VILNIUS GEDIMINAS TECHNICAL UNIVERSITY
FACULTY OF MECHANICS
DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING

Neringa Mžavanadze

ENHANCING END-TO-END SUPPLY CHAIN PERFORMANCE BY OPTIMIZING INBOUND MATERIAL PLANNING PROCESSES IN THE FAST-MOVING CONSUMER GOODS INDUSTRY

TIEKIMO GRANDINĖS NAŠUMO TOBULINIMAS OPTIMIZUOJANT ŽALIAVŲ PLANAVIMO PROCESUS VARTOJIMO PREKIŲ GAMYBOS PRAMONĖJE

Master graduation thesis

Industrial Engineering and Innovation Management study programme,
State code: 6211EX056

Vilnius, 2024

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Supervisor Associated Professor Eligijus Toločka ______________ ____________
(Academic degree/teaching title, first name, last name) (Signature) (Date)

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For student Neringa Mžavanadze

Master Thesis title: Enhancing End-to-End Supply Chain Performance by Optimizing Inbound Material Planning Processes in the Fast Moving Consumer Goods Industry

Deadline for completion of the final work according to the planned study schedule.

THE OBJECTIVES:

Tasks to achieve the goal:
The aim of the work is to identify inbound material flow supply weakness and impact on end-to-end supply chain, propose solutions and implementation plan of new processes/tools.
Work objectives:
• Make analysis of theoretical aspects in end-to-end supply chain management and inbound material flow planning processes
• Investigate supply chain management systems integration and collect data about end-to-end supply chain performance in fast moving consume goods industry.
• Identify supply chain weaknesses according to investigation findings.
• Provide proposals for supply chain improvement in fast moving consume goods industry.

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Annotation

This master's thesis analyzes post-COVID-19 supply chain trends, focusing on how major external factors have disrupted traditional supply chain models. The study argues that traditional supply chains are no longer viable and cannot ensure business continuity in the current market environment. A new end-to-end supply chain model is introduced, characterized by its transparency and reliance on various digital tools to enable better responsiveness to issues.

The second part of the thesis presents qualitative research conducted on 11 FMCG (Fast-Moving Consumer Goods) inbound supply chains using the People, Technology, Processes framework. This involved physical audits of factories, focusing on key aspects such as material planning processes, master data quality, risk assessment and management, inventory accuracy, supplier management, training solutions, and performance management. The research identified current risks and gaps in the inbound supply chain and proposed solutions to address these issues. A comparative model illustrating the inbound process before and after implementing the proposed solutions is created and presented.

Keywords: Supply Chain Disruption, End-to-End Supply Chain, Fast-Moving Consumer Goods, Inbound Supply Chain, Risk Management, Inventory Management, Supplier Management, Continuous Improvement, Manufacturing

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Pavadinimas	**Tiekimo grandinės našumo tobulinimas optimizuojant žaliavų planavimo procesus vartojimo prekių gamybos pramonėje**
Autorius	**Neringa Mžavanadze**
Vadovas	**Eligijus Toločka**

Kalba: anglų

Anotacija

Magistro baigiamasis darbas analizuoja kaip po COVID-19 neprognozuojami išoriniai veiksniai sutrikdė tradicines tiekimo grandines. Tyrime teigiama, kad tradicinės tiekimo grandinės privalo pasikeisti, kad prisitaikytų prie besikeičiančių aplinkos faktorių ir užtikrintų pramoninio verslo tęstinumą. Pristatomas naujas „end-to-end" tiekimo grandinės modelis, pagrįstas skaitmeniniais įrankiais, suteikiančiais geresnį rizikos matomumą ir leidžiančiais geriau reaguoti į problemas.

Antroje darbo dalyje pateikiamas kokybinis tyrimas, atliktas 11 greitai vartojamų prekių gamyklų. Atlikti gamyklų vizitai ir žaliavų bei pakuotės tiekimo procesų auditai – daugiausiai dėmesio skiriant medžiagų planavimo procesams, pagrindinių duomenų kokybei, rizikos vertinimui, atsargų ir tiekėjų valdymui, mokymų ir kvalifikacijos sprendimams. Duomenys analizuoti naudojant „Žmonės, Technologijos, Procesai" tyrimo struktūrą.

