential risks that could disrupt operations, followed by assessing their likelihood and impact. This leads to a prioritization process, ensuring that the most critical risks are addressed first. The development of risk mitigation strategies is then explored, focusing on proactive measures to minimize disruptions, while the final step involves implementing a structured risk management plan to enhance resilience and adaptability. Building on this, the thesis examines the specific actions pursued to improve logistics efficiency, starting with order variability and the development of solutions that integrate flexibility rules into logistic agreements. This includes an in-depth analysis of data interpretation, counterproposals, and the optimization of demand planning. The role of digital tools such as the Tower Tool is discussed in detail, emphasizing its user interface and how it supports decision-making through performance indicators from both Bosch and Iveco, particularly in managing demand variability. Another key aspect is the analysis of Minimum Order Quantities (MOQ) and Minimum Stock Quantities (MSQ), evaluating their significance in order planning, their compliance in real-world scenarios, and the strategic implications of optimizing ordering patterns. The discussion then transitions to the importance of agreements, which formalize the improvements and ensure long-term sustainability. Looking ahead, the thesis outlines a roadmap for future applications, beginning with a testing phase that gathers data-driven insights to validate the proposed solutions. The effectiveness of these solutions is assessed, leading to corrective actions where necessary, and ultimately identifying strategic opportunities for further advancements. In conclusion, the study reflects on its key contributions, acknowledges its limitations, and suggests future research directions that could build on the findings to drive continued improvements in supply chain standardization.

2. Company overview

In this chapter, the thesis will analyze Bosch's history and the evolution of its strategic thinking, starting from its core business areas to its future projects.

2.1. Overview of the Company

The current Robert Bosch GmbH has a corporate structure that allows it to be independent in financial terms and therefore to reinvest part of the turnover in its own organization to create more opportunities for future growth. In particular, 7% of shares is held by the Bosch family, 1% by Robert Bosch GmbH and 92% by Robert Bosch Stiftung GmbH, a charity. This, from its foundation dating back to 1964, has carried forward the thought of its founder which consists in ensuring well-being public by remaining active in the areas of health, science, society, education and relationships international. The idea of wanting to maintain entrepreneurial independence is confirmed with the distribution of voting rights: only 7% to the Bosch family and the remaining 93% to Robert Bosch Industrietreuhand KG, a trust company.
Which product would typify Bosch in 2025? With such an extensive range, it's difficult to say. Researching, testing, and manufacturing is conducted within an international network, involving countless different people. Diversity plays a leading role at Bosch. Today, products still crisscross the world, but they are not leaving from a single starting point anymore. The international manufacturing and research network ensures that products are developed and manufactured where they are needed — local for local. Between these two scenarios lie 120 years in which Bosch has transformed itself from a company with international ambitions to a global player. It all started in 1898, when Robert Bosch took the first step towards internationalization, just 12 years after founding the company. Internationalization has remained a strategy crucial to Bosch's survival. After several setbacks in the crisis-plagued 20th century, the company's strong international orientation was often pivotal in its subsequent upswing.

At the end of the 19th century, Bosch recognized that the German market alone would not be enough if it wanted to sell large quantities of magneto ignition devices. The decision to enter important international markets was decisive in benefiting from the upcoming boom in motorization. Bosch had to identify the right entry strategy. Often, personal contacts were the best way to get a foot in the door. The Paris motor show, for example, was one of the best places to meet other experts and make important connections. This is how Robert Bosch got to know people with in-depth knowledge of the local market and with a wealth of experience. Such local companies would take over the sale of Bosch products with great expertise, like in China in 1909 and in Japan in 1911. Setting up subsidiaries and production locations outside of Germany was still the exception rather than the rule for Bosch. Until 1914, there were only two major manufacturing locations outside of Germany: in France and in the U.S. The more international a business activity became, the more Bosch had to contend with international competition. Research and development, which was clearly concentrated in Germany up to the 1980s, was transformed into a global development network. Local engineers were better placed to translate local needs into solutions "Invented for life." Individual divisions around the world were handed product responsibility. As early as in the development phase of a new product, associates from different locations around the world would work together. Crucial factors influencing these developments included the increasing speed of data transfer and the opportunities offered by the internet. In the years that followed, increasingly virtual teams were set up, with team members from different locations around the world working together to develop new products.

2.2. Core Business Areas

Bosch, a global technology and services leader, operates in several key business areas that focus on innovation, sustainability, and digitalization. The company's diverse portfolio allows it to maintain a strong position in multiple industries, constantly adapting to new technological trends and market demands.

Mobility Solutions, One of Bosch's largest and most essential business areas, is its mobility solutions sector, which caters to the automotive industry. This includes everything from powertrain solutions for vehicles to advanced technologies for autonomous driving and connectivity (fig 2.1). Bosch is heavily involved in the development of electric vehicle (EV) components, helping to drive the automotive industry's shift toward cleaner, more sustainable options. It also plays a significant role in making driving safer and more efficient through its innovations in sensors and driver assistance systems.

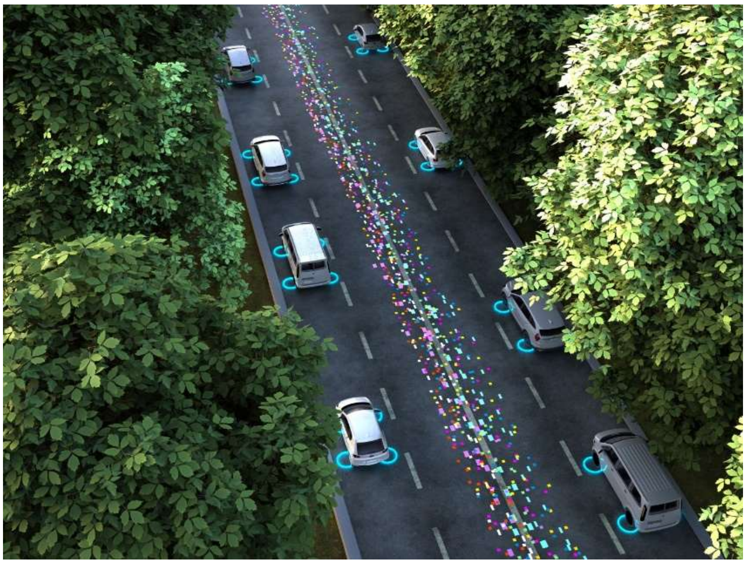

Fig 2.1 *Bosch connectivity.*

Industrial Technology: Bosch's industrial technology division focuses on providing cutting-edge automation solutions to improve manufacturing processes. The company develops equipment and systems that enhance production efficiency, particularly in sectors like automotive, packaging, and food production. As industrial sectors increasingly embrace digital technologies, Bosch also leads in creating smart factory solutions that incorporate IoT and robotics, helping businesses optimize their operations while reducing energy consumption and costs.

Consumer Goods: In the consumer goods sector, Bosch is renowned for its high-quality home appliances (fig 2.2), power tools, and heating solutions. The company designs innovative products that prioritize energy efficiency and user-friendly experiences, making it a leader in the household appliance industry. Bosch's power tools are highly regarded in both the professional and DIY markets, offering precision and durability. In heating, Bosch develops sustainable solutions that help reduce energy consumption while providing comfort in homes and businesses.

Fig 2.2 *Home appliances example.*

Energy and Building Technology: The energy and building technology division of Bosch aims to create smarter, more sustainable living and working environments. Bosch develops integrated building automation systems, such as smart home solutions that connect devices like thermostats, security systems, and lighting to improve energy efficiency and user experience. The company also offers renewable energy solutions, including solar power systems and energy storage, helping to support the transition toward a low-carbon economy.

Research and Development (R&D): Innovation is at the heart of Bosch's strategy, with a significant portion of its resources dedicated to research and development. The company invests heavily in emerging fields like artificial intelligence (AI), the Internet of Things (IoT), and digitalization, creating products and solutions that are more connected, efficient, and responsive to customer needs. Bosch's commitment to sustainability is also reflected in its R&D, with ongoing efforts to create cleaner energy solutions and more environmentally friendly technologies across all its business areas. Healthcare Solutions Bosch has also made inroads into the healthcare sector, developing technologies aimed at improving patient care. This includes diagnostic equipment, remote monitoring tools, and telemedicine solutions, which are designed to enhance the quality and accessibility of healthcare services. With its innovations, Bosch is helping to improve healthcare outcomes while addressing the global challenges of an aging population and healthcare system inefficiencies.

2.3. Company Evolution and Way of Thinking

1886 – In Stuttgart, Germany, Robert Bosch founded the "Workshop for Precision Mechanics and Electrical Engineering." This company would eventually come to be known as the Bosch Company, a world leader with a global reputation.

1897 – Bosch manufactured his first magneto ignition device (fig 2.3) , patented for Bosch in June 1897. The first magneto was mounted on a vehicle engine that autumn.

Fig 2.3 *Magneto ignition device*

1902 – The Bosch Company was awarded a patent for their spark plug in 1902. Since its invention, the original operating principle of the spark plug has never been changed. It continues to provide vehicles with the same reliability and trustworthiness as ever before.

1912 – Bosch decided to cross the pond and began setting up manufacturing centers in the United States. The Bosch factory in Massachusetts begins manufacturing the magneto ignition device, Bosch's star product.

1921 – Up to this point, the garage concept had been exclusive to Germany, but Bosch decided to expand it further. The idea of workshops caught on so fast that, in under a decade, there were already 70 countries supporting 2,750 workshops.

1926 – Unveiled in 1926 by Bosch, the windshield wiper put an end to the troubles posed by weather and technical shortcomings for drivers. The system was powered by a small electric motor situated above the car battery and was not reliant on the engine running.

1927 – Bosch revolutionized the industry with the world's first large-scale production of diesel injection pumps and injectors. Initially used only in trucks, the first diesel-injection pump for cars went to market in 1936.

1951 – The Gutbrod Superior 700 (fig 2.4), a two-seater with a fold-down sunshade, was advanced with injection technology increasing power from 26 to 30 HP. The carburetor version of the compact car, which was exhibited at the Frankfurt Auto Show in 1951, consumed a good eight liters of gas per 100 kilometers.

Fig. 2.4 *The Gutbrod Superior 700*

1967 – On September 14, 1967, Bosch unveiled the electronically controlled "Jetronic" at the International Motor Show (IAA) in Frankfurt: a manifold injection technology for automotive petrol engines.

1976 – With a passion for improving neighborhood communities and protecting the environment, Bosch invented the Bosch oxygen sensor or LAMBDA sensor. This allowed cars to smoothly hit emissions standards for the first time.

1978 – ABS braking became a standard safety feature on all cars. Although Bosch had initially registered a patent for ABS braking back in 1936, it wasn't until the electronic technology of 1975 became available that ABS braking could become a reality on most vehicles.

1980 – Bosch was the first European company to manufacture electronic triggering units for passive safety systems. This set the standard in road safety.

1995 – In an effort to help support drivers during critical driving situations, Bosch began using the electronic stability program (ESP) in vehicles. It has since been credited for saving 15,000 lives and has earned the nickname "Electronic Guardian Angel."

1997 – To further help drivers experience a safe and comfortable ride, Bosch unveiled its TravelPilot navigation system. This innovative technology has led to many modern developments, including Adaptive Cruise Control and Night Vision, for improved safety.

2000 – Up to this point, Bosch has continued to innovate new technologies that improve the driving experience and safety of all vehicles. It's no surprise that in the early 2000s they became a pioneer in the automotive driving space with the launch of a vehicle capable of automatically braking and accelerating in traffic.

2007 – Bosch introduces a new start/stop system technology that stops the engine when the vehicle is in motion so that it does not consume any fuel.

2013 – Bosch develops a motorcycle stability control (MSC) system that supports the rider during both braking and accelerating while either riding straight or cornering.

2017 – Bosch pushes out the eAxel all-in-one electrical power train. With the combination of motor, power electronics, and transmission all into one system, Bosch helps vehicles boost efficiency while reducing the costs of production.

2025 –With an expansive history of providing passionate innovation in the automotive world (fig 2.5), Bosch will continue to be a world leader in this sector. Every year the Bosch Company works hard to achieve new goals and set new standards in car manufacturing and repair.

Fig 2.6 *Example of Bosch innovation in car manufacturing*

2.4 Current Philosophy and Approach

LEAD WORK WIN “LikeABosch”. “LEAD”, “WORK”, and “WIN” succinctly summarize what Bosch now needs most to take on the challenges ahead. The company wants to become even better in a total of nine areas. Among other things, the initiative is about strengthening the diversity of talent, inspiring customers, and fostering a winning mentality. Each of these nine focus areas is crucially important for changing the Bosch culture.

“By concentrating our combined efforts on these key areas, we can take our company a huge step forward. All of us on the board of management are firmly convinced of that.”

-Bosch Chairman Stefan Hartung

“LEAD WORK WIN LikeABosch” is intended to inspire teams around the world and help them collaborate even better, and in this way to make their business activities even more successful. It’s now up to all executives and associates to breathe life into the focus topics. Robert Bosch GMBH philosophy is based on 4 main steps

Collaborative Culture: The work environment at Bosch Italy promotes a collaborative and cross-functional approach. Teams often work together across different divisions to solve complex problems. There is a focus on continuous learning and professional development through internal training programs and workshops.

Employee Development: Bosch is known for its commitment to employee growth. The Italian branch provides opportunities for career advancement, skill development, and leadership training. Employees are encouraged to contribute ideas for innovation and improvement across all divisions.

Diversity & Inclusion: Bosch Italy promotes diversity and inclusion in its workplace, fostering an environment where individuals from different backgrounds, genders, and experiences can work together harmoniously. The company values teamwork, open communication, and mutual respect.

Sustainability & Work-Life Balance: Bosch is committed to sustainability in its operations, and this extends to its workplace culture. The company provides a flexible work environment, including options for remote work in certain roles, while also emphasizing a strong commitment to work-life balance.

In summary, the Robert Bosch GmbH branch in Italy, including its Perbit division, offers a dynamic, high-tech, and collaborative workplace. The logistics division is key to ensuring efficient operations, while the SCC division focuses on optimizing supply chains. Bosch's overall operations in Italy reflect its global emphasis on innovation, sustainability, and employee development.

2.5 Bosch economical approach

The automotive sector is currently navigating a period of crisis, and Bosch has adopted a deliberate strategy to weather the storm: maintaining its leadership position, as illustrated in the revenue data presented below. (Fig 2.7)

This approach enables Bosch to preserve its influence within the industry, playing a pivotal role in market stabilization. By retaining its leadership, the company secures critical supply chains and sustains strategic partnerships, ensuring operational continuity across the sector.

This strategy has proven effective, as it fosters stability and paves the way for recovery and eventual growth. Conversely, an alternative strategy adopted by some companies involves existing their core business to explore opportunities in unrelated markets. While this diversification can offer potential growth, it carries significant risks and costs due to the need for new infrastructure, expertise, and substantial capital investment. Studies suggest that, given these factors, maintaining leadership within the existing sector, even during a crisis, is a more sustainable and profitable long-term strategy than pursuing diversification into uncertain markets.

This approach aligns with the principles outlined in Ansoff's Growth Matrix (1957), which categorizes corporate strategies into four main areas: market penetration, market development, product development, and diversification. According to Ansoff, diversification, particularly when entering unrelated markets, poses the highest level of risk due to the necessity of acquiring new capabilities and infrastructure.

As Ansoff explains, "corporate diversification requires extensive capital investment and exposes companies to uncertainties that can undermine long-term profitability" (Ansoff, 1957). In contrast, Bosch's focus on market penetration, strengthening its leadership within the existing automotive sector, demonstrates a lower-risk, sustainable approach to navigating economic turbulence.

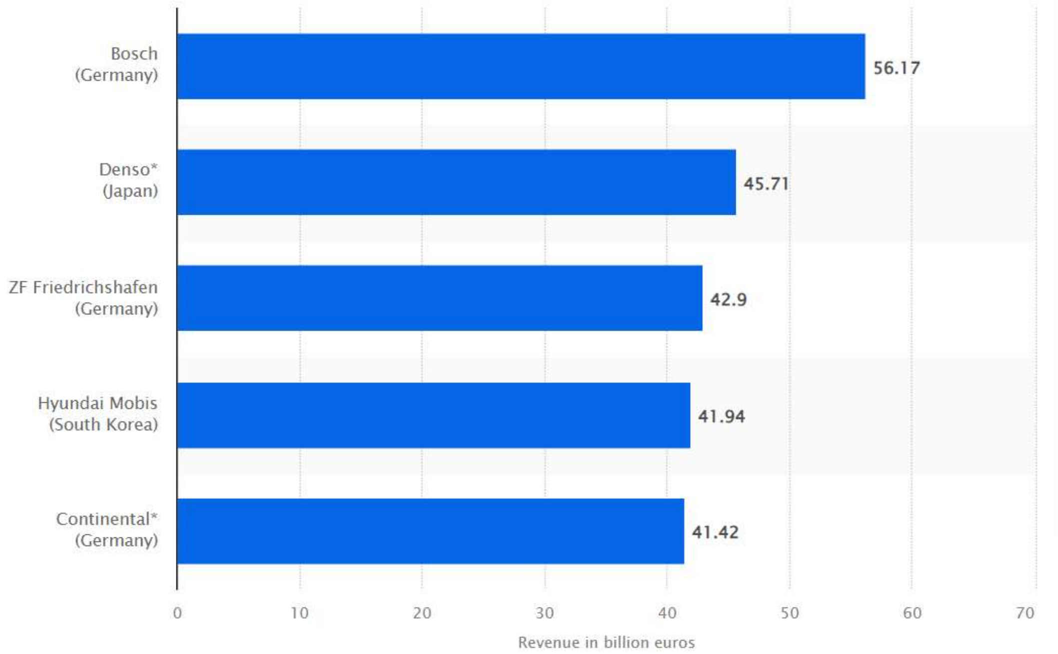

Fig. 2.7 *Principal Suppliers sorted by revenues.*

3. Automotive Sector Overview

In this chapter, the key trends in the automotive sector in 2025 will be explored to give a general overview of the situation in which this work it's been made, then the focus will shift on the challenges Bosch has to face to optimize his supply chain.

3.1. Key Trends in the Automotive Industry

In late 2024, the automotive industry was during a remarkable transformation, with data highlighting major shifts across the globe. Electric vehicles (EVs) surged in popularity, accounting for 20% of the 16 million cars sold in the U.S.(Barron's) , a dramatic rise from just 4% in 2019, with battery electric vehicles (BEVs), plug-in hybrids (PHEVs), and mild hybrids (MHEVs) leading the charge. Europe saw BEVs make up 15% of car sales, while China solidified its leadership as BEVs captured 27% of new vehicle sales. Meanwhile, traditional gasoline cars faced steep declines, particularly in China, where sales dropped by 17% to 11.6 million units, representing only 51% of new car purchases. On the global stage, China further expanded its dominance with 1.28 million "new energy vehicles" exported, marking a 6.7% (AP News)increase from the prior year. At the same time, technology companies like Foxconn made bold moves into the EV market, unveiling models like the sleek Model B EV and forging partnerships with Stellantis NV and ZF Friedrichshafen AG to stake their claim in the growing sector. The rise of EVs also began to reshape global energy dynamics, as declining oil imports in markets like China signaled a potential peak in oil demand. These trends demonstrate the industry's rapid shift toward electrification, tech integration, and sustainability, setting the stage for a cleaner, more innovative future.

3.2. Supply Chain Challenges

The automotive industry grapples with numerous supply chain challenges, exacerbated by its global scale and operational complexity. Among the most pressing issues is the dependency on international suppliers for critical components, such as semiconductors sourced from Asia and raw materials like cobalt and lithium for EV batteries. This reliance exposes companies to geopolitical risks, including trade tensions and tariffs. For example, the U.S. Inflation Reduction Act incentivizes domestic EV production, pressuring manufacturers to localize supply chains amidst evolving trade policies. Additionally, regulatory changes, such as import restrictions on Chinese technology, frequently necessitate rapid supplier adjustments, raising costs and delaying timelines.

Demand variability further complicates supply chain management. Shifts in consumer preferences toward electric vehicles (EVs) and sustainability introduce unpredictability in demand, often leading to inventory mismatches. External factors like economic slowdowns, fuel price fluctuations, and geopolitical disruptions amplify market volatility, as evidenced by the 49% surge in global EV sales in 2023, which strained battery supply chains. These dynamics are exacerbated by the bullwhip effect, where small shifts in consumer demand create significant distortions in upstream production schedules. As highlighted by Lee, Padmanabhan, and Whang (1997) in "The Bullwhip Effect in Supply Chains," small variations in consumer demand can lead to amplified fluctuations in production and inventory levels, creating inefficiencies that companies like Bosch must carefully manage.

Logistical challenges also play a critical role. Coordinating the transportation of parts across continents involves intricate planning, often derailed by port congestion, labor strikes, or adverse weather events. Rising freight costs, particularly for container shipping, continue to pressure margins, while inconsistencies in last-mile delivery impact distribution of spare parts and customer satisfaction.

Supplier management poses another hurdle, with ensuring consistent quality across a diverse network being particularly challenging when sourcing from low-cost regions. Financial instability among smaller suppliers during industry downturns further threatens supply continuity. Meanwhile, the integration of advanced technologies, such as AI, IoT, and blockchain, into legacy systems offers potential efficiency gains but remains costly and time-intensive. This digitalization also increases exposure to cybersecurity risks, with potential disruptions to operations. As Ivanov (2020) discusses in "Supply Chain Viability and the COVID-19 Pandemic: A Digital Twin Perspective," AI-driven digital twins can help companies like Bosch improve their resilience by simulating supply chain scenarios and proactively addressing potential disruptions.

Sustainability pressures are intensifying, driven by stricter environmental regulations and growing demand for ethical sourcing. Governments worldwide are imposing emissions limits and recycling requirements, complicating production and logistics. Ethical concerns around materials like cobalt, over 60% of which is sourced from the Democratic Republic of Congo under questionable mining practices, have further elevated scrutiny on supply chains.

Inventory management remains a perpetual challenge. The reliance on just-in-time (JIT) systems to minimize costs has revealed vulnerabilities, particularly during disruptions such as the global semiconductor shortage. Striking the right balance in stock levels across global warehouses is crucial but increasingly difficult amidst demand fluctuations.

Finally, workforce challenges add to the strain. The industry faces a shortage of skilled labor in critical areas such as logistics, manufacturing, and data analysis. Labor disputes and strikes, such as the 2023 United Auto Workers (UAW) strike, underscore the fragility of operations, with such events costing the industry billions in lost revenue.

In sum, the automotive sector's supply chain challenges are multifaceted, requiring strategic resilience and innovation to navigate a landscape marked by volatility, evolving regulations, and technological transformation.

4. Current Logistics Systems in the Company

In this chapter, we will describe how logistics operate within Bosch, focusing on its supply chain strategies, inventory management, and transportation systems. Bosch's logistics network is designed to ensure efficiency, flexibility, and sustainability, integrating advanced technologies and data-driven solutions to optimize the flow of goods and materials across its global operations.

4.1 Logistics secures success.

About 24,400 associates work within the Bosch logistics organization worldwide. They make sure that 250,000 customers receive on-time deliveries every single day from 225 plants (data from Bosch). These figures alone show the kinds of challenges logistics tackles in order to keep complex supply chains running and ensure smooth cooperation with suppliers and customers. But what role does digitalization play in this, and how does it help make the handling of goods even more efficient through connectivity and automation?

Fig. 4.1 *Logistics sector in Bosch.*

Supply chain excellence: stable supply chains and customer satisfaction.

These days, it has become a fixture of our working lives: the internet of things (IoT). Logistics at Bosch is no exception. And that's not all. The goal is to monitor flows of goods digitally, without any gaps, and to harness artificial intelligence (AI) to optimize processes – all in a global network that includes customers, logistics service providers (LSPs), and suppliers. Working with these partners, Bosch develops innovative logistics concepts to ensure that supply chains are competitive, reliable, and stable. The overarching aim is to respond optimally and rapidly to customers' individual wishes and requests.

4.2 Logistics Connected Supply Chain

Digitalization is an essential part of this, and the logistics of tomorrow is unthinkable without data. As a leading IoT company, Bosch is thinking in visionary terms as it looks to the future – just as the company founder would have wanted. Bosch logistics associates already use innovative technologies like AI and sensors today, integrating them into their own systems in some cases. They then gradually further develop these systems. Through it all, the focus is on making sure the entire supply chain is digitalized, from the customer to the supplier. Bosch also takes the same approach to managing production and internal transportation at its plants (fig 4.2).

ProCon is a good example. Logistics planners are constantly faced with the question of when which order should go into production. With ProCon, a software program developed specifically for this purpose, the Bosch teams have an automated tool that allows them to manage, visualize, and optimize processes. In this way, they can visualize the current production situation in real time on screens at the plant, for example.

InTrack is another example. The integrated supply chain event platform supports logistics processes and offers mobile data collection solutions. At the same time, it connects the associates working on the projects, allowing for transparency across the entire supply chain.

Availability of materials: resource conservation and global transportation strategy.