Tyrime buvo nustatytos esamos rizikos ir spragos žaliavų ir pakuočių tiekimo grandinėje ir pasiūlyti sprendimai, kaip jas pašalinti. Sukurtas ir pateiktas lyginamasis modelis, iliustruojantis proceso būklę prieš ir po siūlomų sprendimų įgyvendinimo.

Prasminiai žodžiai: Tiekimo grandinės sutrikimai, Pramoninė Gamyba, rizikos valdymas, atsargų valdymas, tiekėjų valdymas, nuolatinis tobulėjimas.

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ABREVIATIONS

BBD – Best Before Date

COGI – Controlling Goods Issue

E2E – End to End

ERP – Enterprise Resource Planning

FG – Finished Goods

FMCG – Fast Moving Consumer Goods

FMOS – Factory Manufacturing Operations Systems

IDOCS – Intermediate Document

JIT – Just-In-Time

KPI – Key Performance Indicators

MD – Master data

MOQ – Minimum Order Quantity

MRP – Material Requirement Planning

PO – Purchase Order

PPT – People Process Technology

SC – Supply Chain

SCM – Supply Chain Management

SLA – Service Level Agreement

SOH – Stock on Hand

SS – Safety stock

WIP – Work in Progress

INTRODUCTION

Relevance of the topic. During 2021 we have faced one decade worth of disruptions in material supply chain, and this will continue for the near future. We saw labor shortages from Covid-19 restrictions, rising fertilizer prices making farmers change crops, Europe's energy crisis with soaring gas and electricity prices, geopolitical tensions USA-China, War in Ukraine, extreme weather events, monetary policy change – global supply chain problems are leading to empty shelves at grocery stores and paralyzed businesses unable to operate. Previously used and perfected just-in-time delivery in manufacturing is no longer an option – businesses need to prepare, secure enough stock and a healthy supply chain, to ensure business continuity.

Three main parts of production supply chain are important to highlight: Inbound, Outbound, Manufacturing. Building a resilient end-to-end supply chain requires full visibility and traceability of raw materials, thus working with suppliers, having integrated system solutions and trust based long term relationships is key. Making manufacturing plants attractive to personnel and external contractors (Mechanical maintenance, construction, truck drivers, etc.) ensures employer reputation is high, which results in low staff turnover rate and quality applicants. Ensure timely technical maintenance, safe supply of spare parts and emergency backups. Outbound production supply must be flexible to quickly react to customer demand – not to overflow market warehouses but keep a high case fill level as a KPI. Good relationships with haulers are also key – it is no longer a buyers' market.

Problem of research. Supply chain disruptions due to recent global events. The need to strengthen inbound material supply for business continuity and continued material/information flow.

Research Object. In this master thesis I will analyze supply chains of 11 FMCG production facilities, identifying weaknesses and opportunities for improvement, gathering the learnings, building the processes.

Aim of research. Identify inbound material flow supply weakness and impact on end to end (E2E) supply chain, propose solutions and implementation plan of new processes/tools.

Tasks:

1. Make analysis of theoretical aspects in end-to-end supply chain management and inbound material flow planning processes
2. Investigate supply chain management systems integration and collect data about end-to-end supply chain performance in fast moving consumer goods industry.

3. Identify supply chain weaknesses according to investigation findings.
4. Provide proposals for supply chain improvement in fast moving consumer goods industry.

Research Methods.

1. Overview of and analysis of scientific literature.
2. Qualitative case study, interviews with matter experts.
3. Visual inspection and observation methodology while physically visiting the production plants.
4. Focus groups to discuss preliminary findings.