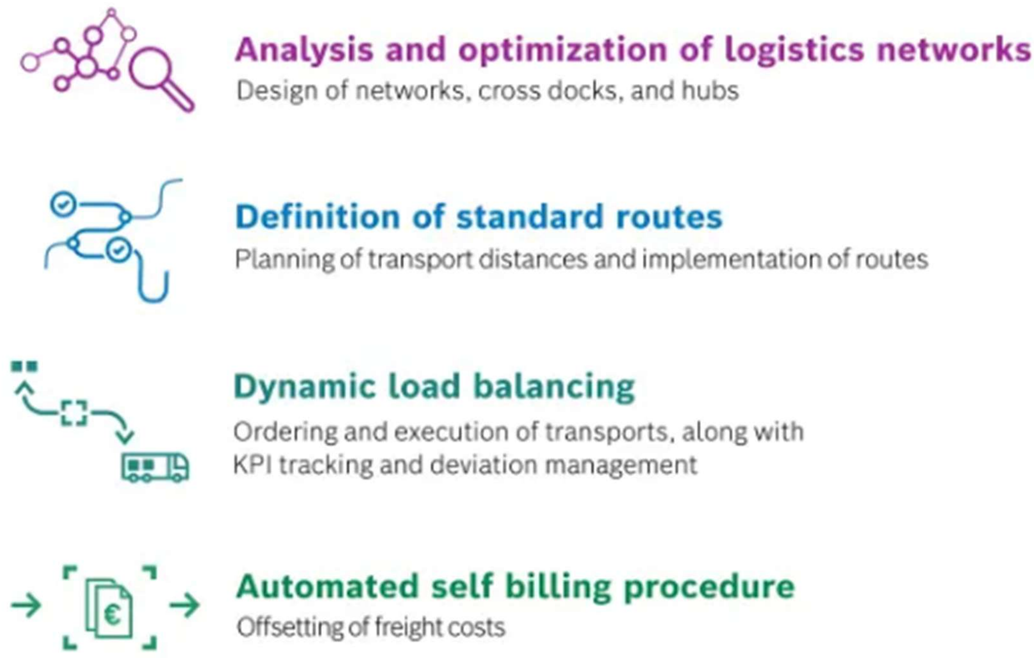

Fig. 4.2 *Key points in Bosch logistic.*

Transparency and efficiency – two keywords that are highly important in logistics at Bosch. Bosch takes customer wishes and requests into account at an early stage of its logistics concepts and considers more than just cost, time, and transportation quality indicators when working with suppliers. The logistics teams pay just as much attention to keeping CO_2 emissions as low as possible, along with the subject of resource conservation. The Transport Management Center (TMC) is responsible for the global transportation strategy. It designs transparent, efficient, and environmentally friendly transportation solutions for land, sea, air, and rail transportation to the various regions.

The Bosch logistics team incorporates this same approach to sustainability into packaging development and process standardization as well. Here too, Bosch emphasizes not just cutting costs, but also conserving raw materials and other materials. In this way, the Bosch logistics organization makes its contribution to the company's overarching goal of climate neutrality.

At the same time, every logistics concept always must stand up to one key requirement: ongoing availability of materials. Ensuring that is a crucial part of logistics at Bosch. That is why innovative Industry 4.0 technologies including RFID solutions, driverless transportation systems, and image recognition are used to ensure optimum, interconnected warehousing at all warehouse sites around the world.

4.3 Forklift warehouse logistics.

Logistics of tomorrow: innovation management and disruptive technologies.

The world is growing more and more digital. Trends like new technologies, smart cities, autonomous driving, innovative transportation and mobility concepts, and the topic of sustainability are all essential parts of the logistics of tomorrow. As a leading IoT company, Bosch is in an excellent position, having recognized the potential of Industry 4.0 early on.
That is why the Bosch logistics organization continues to focus on the digital expansion and development of the supply chain and invest in new technologies to optimize processes and worldwide connectivity on an ongoing basis. This also includes a standardized crisis management process to allow us to respond reliably – and, above all, early on – to risks as they emerge.

Targeted innovation management and trend scouting practices allow the logistics teams to evaluate and implement forward-looking topics such as real-time location of objects and augmented reality.
The requirements that apply to the logistics of the future are stringent, and continuous innovation is the driving force. That is because they are what drives the ongoing evolution and development of the supply chain. The Bosch logistics organization continues to count on associates who put their skills and expertise to work to advance further digitalization within logistics at Bosch. Their goal? Even more sustainability, efficiency, and connectivity within logistics processes – and the very same levels of quality and customer satisfaction that Bosch has always viewed as the benchmark for everything. Invented for life indeed.

5. Focus on Workspace

Robert Bosch GmbH's Italian branch (fig 5.1), specifically within the context of Perbit (a subsidiary focused on providing human resources software solutions), operates in various key areas, with a focus on logistics and multiple divisions, including SCC (Supply Chain Control) and others.

Fig 5.1 *Bosch offices in Turin*

5.1 Logistics at Bosch Italy (Perbit Division)

Warehousing & Distribution: Bosch's logistics operations in Italy are central to its broader supply chain network. The Italian branch, particularly in areas like Milan and Turin, engages in warehousing and distribution of Bosch products, including automotive components, industrial tools, and home appliances. The warehouse facilities are equipped with advanced systems for inventory management, ensuring efficient operations. Logistics teams manage inventory flow, order fulfillment, and transportation to ensure timely delivery of products.

Automation & Technology: Logistics at Bosch Italy is highly automated, leveraging advanced technologies such as robotics, automated guided vehicles (AGVs), and sophisticated warehouse management systems (WMS). These technologies streamline processes, reduce errors, and improve delivery times. The logistics team is skilled in maintaining and operating these systems, ensuring smooth and efficient operations.

Sustainability Initiatives: Bosch Italy's logistics division also emphasizes sustainability. Bosch is known for integrating eco-friendly practices, such as optimizing transportation routes to reduce fuel consumption, adopting electric vehicles for deliveries, and minimizing waste in packaging. The sustainability aspect is ingrained in the logistics operations at the Italian branch.

5.2 SCC (Supply Chain Control) Division

Role & Responsibilities: The SCC division at Bosch Italy plays a crucial role in managing the end-to-end supply chain process. This division ensures that all materials, parts, and products flow seamlessly across various stages—from procurement to manufacturing, to delivery to end customers. Supply Chain Control teams manage the coordination of suppliers, manufacturers, and customers.

Supply Chain Optimization: The SCC division focuses on optimizing supply chain efficiency by analyzing data to identify trends, bottlenecks, and potential improvements. They utilize sophisticated software tools to manage supply chain risks, reduce lead times, and optimize inventory management. By implementing lean supply chain principles, SCC teams work to eliminate waste and ensure cost-effective production and delivery processes Fig (5.1).

Fig 5.2 *Optimizing Supply chain*.

Cross-Functional Collaboration: The SCC division also works closely with other divisions such as procurement, manufacturing, and logistics to ensure smooth operations. This cross-functional collaboration ensures that the supply chain operates without disruptions and meets Bosch's stringent quality standards.

Other Divisions:

R&D and Innovation: Bosch's Italian branch is heavily involved in research and development (R&D), particularly in automotive technologies, home automation, and industrial products. R&D teams are responsible for creating innovative solutions that align with Bosch's global goals in electrification, connectivity, and sustainability. Engineers and product developers collaborate to create next-generation products and improve existing ones.

Production and Manufacturing: Bosch Italy's manufacturing facilities are highly advanced and focus on precision engineering and quality control. These plants produce a wide variety of products, from automotive components like sensors and control units to power tools and household appliances. The production lines are often automated, and workers are highly skilled in managing these processes.

Sales and Marketing: The sales and marketing division plays a key role in promoting Bosch's products across Italy and the broader European market. They work closely with retailers, distributors, and customers to understand market needs, drive sales, and maintain customer relationships. This division is deeply involved in understanding the local market dynamics and tailoring Bosch's products to meet customer demands.

5.3 Workplace Environment

Main role in SCC logistic is order management

Order management encompasses the comprehensive oversight of customer orders from placement to delivery, ensuring a seamless flow throughout the process. This involves tracking orders, coordinating with various departments, and managing fulfillment to align with customer expectations. By effectively managing orders, businesses can ensure that the correct products reach the intended customers at the right time, minimizing errors and inefficiencies while maintaining high levels of satisfaction.

The process begins with order processing, which includes verifying product availability, confirming payments, and generating order acknowledgments. A crucial element is inventory management, where businesses ensure sufficient stock to fulfill orders. When inventory falls short, the process may involve reordering, backordering, or offering alternative solutions to meet customer needs. Shipping and fulfillment follow, involving the preparation, packing, and dispatch of products, as well as selecting appropriate carriers to ensure timely delivery.

Maintaining clear and consistent communication with customers is integral throughout this process. Providing updates on order confirmation, shipping status, and tracking details reinforces trust and transparency. Additionally, the management of returns and exchanges is vital, addressing customer concerns with efficient handling of refunds or replacements when necessary.

Order management plays a pivotal role in achieving both customer satisfaction and operational efficiency. Modern businesses increasingly rely on Order Management Systems (OMS) to automate and optimize these tasks, enabling smoother operations and improved responsiveness to customer needs.

My division is set to work in an office shared with countability each of the components pursue similar task but with different customer.
in fact each of them follows and supports a specific plant or a specific customer, (Stellantis, Ferrari, Piaggio) .
Most of the order are passed by sap platform , while some of them are still manual → Iveco.

SAP (Systems, Applications, and Products in Data Processing) is a comprehensive software platform widely used for managing business processes, including logistics and order management. In logistics and order management, SAP automates the flow of goods, tracking inventory, managing orders, and ensuring efficient communication within and outside the organization. The platform plays a crucial role in optimizing processes such as order fulfillment, shipping, invoicing, and logistics tracking.

Here's a breakdown of how SAP works in logistics and order management (FIG 4.3) , including the role of EDI (Electronic Data Interchange) and the handling of delivery notes

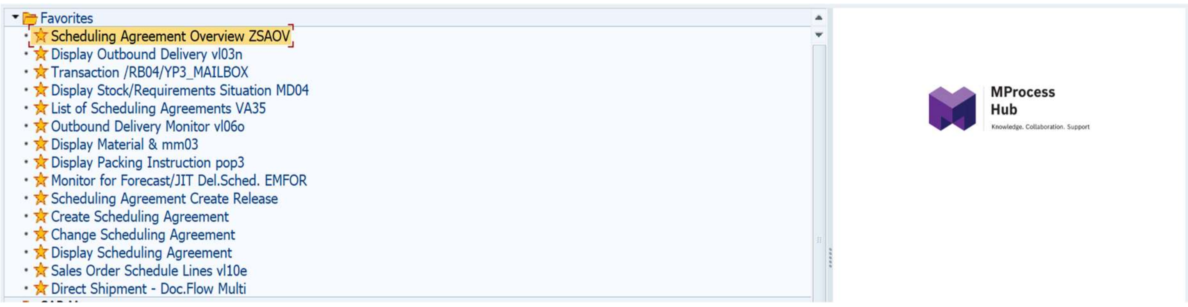

FIG 5.3 *Sap overview*.

5.4. Order Management in SAP:

Sales Order Creation: The process begins with the creation of a sales order in SAP. This is done by entering customer details (1), product (4), quantities (5), pricing (2) , and delivery information(3). The sales order is used to track customer requests and is linked to inventory management, billing, and delivery.

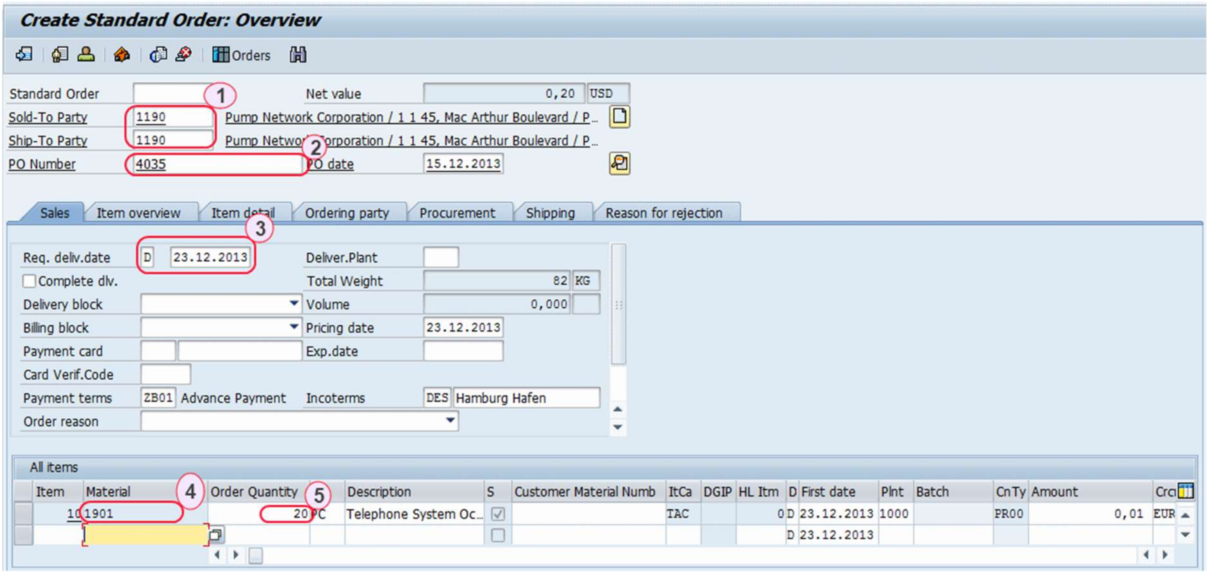

FIG 5.4 *Order creation overview.*

Order Confirmation: After the order is entered, SAP can automatically confirm the availability of the goods, check for stock levels, and confirm delivery schedules. The system ensures that the requested products are available in the required quantities.

Delivery Scheduling: Based on the availability of goods, the system schedules the delivery date and communicates it to both the logistics team and the customer. This is essential for ensuring timely order fulfillment.

2. Logistics in SAP:

Inventory Management: SAP manages the entire lifecycle of inventory, tracking the goods from raw materials to finished products. When an order is placed, SAP checks the availability of the goods in inventory. If stock is insufficient, SAP can trigger procurement requests.

Warehouse Management: SAP integrates with Warehouse Management (WM) systems to ensure that inventory is stored efficiently. When an order is ready to be fulfilled, SAP sends out instructions for picking and packing.

Goods Issue/Shipping: Once the order is packed and ready, SAP generates a Goods Issue document, marking the stock as being shipped out. This reduces inventory levels and updates the system in real time.
Transportation Management: SAP offers transportation management (TM) features that help plan, execute, and monitor transportation operations. This includes managing carriers, route optimization, and freight costing.

3. EDI (Electronic Data Interchange) in SAP:
EDI Integration: EDI is used for the electronic exchange of business documents between SAP and external systems. In the logistics and order management process, EDI allows seamless communication with suppliers, customers, and third-party service providers, reducing manual intervention and errors.
Order Processing via EDI: EDI is often used for receiving orders from customers in a standardized electronic format (fig 4.5). Once an EDI order is received, SAP processes it automatically, creating a sales order without manual entry.

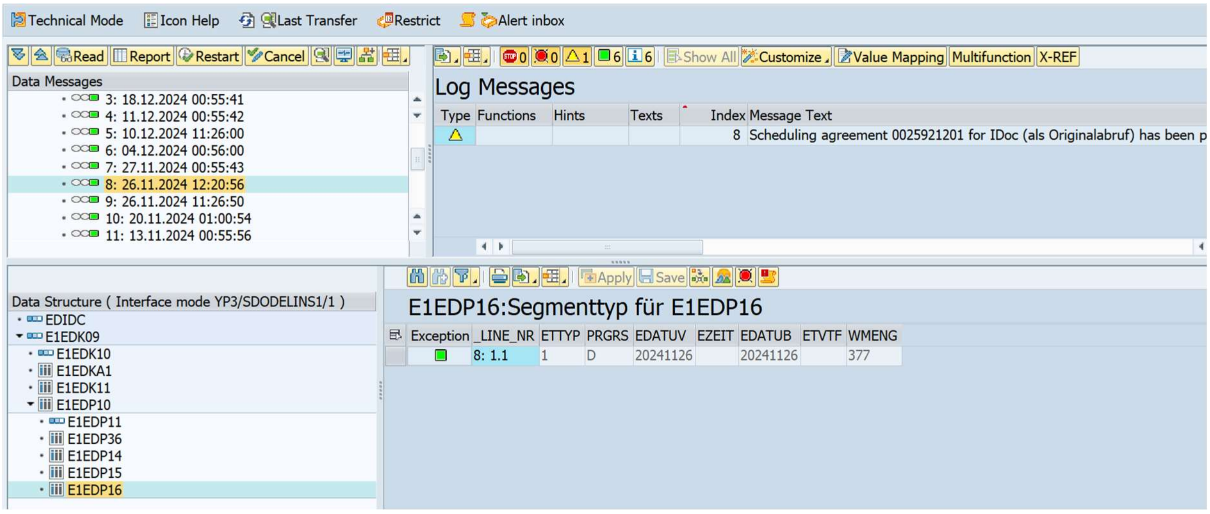

FIG 5.5 *EDI reception*.

Shipping Notifications and Invoices via EDI: After goods are shipped, SAP can send EDI messages, such as Advance Shipping Notices (ASNs), to inform customers about the shipment status. Similarly, invoices can be sent via EDI to ensure quick processing and payment.
Electronic Communication of Delivery Notes: Delivery notes are also communicated via EDI to external partners or customers, ensuring that all stakeholders are informed of the shipment and delivery status. This provides real-time updates on deliveries and reduces delays.

4. Delivery Notes in SAP:

Creating Delivery Notes: When a goods issue is made, SAP automatically generates a delivery note (FIG 4.4). This note contains details about the goods being shipped, including the quantity, product description, delivery address, and shipping method.

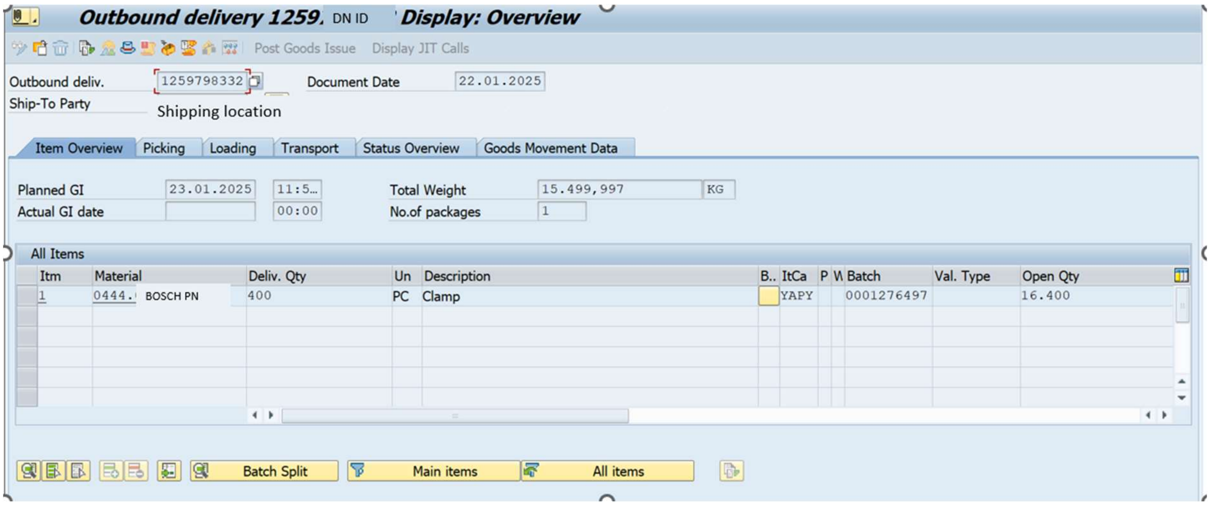

FIG 5.6 Delivery note display.

Delivery Note Printing: The delivery note can be printed for inclusion with the shipment or transmitted electronically via EDI to the customer. The delivery note serves as proof that the goods were shipped and acts as a reference document for both parties.

Linking Delivery Note to Invoice: After goods are delivered, the delivery note can be used to create an invoice. SAP links the delivery note and the sales order to the invoice, ensuring accurate billing based on what was actually delivered.

Tracking and Reconciliation: In the event of discrepancies, SAP allows for tracking delivery notes to reconcile any issues with the shipment or inventory.

5.5 Key Benefits of Using SAP for Logistics and Order Management:

SAP streamlines business operations by automating order creation, inventory checks, and delivery scheduling, significantly reducing manual effort while providing real-time updates on stock levels, order status, and deliveries to enhance decision-making. As Davenport (2000) explains in Mission Critical: Realizing the Promise of Enterprise Systems, ERP systems like SAP transform business processes by automating routine tasks, minimizing human errors, and enhancing operational efficiency. Similarly, Monk & Wagner (2012) in Concepts in Enterprise Resource Planning highlight how SAP integrates multiple functions—such as sales, inventory, shipping, and invoicing—into a seamless workflow, ensuring better coordination and visibility across the supply chain.

Its seamless communication with external partners through EDI enables the automatic exchange of orders, shipping notifications, and invoices with customers, suppliers, and third-party logistics providers. Kalakota & Whinston (1996) in Electronic Commerce: A Manager's Guide emphasizes the role of Electronic Data Interchange (EDI) in expediting business transactions, reducing the reliance on manual data entry, and improving data accuracy in supply chain operations. Additionally, van Weele (2018) in Purchasing and Supply Chain Management discusses how EDI enhances supply chain collaboration, reducing inefficiencies and delays by automating document exchanges.

By ensuring accurate inventory management, order processing, and timely deliveries, SAP improves order fulfillment efficiency and customer satisfaction while minimizing errors and paperwork through automation and EDI integration. As observed by Koch, Slater, & Baatz (1999) in SAP Nation: A Runaway Software Economy, SAP plays a crucial role in optimizing inventory control and order fulfillment by providing real-time insights into stock levels and order status. Furthermore, Turban, Pollard, & Wood (2018) in Information Technology for Management: On-Demand Strategies for Performance, Growth and Sustainability illustrate how SAP-driven automation enhances logistics efficiency, ensuring timely deliveries and reducing operational bottlenecks.

SAP provides a powerful system for managing logistics and order fulfillment processes, integrating different functions into a unified digital infrastructure. EDI plays an essential role in reducing manual data entry and improving communication efficiency, while delivery notes serve as crucial documents in tracking and confirming goods shipments, further reinforcing supply chain visibility and operational accuracy.

While EDI release is spread among logistic universe, in some cases orders are still manual. Customer sends orders through many different communication channels, mostly file by email or uploaded on specific portal.
The task in this case is translate those order in SAP language separating actual orders from forecast
The Supplier undertakes to use for any delivery, in accurate manner, the Advanced Shipping Notice (ASN) containing all the information included in the delivery note. In case Supplier should not use the ASN, the latter shall be liable for the reasonable and documented costs borne by Purchaser for the manual booking.
Supplier must submit the Pickup Notification (PUN) and if available, the confirmation Pick-Up Request via Supplier Portal (when required by Purchaser)
Supplier must submit PUN via e-mail or otherwise communicated by the Purchaser) the latest one day prior to physical shipment

6. Our Tasks

In this labor of thesis, I will provide a comprehensive account of the activities undertaken to support the enhancement and standardization of IVECO logistics and supply chain operations. The primary focus of this work revolves around addressing critical challenges associated with suboptimal delivery performance, which were primarily attributed to significant variability in demand patterns. These fluctuations manifested both in terms of unexpected surges and reductions in demand, without due consideration of critical factors such as lead times or transit times.

To mitigate these issues, the implementation of a frozen zone was needed.

This approach required extensive negotiations between the production plant and Bosch to collaboratively minimize demand variability and, consequently, improve delivery performance metrics. By establishing a more stable demand environment within the frozen zone, it became possible to improve the reliability of logistical operations.

Through detailed analysis of various clusters, we explored feasible scenarios to reducing demand variability. The findings underlined the necessity of adopting stricter measures to enforce the frozen zone, thereby facilitating a more predictable supply chain environment. These discussions served as a platform to address multiple critical points, ultimately laying the groundwork for a revised and more solid agreement between the involved parties.

In particular, the main topics were:

- Order variability and how to evaluate it;
- Delivery performance and how to be calculated;
- Moq;
- How to find the main criticalities/ where to pursue the analysis;
- Tools to monitor the situation;
- Direct line between customer and supplier.

7. Overview of the Situation

In this chapter the thesis will describe the current commercial situation between Bosch and Iveco, focusing on the reasons behind the necessity of the Logistic agreement.

7.1. Current State Analysis

IVECO goal was to simplify all the logistic tasks by implementing a new management software, to digitalize all the activities connected to the logistic, to have a better overview and aligning goals and procedures to suppliers.
Among various changes it was implemented the Moq in the ordering schedule, the format of the orders was simplified to be already translated in SAP language, in general the idea was to improve a standardize all the supply chain.
As predictable this change wasn't as easy as expected but it encountered the disposability of various suppliers due to various advantages this change led to.
This radical change picked up many topics to be discussed, from legal to economical aspect, in this thesis the focus will be pointed on logistics and supply chain aspects: order variability, moq, delivery performances.
The logistic situation between IVECO and Bosch was quite messy, as there wasn't a proper agreement or document able to clarify all the dispute causes; most of the issues regarded to whom address the extra costs, consequences of shipment delay or backlog.
Extra costs consist in special urgent freight needed in case in delay of the shipping, or in errors from the ordering parts, production backlog and so on, which missed a regulation causing Bosch to bear some costs due to Iveco mistakes.
The root causes of this misalignment were plural, and all of them had to be analyzed to find a starting point from which the new agreement would have been built.