The conducted research and its results were approbated in the presentations made at scientific conferences:

- 18th Prof. Vladas Gronskas International Scientific Conference, Kaunas, Vilnius University, Kaunas faculty, Lithuania, 1st of December, 2023 - "ENHANCING SUPPLY CHAIN SYNCHRONISATION IN THE FAST MOVING CONSUMER GOODS INDUSTRY"
- 27th Lithuanian Junior Researchers Conference "Science-Future of Lithuania, Vilnius, Vilnius Tech University, Mechanical faculty, 26 April, 2024 - "ENHANCING END-TO-END SUPPLY CHAIN PERFORMANCE BY OPTIMIZING INBOUND MATERIAL PLANNING PROCESSES IN THE FAST-MOVING CONSUMER GOODS INDUSTRY"

1. ANALYSIS OF THEORETICAL ASPECTS OF SUPPLY CHAIN MANAGEMENT

Supply chain is defined as a group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-consumers (Lu, 2011). This chapter provides an in-depth exploration of the theoretical foundations of Supply Chain Management (SCM). It examines fundamental concepts and traces the historical development of SCM theories, offering insights essential for understanding the complexities of modern supply chains.

1.1. Supply Chain Flows

Most authors agree that supply chains are dynamic and involve constant flow of information, product, and funds among different stages (Chopra et al., 2016). While

Material (product) flow includes all components, raw materials, packs, other items needed for production of a product and finished good movement from production facility to the customer. All these flows need accurate planning, optimal transportation routes, just in time delivery, suitable warehousing facilities.

Information flow – industry specific information moving upstream and downstream the value chain. Could be demand, forecast, scheduling information, purchase orders, designs, contracts, and agreements, etc. Information flow is the driver for the whole supply chain.

Financial (funds) flow – for any supply chain there is a single source of finance – the end consumer. It starts at the end of our Supply chain and goes backwards paying for all materials, services, labor needs to deliver the final product to the consumer.

1.2. Supply Chain Components

Sunil Chopra with co-authors in their book argues that the term supply chain conjures up images of product or supply moving from suppliers to manufacturers to distributors to retailers to customers along a chain. This is certainly part of the supply chain, but it is also important to visualize information, funds, and product flows along both directions of this chain. The term supply chain may also imply that only one player is involved at each stage. In reality, a manufacturer may receive material from several suppliers and then supply several distributors (Chopra et al., 2016). Figure 1 depicts a standard structure of a supply chain consisting of suppliers, inbound logistics processes, manufacturing, outbound logistics or distribution, then sales and end consumer.

Figure 1. Standard supply chain flow illustration

Source: designed by author

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service. (Chopra et al., 2016)

These flows go through 5 main components that will be reviewed further:

- Sourcing and Procurement (Inbound material flow)
- Manufacturing
- Distribution
- Retailers
- End consumer

1.2.1 Inbound material flow – sourcing, procurement and material ordering

Sourcing is recognized as a critical component of supply management with activities such as identifying appropriate suppliers, negotiating terms and generating value by ensuring cost efficiency and risk mitigation (Ketchen et al., 2014). Wang et al. (2010) describes sourcing as the process where companies acquire resources from suppliers, which enable them to execute their operations and services.

Chopra et al., (2016) describes procurement as an essential part of profitability. Businesses recognized that increasing profits through sales growth required significantly more effort than achieving similar returns through procurement cost reduction. Consequently, top management began overseeing major purchases, relying on procurement specialists for guidance. Economic purchasing was acknowledged as a strategic function with a significant impact on the bottom line. However, once procurement was completed, responsibility shifted to a more routine materials management function. Thus, materials management can be defined as the suite of activities and processes focused on economically procuring inputs for the enterprise and efficiently managing the outflow of funds.

Piasecki D.J. describes ordering/replenishment of materials as the most frequent activity in inventory management. Ordering techniques take data of forecasted demand, actual demand, safety stock, lot sizing, unrestricted stock and converts it into purchase orders with quantities and dates. Author describes various techniques used to do this including fixed reorder point, time-phased reorder point, periodic review, kanban, material requirements planning (MRP) and other. The effectiveness of each of these techniques is dependent on the accuracy of data inputs. (Piasecki, 2009)

1.2.2 Manufacturing

The process of converting inputs into the finished product sold to the end consumer. This is accomplished by human labor, machinery, and intellectual know-how. Operations strategy define the way a company chooses to produce goods.