First aspect that had been analyzed was the **order variability**.
Order variability was out of control, as no limits were set without taking into account any frozen zone.
Frozen zone is a period of time in which the plant can't modify the shipment, for example if the transport is already In transit, any variation in that period of time would lead in a

delay or in advance.
So, it wasn't rare that an order places many weeks before could undergo some changes in the requested company, and especially if this quantity increased, it became almost impossible to fulfill this request, as for insufficient stock or insufficient time to change the delivery, sometimes in fact there were changes even after the order left the warehouse.
In case of delay in the shipment there could be costly consequences, from the necessity to organize a special freight or , in extreme cases, a delay could lead to a stop in the production line , which would cost a lot of money and time to the plant.
To reduce the risk of a Plant Shutdown, there may be the necessity to organize special freight, which are used in emergency due to them being faster but more expensive.
Not being able to forecast the demand left the supply chain in a difficult position, not being able to anticipate high demand period or vice versa low demand period, so they can't organize on when to intensify or reduce production capacity.
Second aspect was the **MOQ and MSQ** : minimum order quantity and minimum shipping quantity, they represent the same concept but the first in an economic view, and in fact is stipulated in the contract by the salesmen as the purchase order is generated.
The MSQ depends more on a logistic point of view, for instance how many pieces or boxes can be moved at once in the warehouse.
This quantities should be as far as possible equal, or at least the MSQ should be multiple of the MOQ.
Where is present a misalignment between those two values, there may be a delay or a low delivery performance.
Then Bosch's delivery performances were put under analysis, especially were the root cause weren't referable to previous point, to underline Bosch mistakes too.
All these factors combined led to high costs and low delivery performances, so IVECO contacted its customer to find a solution to meet in the middle to improve the relationship between plant, customers and distributors.
Their first step was to send a proposal in which there were defined some general parameters expecting the customer to accept them as they were.
As predictable this step generated a discussion from which each customer wanted to protect their interests, and in some cases some of the proposal weren't feasible.
Focusing on Bosch side the situation revealed to be far more complex than expected.

7.2. Data Collection and Analysis

Bosch wanted to have a general overview, as long as it was asked to improve their delivery performances, it was important to know if and how that was feasible.

Above all it was important to distinguish whereas root causes of low DP depended on plant production error or backlog, or instead to be blamed on IVECO.

One of the main causes of delay, could in fact be errors in the ordering phase, for instance if the order quantity isn't scheduled based on moq or its multiples.

Another incisive factor is the excessive variability, especially if the actual order varies a lot from the original forecast within the last weeks before shipping.

Based on this possible variabilities it was needed to pursue a dive deep into orders and deliveries history in order to make clear the actual situation, and separate different cases, to find the better way to act.

Therefore Iveco created a database making list of the history of some selected PN (part-number→ code that define a specific object) from whose there were reported quantity and it was calculated the % of variation from week to week.

Those PNs were selected from different countries UE and extra UE and from different productive plants and all orders and delivery history were examined to keep track of their variability, its aim was to prove that order variability is directly proportional with delivery performances.

All the PN were aggregated in many different clusters based on plant and type of material, for example a couple of plant and material (Plant Cluj, valve) and all the respective data.

IVECO then listened BOSCH requests and provide a database with all the cluster selected and their respective information.

There were track of order history and respective delivery performances, this set of information set the base for the analysis, in case of critical factors further verification were made directly with production plants.

This analysis were combined with all the data already found on SAP database, including : order history, official MOQ, actual deliveries, this comparison set the basis for the topic to be discussed and to underline where the criticalities were focused.

7.3. Identifying Potential Solutions

At first to implement this variation it was needed to set some limits to give the same treatment to all the customers; a new set of rules shall be decided, meeting the mind of customers, supplier, and distributor.

This Supplier Logistic Agreement defines the logistic rules for the supply of Products from the Supplier referenced above to the Purchasers' plants. Suppliers comply with the provisions herein set forth when is developing, structuring, and planning supply chain solutions and is delivering Products to any Plant.

This Logistic Agreement shall enter into force from the last signature by the Parties and shall remain in force for a period of 1 year. At least 3 months prior to the expiration of the 1-year period, the Parties shall meet in good faith to re-evaluate the parameters and the main content and to decide whether to apply the same agreement or make any modification. If no agreement is reached, unless differently agreed in writing between the Parties, the Logistic Agreement will be considered automatically terminated at the expiration of the 1-year period. The Parties agree to review the Logistic Agreement at least every 12 months to re-evaluate the parameters and the main content according to a data-driven approach.

Before verbalizing the actual agreement, the parts (BOSCH and IVECO) explored many different solutions for many possible phases and different problems, but the brainwash underline the vastity of the rose of possibilities, and it would have been very costly, in terms of effort time and money, to debate on every single plant, planner or even material. Especially because it was impossible to define for each issue a precise impact on time or costs.

It became clear that the best chance to fastly improve the situation was to keep under control major causes of extra-costs or delay by selecting specific cluster, for a limited period of time , 1 year.

During this period are expected monthly meetings to analyze the situation and decide whether to intervene or have further meetings with the more critical situations.

8. Risk analysis

Before the actual start of the project, we conducted a risk analysis on the next steps, anticipating potential delays due to the variable nature of the project. To systematically assess and mitigate foreseeable risks, we utilized a risk matrix (TABLE 8.1)., a widely adopted tool in risk management frameworks such as ISO 31000. The risk matrix allowed us to classify risks based on their likelihood and impact, enabling a structured approach to prioritizing mitigation strategies. This method aligns with best practices in Enterprise Risk Management (ERM) and Failure Mode and Effects Analysis (FMEA), ensuring a proactive response to project uncertainties.

8.1. Identify Risks

Risk analysis started by identifying key threats such as delivery delays, vehicle breakdowns, supplier shortages, payment disputes, and adverse weather. Assessing these risks involves evaluating their likelihood and impact delivery delays might be frequent but manageable with moderate financial consequences, while payment disputes, though less likely, could have severe effects on cash flow. Prioritization focuses on mitigating high-probability, high-impact risks like operational inefficiencies and supply chain disruptions. Mitigation strategies include maintaining buffer stocks, digitalize tracking system for delivery visibility, defining clear SLAs, the logistic agreement.
Digitalizing management software we could also incur in risks in terms of cybersecurity or incompatibility of technological systems between partners
Implementing these strategies requires assigning responsible parties, formalizing communication protocols, and automating payment processes. Monitoring involves tracking delivery timelines, cost variations, and incident logs, with reviews and supplier audits to adapt as needed.
Strategic risk is part of high-impact risk as if there is a misalignment of strategic objectives, could lead to extremely high waste in terms of time and effort and above all of resources.

8.2. Assess Risks

We evaluated the likelihood and impact of each risk by analyzing historical data extracted from Iveco database, to estimate the frequency of delivery delays and fluctuations in logistics costs.

We Conducted qualitative assessments to estimate the potential for contract disputes and reputational harm from service failures. It wasn't feasible to quantify risks by calculating measurable impacts, as there wasn't a proven correlation between cause and effects in cases such as the financial loss incurred from order variation affecting production schedules.

Risk	Likelihood	Impact	Rating
Delivery Delays	High	Medium	High
Payment Disputes	Medium	High	Medium
Natural Disasters	Low	High	Medium
Strategic Risks	Medium	High	High
Technological Risks	Low	Medium	Medium

Table 8.1 *Risk matrix*

8.3. Evaluate and Prioritize Risks

Ranked risks by their severity to focus on those requiring immediate action. High-priority concerns included frequent delivery delays that directly affect production timelines. Contractual risks, although generally manageable, should be mitigated with clearly defined clauses addressing performance and resolution processes, all steps included in the agreement discussions.

Supply chain risks deserve proactive planning and continuous monitoring, given their potential to disrupt operations significantly.

8.4. Develop Risk Mitigation Strategies

We Created targeted strategies to address key risks. For operational risks, Iveco decided to implement a total new managerial software to improve and standardize communications between parts. To mitigate financial risks, established unambiguous payment terms in the contract.
Then addressed supply chain risks by diversifying sourcing locations and pre-approving alternative suppliers. Mitigate contractual risks by including service-level agreements (SLAs), penalties for delays, and clear dispute resolution terms.

8.5. Implement Risk Management Plan

There were proposed risk mitigation strategies by formalizing communication protocols with suppliers and logistics partners to streamline information exchange and enhance operational coordination. Dedicated personnel were assigned to monitor and report operational performance, ensuring that potential issues were promptly identified and addressed to keep track of them and to address were to intervene. Additionally, payment processes were automated to minimize the risk of financial disputes and improve overall transactional efficiency.

8.6. Monitor and Review Risks

Continuously track and assess risks to adapt strategies as needed. Use performance indicators such as on-time delivery rates, cost variations, and incident logs to evaluate effectiveness. Testing period of 1 year to analyze variations paired by regularly audit suppliers to ensure continued compliance with agreed terms and performance standards.

9. Action Pursued

Our scope was to analyze the most critical activities that may have been caused of misalignment between Bosch and Iveco, leading to orders delay or anticipation, found a way to standardize them for both side and monitor if the new set rules will be followed.
We focused on the most impacting logistic topics: order variability and MOQ.

9.1. Order variability and BOSCH DP

Order variability can be defined as the degree to which the quantity and timing of customer orders deviate from their expected or forecasted patterns over a specific period. This phenomenon typically arises due to factors such as fluctuating customer demand, market dynamics, inaccuracies in demand forecasting, or strategic ordering practices like batch ordering and order amplification. Variability in orders often propagates upstream in the supply chain, amplifying inconsistencies in production schedules, inventory levels, and capacity planning, which can lead to inefficiencies such as stockouts, overstocking, and increased operational costs. As noted by Bray and Mendelson (2015) in "Production Smoothing and the Bullwhip Effect", implementing production smoothing techniques can mitigate such inefficiencies by stabilizing order patterns and reducing excess inventory.
Managing order variability requires a combination of robust forecasting techniques, collaborative planning, and the implementation of mechanisms like frozen zones or order smoothing strategies. Cannella and Ciancimino (2010) in "On the Bullwhip Avoidance Phase: Supply Chain Collaboration and Order Smoothing" emphasize that supply chain collaboration and order smoothing policies play a crucial role in reducing demand distortions and improving overall supply chain efficiency.
In industries dealing with perishable goods, the impact of order variability can be even more pronounced. Cannella and Framinan (2016) in "Order Variability in Perishable Product Supply Chains" highlight how perishability amplifies demand fluctuations, making it essential to adopt strategies that enhance demand visibility and inventory management to prevent waste and stock imbalances
We set out to demonstrate two critical points: first, that excessive order variation was the primary root cause of Bosch's low delivery performance in specific clusters; and second,

that it is essential to establish frozen zones where orders can no longer be modified.
To support this analysis, we leveraged a database provided by Bosch. The data was clustered to offer a broader perspective, and demand variation was calculated for each part number (PN).
In addition to assessing demand variability, we measured the average delivery performance. For clarity, a 90% delivery performance indicates that 90% of ordered materials are shipped on time. This approach aimed to highlight the correlation between high demand volatility and poor delivery outcomes.
The data revealed that even during transit periods, ranging from 2 to 12 weeks depending on the cluster, Iveco frequently adjusted order quantities, either increasing or decreasing them. However, since shipments were already in route, no corrections could be made, leading to diminished delivery performance.
This analysis laid the groundwork for our presentation to Iveco. It underscored the necessity of implementing frozen zones, defining corridors with maximum permissible variations, and providing evidence to justify this critical operational shift.

9.1.1. Our solution

Our solution was to propone a correlation table in which DP and percentage variation were correlated, once proven the correlation, to propose a possible solution.
We also compared different clusters with different lead time, highlighting the transit time to underline the need of a frozen zone.
For each Cluster were used two different values Pe+ and Pe-, to describe the percentage of reduction or increase of the ordered quantity, calculated on the previous weeks.
Weeks +1,+2,+4 and +8 were considered, so if the table gave the value of 13.1% pe+ on week + 2 means that that IVECO ordered a 13.1% larger quantity of that cluster respect to the forecast order 2 weeks before.
As shown in the table below (FIG 10.1), high variability really was an issue, as we could find a variability of 10% of the quantity even during the transit time, request impossible to fulfill, proven by the low average delivery performances (DP avg).
The reason why pe+ and pe- doesn't compensate each other is because the analysis is made at a cluster level, so increases and decreases at PN level are calculated separately: if a fuel supply module made for a specific vehicle increases requested quantity, it doesn't compensate a reduction of another module made for another vehicle.

			Comparison Week									
			Executive week - 1		Executive week - 2		Executive week - 3		Executive week - 4		Executive week - 8	
LT	Transit Time	DP Avg	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-
6	2	67%	10,0%	17,2%	13,1%	22,8%	13,0%	29,5%	17,0%	30,4%	20,0%	26,7%

FIG 9.*1* *Example of order variability analysis*.

9.1.2. DATA interpretation

First proposal was to set well defined flexibility rules for all the cluster, implementing some corridors limits within the demand could vary, limits directly decided by Bosch adopting pre-set guidelines already in use with different customers.
The parts met and those terms were discussed, on its side Iveco found those limits too strict especially for specific cases, furthermore apply those changes would have been too cost extensive.
Additionally, it was not granted that all the delivery issues would be resolved by just following these rules: risk to address wrongly the resources worsening the overall situation.
Based on Iveco answer, Bosch had to try another approach focusing on the differences between cluster and among different possibilities, as evicted from the database analysis, particular cases underlined that Bosch managed to achieve an high DP even in high variability scenarios.
All the analyzed clusters were categorized into four macro-scenarios:

1. High DP, Low Variability: This represents the ideal scenario, where minimal corrections are required. It serves as a benchmark for best practices.
2. Low DP, Low Variability: This situation may indicate Bosch's direct responsibility or point to specific issues, such as plant closures or operational failures. Some clusters reported negligible or very low DP due to such disruptions.
3. High DP, High Variability: Although not optimal, this scenario demonstrates Bosch's flexibility and ability to quickly adapt to fluctuating conditions. As a result, less stringent corridor variation limits may be acceptable.
4. Low DP, High Variability: Here, variability is strongly correlated with orders issues, necessitating tighter control measures. Implementing stricter, feasible operational thresholds should be prioritized.

9.1.3. Counterproposal

Bosch counterproposal consisted in selecting clusters for each different situation, and give specific corridor limits based on the macro-scenarios they were part of ,including plant from extra UE in which variability have a bigger impact.

As anticipated for the cases in which DP was already high there were set less strict limits, but it was anyways asked to reduce this variation to permit keeping the same performances; instead clusters with high variability and low DP were put under the lens as possible critical situation, setting stricter corridors to be respected.

The corridor limits were proposed as more restrictive as the shipment week get closer (8 week before the shipment is acceptable a wider variation than two weeks before.

To the four scenarios were assigned four different level of acceptance:

Scenario	Transit	Range	Week -1	Week -2	Week -3	Week -4	Week -8
High DP Low Variability	2	Acceptable	0%	0%	3%	5%	7%
		Optimal			1,5%	3%	4%
Low DP Low Variability	2	Acceptable	0%	0%	3%	5%	7%
		Optimal			1,5%	3%	5%
High DP High Variability	2	Acceptable	0%	0%	5%	7%	10%
		Optimal			3%	5%	7%
Low DP High Variability	2	Acceptable	0%	0%	4%	6%	7%
		Optimal			3%	4,5%	6%

Table 9.1 *Level of acceptance of different scenarios.*

Values reported on Table 9.1, represent the maximum acceptable variation calculated on percentage of total quantity and the corridor is the same in case of increase or decrease. The real target is to keep the variation within optimal level (ex. within 1.5% in the first scenario) to grant the highest feasible DP; in exchange Bosch was asked to higher their performances to keep an high level even where the values were already acceptable, different scenarios requested different values of DP, in general guidelines were to keep it between 85% and 100%.

Bosch target is to keep they DP above or at the requested target, as performances near

100% are too cost extensive, especially if not necessary.

Value shown in table are an example on a restricted case, different locations have different LT, Sorocaba plant in Brazil have a transit time of 12 weeks, this means that the frozen zone lasts 12 weeks during which quantity variation must be 0 ; from week 13 must follow the above flexibility rules.
In the figure below (fig 9.2) is represented a formal proposal on a specific cluster, in this case if IVECO keep their variability between +3% and -3% during the week before the transit time BOSCH promises a DP of at least 90%.

			Comparison Week									
			Executive week - 1		Executive week - 2		Executive week - 3		Executive week - 4		Executive week - 8	
LT	Transit Ti	DP Avg	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-	Pe+	Pe-
6	2	90%	0%	0%	0%	0%	3%	3%	5%	5%	7%	7%

FIG 9.2 *Example of BOSCH proposal.*

9.1.4 Integration of Flexibility Rules in the Logistic Agreement

Bosch submitted its proposal by incorporating specific flexibility rules into the logistic agreement. A critical milestone in this process was a subsequent meeting with Iveco, aimed at identifying the most appropriate set of rules that could effectively accommodate the interests of both parties.

The proposed flexibility rules were generally accepted in those clusters where Iveco's ordering behavior had directly contributed to low delivery performance from Bosch, thereby adversely affecting Iveco's own operational efficiency. However, in exchange for agreement with these regulations, Bosch was expected to enhance its capability to meet Iveco's requirements more consistently.

On the other hand, in clusters where Iveco's ordering behavior already aligned or was close to the proposed thresholds, the agreement stipulated that Bosch should achieve a 100% delivery performance. In return, Iveco would agree to further tighten the permissible variations in demand, ensuring greater stability in order patterns.

Prior to finalizing the implementation of these new regulations, a thorough feasibility assessment was conducted in collaboration with Bosch's production planners directly involved in the testing phase. The initial step involved verifying with the plant whether Iveco's requirements were both technically feasible and implementable within a short-term horizon.

To facilitate this assessment, Bosch provided the production team with a detailed list of all part numbers (PNs) under their responsibility that were subject to the testing phase, alongside the corresponding proposed demand variations and required delivery performance levels.

Following this evaluation, all relevant stakeholders expressed a positive response to the proposed ordering policy. They recognized its potential benefits, particularly in terms of improving production planning efficiency by enabling more accurate demand forecasting, largely due to the reduced variability in order fluctuations.

With all parties aligned on this matter, the pilot phase was officially scheduled to commence in January 2025. However, several open discussions remained, particularly concerning the definition of minimum order quantities (MOQ) and the attribution of additional costs arising from these changes.

9.2 Tower TOOL

The selected cluster and their respective corridor limits are being tested, for the period of at least 1 year during which regular meeting are kept to update on critical situation and if the overall supply chain efficiency has been enhanced.
During those meeting based on collected data, Bosch and Iveco performances are evaluated, crucial is to verify whether orders and deliveries respected the target proposed, here comes in hand the creation of a new analytic tool projected by Iveco: The Towertool.
The Tower tool has two main duties, first is to keep track of all orders and deliveries of the selected clusters and in second place to evaluate Iveco and Bosch performances.
It was created due to the necessity to have a common tool able to support the testing period, giving frequent feedbacks on critical situation or actual improvements.
During the testing period is important to monitor all the cluster to register possible trends, as a net improvement of delivery performances due to the flexibility rules being applicated or to notice emerging criticalities and detect them in time to mitigate them.
In case of criticalities, after multiples dialogues, production plant have given the disposability to have open talks on specific clusters problems, on which we may have a direct confrontation with planners to have the possibility to intervene.

9.2.1 How does it works ?

The Tower tool is an online dashboard, developed by Iveco to actively support the agreement testing phase, it has a main role in the analysis of KPIs for both IVG (Iveco group) and Bosch, giving real-time updates on both side performances and creating a database for further analysis.
The tool collects week by week data from the cluster formed by selected PN, data directly collected by Iveco
Highlight its key features such as real-time updates, interactive dashboards, and export options.

9.2.2 User interface

The user interface is almost immediate as the user have the possibility to have access to all the crucial information, and also be able to filter them as needed.
The data research can be filtered by period of time there is a time bar to be dragged in order to reduce the time span, the user can filter by week or period of weeks, for instance in the first kick-off meeting we filtered the data coming from week 1 and 2 of 2025 to analyze if the new rules are already being respected.
The research could be further filtered by cluster and production plant, during the last meetings emerged that a further filter on a PN level would be needed as it would give specific information on a specific case, as the cluster even filtered on production plant may contain many different PNs.
All the filtered data are represented on two different graph, a scatterplot graph in which are represented Bosch and Iveco combined performances and another graph in which the performances are distributed by week.

9.2.3 Data calculation

How Iveco and bosch performances are calculated?

Both parties' behavior is evaluated by a rating called respectively called customer rating and supplier rating.
This rating values varies between -1 and 1 and follow the same logic, using different KPIs as benchmarks, but they both have different sensibilities below and above the value 0, which in this case is intended as the target as every cluster have different target in terms of both order variability and delivery performances.

9.2.4 BOSCH KPI

Being more specific on the calculation method Bosch behavior is evaluated based on its delivery performances.

Delivery Performance is a key performance indicator (KPI) that measures a company's ability to fulfill orders on time and in full according to customer expectations.

$$Delivery\ Performance\ (\%) = \frac{Total\ Delivered\ Quantity}{Cumulative\ Residual\ Demand} \times 100$$

The delivery performance (DP) percentage is calculated on a weekly basis using the cumulative demand of the designated cluster. The inclusion of the term "residual" accounts for any discrepancies arising from early or delayed deliveries.

For clarity, consider the following scenario: If Iveco places an order for 67 oxygen sensors, and the minimum order quantity (MOQ) set by Bosch is 90 units, Bosch will fulfill the order by delivering 90 units, resulting in an advance of 23 units. In the subsequent week, if Iveco orders 113 units, the residual demand for the previous advance will be adjusted to 90 units. Bosch will then deliver the full 90 units, achieving a delivery performance of 100%.

Conversely, if there had been a previous shortfall of 23 units instead of an advance, and Iveco place an order for 90 units, delivering the full 90 units would yield a delivery performance of approximately 80%, as the backlog is factored into the calculation.

Once the delivery performance (DP) was calculated, it was essential to translate it into a universal rating system that allowed for comparisons across different clusters with varying performance targets. To achieve this, the assessment framework was designed to evaluate the ability to meet the predefined target, assigning a value between -1 and 1, where 0 represents the target.

For instance, if the performance target is set at a DP of 90%, any value exceeding this threshold results in a positive rating, while values below it corresponds to a negative rating. However, the system incorporates varying sensitivity levels depending on whether performance is above or below the target. Specifically, a 1% deviation below 90% has a different impact on the rating compared to a 1% deviation above the target, ensuring a more nuanced assessment of performance fluctuations.

9.2.5 Iveco Key Performance Indicator (KPI): Demand Variability

In contrast, Iveco's key performance indicator (KPI) is based on demand variability, which measures fluctuations in demand for a given week over time. Demand variability is defined as the extent to which the requested quantity for a specific week change as the execution date approaches.

For example, assume that in Week 2 of 2025, Iveco forecasts a demand of 100 units for Week 10. By Week 4, this forecast is revised to 120 units, representing a 20% increase. Such a variation poses significant challenges for the production plant, particularly during high-demand periods or supply shortages, as the facility may not be prepared to accommodate the revised quantity.

To address this, once the target and flexibility rules are established, Iveco's customer rating system evaluates the ability to maintain demand stability within predefined corridor limits. Similar to Bosch's supplier rating, this value ranges from -1 to 1, where 0 represents alignment with the target.

A key distinction, however, is that demand variation is calculated based on forecasts in the weeks leading up to the execution date. Specifically, it measures how the demand forecast for a given week (e.g., Week 5) changes over previous weeks (e.g., Weeks 4, 3, etc.).

Since last-minute fluctuations have a greater operational impact, demand variations closer to the execution week are weighted more heavily in the rating calculation.

For clarification, consider the case of the Curitiba Plant cluster. If its demand variation remains within the flexibility rules, staying within a 5% deviation in Week -4 and a 3% deviation in Week -3 but experiences significant fluctuations in Week -2, the overall rating will still be negatively impacted. This weighting system reflects the increased difficulty of adjusting production schedules closer to the execution date, ensuring that the KPI accurately captures the challenges associated with demand volatility.

Data analysis

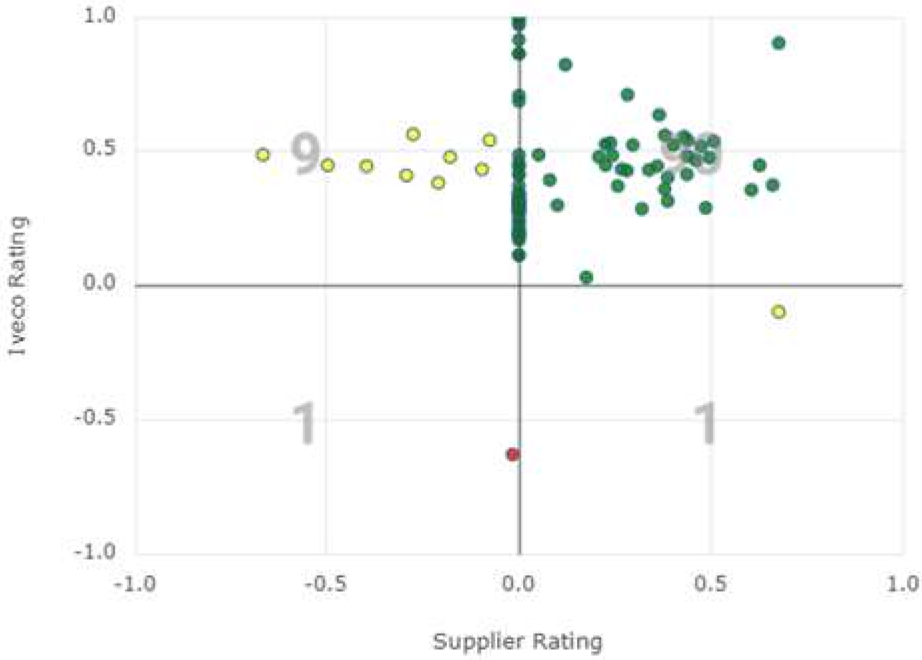

Fig. 9.3 *Data Visualization and Performance Analysis*

Once the data is collected, it is visualized using the scatter plot above (fig 9.3), where each cluster is represented by a combination of customer and supplier ratings. The x-axis represents Bosch's supplier rating, while the y-axis represents Iveco's customer rating. Both axes range from -1 to 1, with the optimal scenario positioned in the top-right quadrant, where both indicators are positive. The results are categorized into four distinct scenarios:

1. Top-Right Quadrant: Both Iveco and Bosch Are on Target

This represents the ideal scenario, where both Bosch and Iveco successfully meet their respective targets. However, it is crucial for Bosch to recognize that the optimal rating is not necessarily at the upper limit (near 1) but rather close to the target (0). Overperforming in terms of delivery performance (DP) may lead to excessive costs for Bosch while providing no additional value within the framework of the supply agreement.

2. Top-Left Quadrant: Iveco on Target, Bosch Not

This scenario is the least favorable for Bosch, as it indicates that delivery delays are primarily attributed to Bosch's backlog or inability to meet demand. During the first review meeting after the start of the testing phase, specific cases within this quadrant were analyzed. The findings revealed that the majority of these issues were caused by minimum order quantity (MOQ) constraints or plant shutdowns in the initial weeks of 2025.

3. Bottom-Right Quadrant: Bosch on Target, Iveco Not

In this case, Bosch successfully aligns with demand fluctuations, but the situation may be misleading. This alignment could result from excessive residual stock or a temporary decline in demand rather than an effective supply chain strategy. Such conditions may lead to inventory imbalances, causing excess stock or supply shortages during periods of high demand.

4. Bottom-Left Quadrant: Neither Iveco nor Bosch Are on Target

This scenario represents the core focus of the testing phase: demonstrating that high demand variability directly impacts delivery performance. In this case, additional costs arising from shipping delays can be clearly attributed. If the situation becomes critical, requiring special freight shipments, the financial responsibility falls on Iveco, as the demand volatility has exceeded the agreed-upon flexibility limits.

9.2.6 CONCLUSIONS

On Bosch side is has been developed a parallel tool called the Mofa tool, which gives an overview of ordering behavior using Bosch data extracted from Sap platform.

The Bosch Mofa Tool, used alongside the Iveco Tower, enables a detailed analysis at the Part Number (PN) level within specific Scheduling Agreements. This tool provides a comprehensive overview of all requests and orders executed for a given material.

Having a Bosch counterpart is essential for cross-referencing results and obtaining a holistic view at both the cluster and PN levels. By comparing outputs from both tools, it is possible to engage in data-driven discussions with production plants, cross-validating results with SAP data. This approach enhances visibility into required improvements and identifies plants or specific PNs that demand further attention.

A critical approach to data interpretation is necessary. During the initial data analysis, clusters that received a rating of -1 on the Bosch side were filtered for further examination.

A deep-dive analysis, conducted in collaboration with Iveco and the plants, revealed key misalignments. In most cases, discrepancies arose because Iveco failed to order the Minimum Order Quantity (MOQ), resulting in inconsistencies in shipment planning.

Additionally, one specific PN exhibited a production shortfall due to an inability to meet high demand.

After direct engagement with the plant, an agreement was reached to temporarily increase production capacity, thereby mitigating delays.

In conclusion, these two tools will play a fundamental role in refining scheduling agreements, particularly in managing order variability. Moreover, delivery performance metrics derived from this analysis will facilitate the identification of further issues, with a primary focus on resolving the ongoing challenge of MOQ misalignment.

9.3 MOQ and MSQ

In the context of Scheduling Agreements, the Minimum Order Quantity (MOQ) represents the smallest quantity of a material that must be ordered in a single transaction to comply with supplier requirements. MOQ is a fundamental parameter in supply chain management, ensuring production efficiency, cost-effectiveness, and optimized logistics by reducing setup times and minimizing order fragmentation.

From a theoretical perspective, the MOQ is closely related to the Economic Order Quantity (EOQ) Model, a key concept in inventory management developed by Ford W. Harris (1913). The EOQ model determines the optimal order quantity that minimizes the total cost of inventory, balancing order costs and holding costs. However, supplier-imposed MOQs can affect this equilibrium by forcing companies to purchase in larger quantities than their EOQ, potentially increasing inventory holding costs. Understanding and aligning MOQ with EOQ principles can help organizations enhance supply chain efficiency while mitigating unnecessary expenses.

Incorporating these principles into scheduling agreements allows companies to better manage procurement strategies, ensuring a balance between supplier constraints and internal operational efficiencies.

Failure to adhere to MOQ requirements can result in significant misalignments between planned and actual shipments, leading to inefficiencies across the supply chain. This issue became evident in the analysis, where nearly 50% of the Part Numbers (PNs)—from a representative sample of over 400—showed discrepancies between the predefined MOQ and the quantity ordered.

9.3.1 Importance of MOQ in Order Planning and Scheduling

MOQ is not an arbitrary value; it is determined during the contractual agreement phase between the supplier and the customer. In addition to defining product pricing, both parties negotiate and formalize the MOQ to establish a consistent ordering pattern. Once agreed upon, orders should always match the MOQ or its multiples to prevent logistical disruptions.

The MOQ is often closely related to packaging and transportation logistics:

- When multiple boxes are stacked to form a pallet (fig 9.3), MOQ may correspond to the quantity contained in a single box.
- In cases where individual boxes cannot be separated, the MOQ is defined at the pallet level, meaning orders must be placed in full pallets rather than individual units.

Failure to comply with MOQ can cause operational bottlenecks, both for suppliers, who need to adjust production and inventory levels, and for customers, who may face inconsistent deliveries.

FIG 9.3 *Pallet splitable in boxes.*

9.3.2 Analysis of Ordering Quantities vs. MOQ Compliance

To assess the impact of MOQ deviations, a detailed analysis was conducted by comparing order quantities against their respective MOQ values. The objective was to identify misalignments that could cause shipping delays, increase inventory costs, or result in operational inefficiencies.

Case Example:

If the agreed MOQ is 50 pieces but a customer places an order for 51, the supplier must choose between two possible actions, depending on stock availability:

- Ship only the MOQ quantity (50), leaving a backlog of 1 piece. This backlog would create a discrepancy between requested and delivered quantities, negatively impacting delivery performance, and potentially delaying the fulfillment of subsequent orders.
- Ship the next MOQ multiple (100) if stock levels allow. While this prevents backlogs, it may result in overstocking at the customer's end. This excess inventory could create logistical challenges, especially if storage space is limited or if future orders continue to disregard MOQ, leading to cumulative inventory imbalances.

Alternatively, some suppliers allow for more flexible MOQ structures when packaging permits. For example, if a pallet of 50 can be subdivided into 5 boxes of 10, customers might be permitted to order in increments of 10, providing more flexibility in demand planning.

9.3.3 Findings and Categorization of Ordering Patterns

The analysis revealed frequent inconsistencies between ordering patterns and MOQ adherence. From the 400+ PNs analyzed, four primary order-shipment behaviors were identified:

- Random order quantities, MOQ-based shipments – Orders were placed inconsistently, but suppliers still followed MOQ guidelines during shipment.
- Random order quantities, random shipments – The most critical case, where neither ordering nor shipping followed a structured MOQ system, leading to significant inefficiencies.
- Orders placed in box multiples, shipped accordingly – A structured approach where orders and shipments were aligned with predefined box quantities.
- Orders placed in pallet multiples, shipped accordingly – The most efficient scenario, where both orders and shipments followed full pallet MOQ guidelines.

In the first scenario as already anticipated this situation can lead to a misalignment between request quantity and shipped quantity, making up situation of delay or advance.
This may have two main issues: in case of excessive shipping Iveco as a customer may have issues in excessive stock and menace not to pay the good in excess or to send it back. Furthermore those misalignment lead to a negative rating on the Iveco Tower tool, in this case Iveco proposed to extract them from the rating calculation, as misleading because, the responsibility is on Iveco side.
We’ve worked with Iveco to set on their software Bosch moq but their software are set on msq, which works differently: as long as the request is lower that their msq, let’s use 30 as example, for instance 25 pcs the software will automatically order 25pcs, if the demand is higher than the msq the order will shift directly to the next multiple of the msq, if the demand is 31 it will order a quantity equal to 60.
For the second and most problematic case, direct intervention was necessary. Meetings were conducted with the responsible teams to adjust ordering patterns where possible, ensuring better alignment with MOQ requirements. However, for PNs where immediate intervention was deemed too time-consuming or cost-prohibitive, a monitoring approach

was implemented. These PNs were placed under observation to evaluate whether their MOQ deviations led to measurable delays or additional costs. Only in cases where a significant negative impact was detected were corrective actions taken.
One of main reason behind Iveco ordering behavior is their It system: their ordering quantities are set based on their minimum shipping quantity (MSQ).

Distinguishing MOQ from MSQ (Minimum Shipping Quantity)

MSQ (Minimum Shipping Quantity), on the other hand, refers to the smallest quantity that can be shipped at one time. It is dictated by plant capacity, transportation constraints, or handling efficiency.
MOQ (Minimum Order Quantity) refers to the smallest quantity a supplier is willing to sell in a single order. It is determined primarily by economic agreements, ensuring that production and distribution costs are justified while providing cost benefits to buyers who purchase in bulk.
Although MOQ is financially driven and MSQ is logistically driven, these two parameters are interdependent. The shipped package must align with the customer's handling and operational capabilities. Ensuring compatibility between MOQ and MSQ is crucial for a streamlined supply chain, as discrepancies between the two can lead to unnecessary stock accumulation, increased handling costs, or order fragmentation.
During the selected part number (P/N) analysis, we identified that the primary cause of order malfunctions was the misalignment between two key variables: Minimum Shipment Quantity (MSQ) and Minimum Order Quantity (MOQ).
Iveco plants provided a database containing the MSQs associated with the selected P/Ns. We then cross-referenced these values with the corresponding MOQs listed in our internal pricing database. The analysis revealed that 80% of the nearly 200 P/Ns exhibiting discrepancies with the MOQ had a non-matching MSQ.
This misalignment is a critical factor contributing to inefficiencies in order processing, material flow, and overall supply chain performance.

9.3.4 Conclusion and Strategic Implications

The findings of this study underscore that MOQ misalignment remains a structural inefficiency impacting supply chain operations, order fulfillment accuracy, and delivery reliability.
While MOQ enforcement is intended to enhance logistical efficiency and cost optimization, deviations from these predefined ordering parameters introduce operational disruptions across the supply network.
To mitigate these inefficiencies, a strict adherence to MOQ policies should be reinforced, particularly in scenarios where non-compliance has already resulted in quantifiable delays or cost overruns. Furthermore, a detailed reassessment of MSQ constraints is necessary to ensure that the MOQ values defined in contractual agreements are aligned with actual shipping and handling capabilities.
From a strategic perspective, resolving these misalignments is expected to:

- Improve order accuracy and shipment predictability.
- Reduce unnecessary inventory accumulation or shortages.
- Strengthen collaboration between suppliers and customers, driving greater supply chain stability.

Ongoing discussions between Iveco and Bosch aim to address these discrepancies and implement corrective measures to minimize shipment-related issues. One potential solution under consideration is the deployment of SAP systems across all Iveco plants. Preliminary data indicate that plants already utilizing SAP experience negligible MOQ-related issues due to automated compliance with ordering parameters.
However, a full-scale SAP implementation across all locations is currently not economically viable, as it would require a substantial investment and an estimated 3-to-5-year deployment timeline.
The root cause of MOQ and MSQ misalignment can be traced back to Iveco's ordering system logic. Specifically, when demand falls below the predefined MSQ, the system doesn't automatically trigger an order for the full MSQ value, even when it significantly deviates from the MOQ. Only if the requested quantity exceeds the MSQ the system will place an order following the next minimum multiple of the set quantity.

This systemic issue leads to unnecessary order inflations, inefficient stock levels, and operational bottlenecks.

An alternative short-term mitigation strategy under discussion is allowing lower MOQs, in exchange for adjusted pricing structures to offset the associated cost inefficiencies.

In summary, while systemic improvements such as SAP standardization offer long-term benefits, immediate process enhancements—such as policy enforcement and system logic refinement—are necessary to ensure greater alignment between MOQ and MSQ, ultimately enhancing supply chain efficiency and operational resilience.

10. Agreement

The official launch of the one-year test period has commenced, with monthly meetings scheduled to address outstanding issues and monitor critical situations.

The initial step involved informing all Bosch plants about the initiative, which was positively received as an effort to enhance overall operational efficiency. A general meeting was held to systematically update planners on the new procedures. One of the primary requests from the plants was to gain direct visibility into the monitoring tool for assessing their own performance metrics.

Additionally, Bosch plants were briefed on the ordering regulations that Iveco is required to adhere to, along with the expected delivery performance standards. By maintaining oversight of potential order variations and Minimum Order Quantity (MOQ) misalignments, it becomes more feasible to accurately attribute responsibility in cases where additional costs arise, as the entire supply chain flow is continuously monitored.

Leveraging this data, an extra-cost tracking file was developed, explicitly defining cost attributions to Iveco when the responsibility is proven on his side.

In parallel, legal implications and contractual frameworks are being defined; however, the primary focus remains on logistics considerations. For the first time, a set of standardized operating guidelines has been formally documented to ensure the feasibility of the agreement while preventing unforeseen cost implications.

As previously outlined, the fundamental principle of the agreement stipulates that Iveco must comply with predefined flexibility rules, whereas Bosch is responsible for guaranteeing the agreed Delivery performances (DP). Any deviations from these established limits will result in cost responsibility being allocated accordingly.

Furthermore, standardized ordering rules have been introduced for all existing order management methods. Some of these methods remain subject to ongoing legal discussions and are therefore classified. In general, order methodologies have been comprehensively defined. For instance, in the case of Advance Shipping Notices (ASN), the specific data elements required, as well as the permissible order placement timeframes, have been explicitly detailed.

The manual order process has also been restructured to follow a strictly defined

procedure, eliminating ambiguities and potential sources of misinterpretation.
All previously unclear areas that allowed for discrepancies or misunderstandings have been formally clarified.
Both companies have contractually committed to adhering to the newly established framework throughout the test period. Monthly meetings will serve to assess deviations from the agreed guidelines, with a review scheduled at the end of the one-year period to address any significant challenges encountered and to determine potential adjustments or expansions to the agreement.
Additionally, the test phase may reveal fundamental incompatibilities between the two companies' operational structures, wherein the associated costs of reconciliation may be deemed excessive. In such a scenario, the parties may ultimately decide to stop the discussion about an eventual agreement.

11. Future Application & Roadmap

The Logistic agreement has just started the testing phase, this make him just in the embryonal phase of the project, due to that future step are already planned, but due to the variable nature of the project it’s difficult to collocate them on a specific timeline, here’s a breakdown of the future objectives and roadmap (fig 11.1)

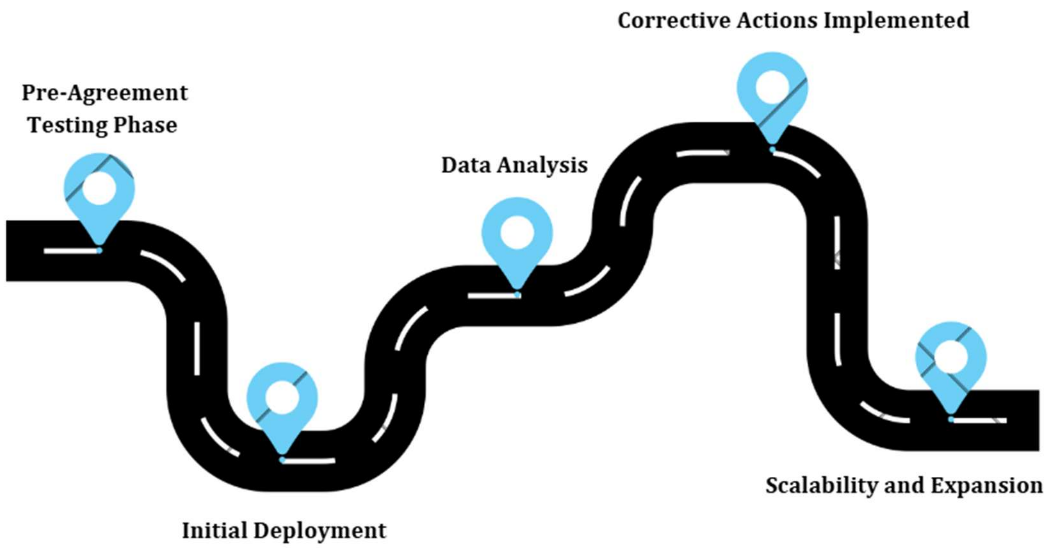

Fig 11.1 *Roadmap for Implementation*

11.1 Testing phase

The initial step in the roadmap is the pre-agreement testing phase, which serves as the primary focus of this thesis. This phase provides the foundation for the subsequent one-year testing period, during which newly established rules are implemented and evaluated. During this stage, all contractual terms are thoroughly discussed and refined to ensure alignment with both parties' requirements. The primary objective is to mitigate potential risks that could hinder the agreement's development, identify key discussion points, and clearly define the Key Performance Indicators (KPIs) to be assessed during the testing period.

Focusing on the logistics agreement case, this phase involved analyzing Iveco's ordering behavior and identifying feasible supply chain corridors, along with the applicable regulatory framework.

11.2. Initial Deployment

On January 15, 2025, the Iveco plant began operating under the new flexibility rules.
As anticipated, the transition experienced a slow start due to the significant procedural changes.
However, a key improvement was the enhanced traceability of both companies' behaviors and a more structured allocation of costs and responsibilities.
With defined operational rules in place, it became easier to assess compliance by Bosch and Iveco.
Rather than mitigating disputes, the increased transparency initially led to further challenges, as some plants hesitated to accept certain financial obligations, to address these issues, focused meetings were conducted to manage critical situations, fostering high levels of collaboration between the parties. As a result, Bosch and Iveco began working together to resolve disputes more effectively.

During this phase, corridor limits were tested within the pre-selected clusters, and data was collected in parallel from both the Mofa tool and the Iveco Tower tool. The objective was to align both companies' perspectives and ensure adherence to the established rules. It was essential to verify the feasibility of implementing the new changes and evaluate whether they delivered tangible improvements in operational efficiency and cost savings. A failure in IT systems alignment posed a significant risk, potentially leading to the collapse of the entire agreement.

11.3. Data-Driven Insights from the Testing Phase

At the start of the testing period, the primary focus for both companies were the implementation of the new data analysis tools: the Mofa tool and the Iveco Tower tool.
During the initial review following the kick-off, the analysis focused on cases flagged as critical by Iveco. Specifically, the investigation began with clusters where Bosch had the lowest performance ratings to identify the underlying causes.
A low Bosch rating indicated poor delivery performance, with a score of -1 representing instances where no deliveries were made despite a demand greater than zero.
Fortunately, only a limited number of part numbers (PNs) exhibited such low ratings—approximately ten cases—of which only one was attributed to Bosch's failure.
Further analysis revealed an issue with the rating algorithm. In nine out of ten cases, Bosch was not actually late but had instead delivered ahead of schedule. This advance fulfilment resulted in no subsequent deliveries, inadvertently triggering a -1 rating.
A specific example illustrates this issue: if a customer orders 20 units of a material with a Minimum Order Quantity (MOQ) of 50, Bosch would ship 50 units. If the next demand falls below 30 units, the previous surplus will cover the requirement, eliminating the need for a new delivery.
To prevent these inaccuracies from skewing the data analysis, such cases were excluded while adjustments were made to the algorithm.
Aside from these exceptions, the misalignment of MOQ emerged as the most significant issue once stable ordering and delivery patterns were established.

11.4. Corrective Actions

To address the critical bottlenecks, it was imperative to implement corrective actions aimed at mitigating the widespread MOQ misalignment. These actions followed two key approaches:

1. Bosch's Operational Adjustments: Bosch plants were instructed to adhere strictly to MOQ requirements without deviations. Additionally, production planning was reinforced to ensure sufficient stock availability, maintaining deliveries at MOQ levels.

2. Collaboration with Iveco: Finding a cost-effective compromise with Iveco was essential.

To facilitate this, a smaller subset of selected PNs was analyzed, and original packaging sheets were collected from plant planners. This process generated a comprehensive database, detailing MOQ specifications along with precise measurements (length, width, height), weight, and packaging units.
Starting from this small cluster Iveco and Bosch are trying to align on the moqs for checking if the criticalities on those PNs are going to reduce, and at the same time if this alignment action is cost-efficient.
Whether the result are positive and the cluster analysis come through the plan is to expand the aligned database in the situation in which the misalignment has a proven huge impact on performances and costs, the plan is within 3 years time to have a total alignment on all the PNs.

11.5. Future Applications and Strategic Opportunities

If the one-year testing period proves successful and the collected data is effectively utilized to mitigate ongoing process inefficiencies, the agreement could serve as a turning point from the start of 2026.

A well-structured logistics framework would free up significant resources—both financial and human—leading to enhanced operational efficiency for both Iveco and Bosch. Moreover, Bosch's improved reliability could increase its attractiveness to potential customers.

From an operational standpoint, if the newly implemented rules demonstrate effectiveness, the scope of the agreement could be expanded by incorporating additional PNs and plants. This would further reduce costs and time-intensive activities, such as claims management.

Furthermore, the establishment of a historical database and case studies from this initiative would provide valuable reference points for future projects.

By demonstrating tangible cost savings, Bosch could extend similar proposals to other partners, reallocating freed-up resources towards innovative systems and enhanced IT connectivity.

This roadmap ensures that the agreement leads to a sustainable and scalable logistics framework, leveraging insights gained during the testing phase to drive future innovation and operational excellence.

12. Conclusions

In the conclusion of this thesis, we summarize the key findings, highlighting the significant insights gained throughout the research. The study provides a comprehensive analysis of the activities pursued to support Iveco supply chain standardisation.
However, it is important to acknowledge the limitations of the study, such as the limited duration in face of the high time-consuming activities, which may have impacted the scope of the results. Finally, the thesis suggests potential areas for future research, including AI tool implementation, which could further expand the understanding of this field.

12.1 Summary of Key Findings

During my internship in logistics sector of Robert Bosch Gmbh branch in Italy, I had the possibility to support an important topic as The logistic agreement between two of the biggest company in the automotive sector: Bosch and Iveco.
Specifically during the pre-test phase and at the start of the testing period, having the possibility to assist in the base setting of future actions, And what are the main steps to prepare at the best the implementation of a new set of rules and agreement between two big companies, and all the issue this could lead to even if the two are aligned in the way of thinking.
Before entering in discussion about such an important topic, many points have to be discussed, to avoid legal issues or delay and even stops analyzing all the possible scenarios and trying to mitigate most probable risks.
In this case we found out that the less risky and the most useful route to follow was to introduce a set on rule on the most impacting phases of the logistic flow: ordering and delivery behavior.
Before acting is crucial to have a general overview of the situation, specifically we build a database containing all the data of the orders during the year before the starts of the discussion, June 2023-November 2024.
Based on this report we focused on Iveco order variability and Bosch delivery performances, after many meeting and discussion our work provided a set of rules to be

followed, based on feasible ranges, setting corridor limits within ordering quantity may varies in exchange of an higher delivery performance from Bosch.
Having assured the route to follow, has become necessary to monitor action and results, in first place to assure the correct conduct of the test on both side if the rules are respected, to have the possibility to intervene in case of criticalities and actually see if the test leads to the expected results.
During the development of the monitor tool further step is to elaborate a dedicated unit of measurement; the scope is to have an actual value that could instantly indicate whether Bosch or Iveco are on target or not.
Having assured which are the selected KPIs and how to evaluate them the testing phase has started this is a key turning point as the main side effect of this agreement is that Bosch would set a standard of quality and rules to follow for its customers.
Having proof and an history of cases in which this approach worked, Bosch will have the power to propose such action to other major customers and that would lead to a huge saving in time and enhancing in the whole supply-chain.

12.2 Limitations of the Study

The main constraints faced during the study were due to the difficult to gather reliable data, and the database constructions was really time consuming, furthermore eventual criticalities were slow to be exposed as especially in the first phase data tool were far from reliable and corrective action may take months to be implemented, and not rare were the cases in which Iveco or Bosch made resistance to proposed correction.
So due to implementations slowness also data analysis cannot be totally pursued by checking tools result, as the reason behind low rating can be extremely different one from another, and case specific, due to that we constantly check data and results and investigate on the reason behind issues and criticalities before reporting to plant if it is proven to be a logistic issue, or directly to Iveco if is an issue with data collection or calculation.
In general the critical resource in this agreement is the time as it may takes years to be fully implemented, on the other hand the highest time consuming activities have already been performed and they serve as base for future development, generating a waterfall of actions faster and faster, enhancing the overall supply chain management.

12.3 Future Research Directions

As an answer to the main constraint just mentioned Bosch is also working in tools powered by AI aimed to reduce the time needed to perform the actions mentioned in this thesis, in parallel in fact we are trying to implement AI in everyday works, developing automated transactions able to perform MOQ analysis based on the database created for Iveco and from the data collected from data tools, this is a long process as the biggest issue is to keep the data security and encryption while providing reliable result.
The goal is to reduce human error and fast-track not only everyday activities but also biggest projects, as the Iveco logistic agreement, within a short period of time, this may help a lot the agreement itself as data analysis and rules implementation would be automated and faster, facilitating the flex rules implementations on wider cluster having the possibility to control a major quantity of data without losing efficiency.
Both this positive outcome can lead to a third as the resulting time saved is planned to be used in new projects, as the supply chain standardization, with other customer, exploiting our work performed and new tool that optimize and accelerate the process.

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