In the book Strategic Supply Chain Management: The Five Disciplines for Top Performance, authors Cohen and Roussel (2005) suggest looking at each supply chain as a strategic asset, and differentiate types of manufacturing strategies:

- *Make to stock* is the best strategy for standardized products that sell in high volume. Larger production batches keep manufacturing costs down, and having these products in inventory means that customer demand can be met quickly.
- *Make to order* is the preferred strategy for customized products or products with infrequent demand. Companies following this strategy produce a shippable product only with a customer order in hand. This keeps inventory levels low while allowing for a wide range of product options.
- *Configure to order* is a hybrid strategy in which a product is partially completed to a generic level and then finished when an order is received. This is the preferred strategy when there are many variations of the end product and you want to achieve low finished-goods inventory and shorter customer lead times than make to order can deliver.

- *Engineer to order*, which shares many of the characteristics of make to order, is used in industries where complex products and services are created to unique customer specifications.

While Peter T. Ward and Rebecca Duray (2000) took it one step further and conducted research into dynamics between environment, competitive strategy and manufacturing strategy, where they defined long-standing conceptual arguments linking environment, competitive strategy, manufacturing strategy, and performance are upheld empirically among high performance firms, but not ones with relatively poor business performance. They also found no direct link between environmental dynamism and manufacturing strategy; rather this relationship is being mediated by competitive strategy.

1.2.3. Inventory management

Inventory comprises all raw materials, work in progress, and finished goods within a supply chain, recorded as assets of a firm. (Chopra et al., 2016) Inventory management is the control of inventory in a manner that best achieves the business objectives of an organization. It not only involves the physical management of inventory, but also the management of data used to describe inventory and the systems used to process data. Inventory management ultimately comes down to having the right inventory in the right form in the right quantity in the right place at the right time at the right cost. (Piasecki, 2009)

Same author (Piasecki, 2009) lists down main types of inventory:

- Finished goods
- Unfinished goods (components, ingredients, raw materials, semi- processed materials, subassemblies)
- Maintenance, repair and operating inventory (office supplies, maintenance and repair spare parts, other consumables)
- Work-in-process (inventory account – summarized value of in-process materials)

Company inventory accounts for a large part of their frozen cash, thus it is needed to have a right level of stock. Having very low stocks increases risks to have a shortage of a material, which in turn can stop the whole production causing extensive no value added costs, not being able to fulfil customer orders, damage of company reputation.

On the other hand – too much inventory is a liability. Spoilage and theft are some of the risks that come with it. Company needs to store and pay warehousing for nonmoving goods. And if not sold in time – production might have to be disposed of at clearance costs or even destroyed.

According to Arnold T. and coauthors, a company aiming to optimize profits will typically pursue the following goals: Maximum customer service; Low-cost plant operation; Minimum inventory investment (Arnold et al., 2008).

While management literature suggest that a manufacturing firm's performance is best evaluated through metrics such as throughput (output per unit of time), inventory levels, and operating costs. Businesses are advised to minimize inventory, reduce operating expenses, and increase throughput to enhance their bottom line. (Chopra et al. 2016) However, the reality in recent global contexts differs somewhat, as companies often maintain stocks as safeguards against supply or production delays or the receipt of substandard goods. Mathematically calculated safety stocks may not always suffice in such situations due to the unpredictability of factors affecting material and product flow. Additionally, the lack of reliable data further complicates the computational process.

Safety stock is an additional essential measure to avoid Out of stock and sales loss. Safety stock is primarily used to buffer against variation in demand, supply, or process variability. Safety stock is maintained because it's impossible to foresee future events with absolute certainty. The amount of safety stock will depend on forecast accuracy, consistency of supply and processes, desired service level (Piasecki, 2009)

As shown in Figure 2, safety stock serves as a buffer against unforeseen circumstances between cycle stock deliveries. If a delivery is late, demand increases, or a quality issue arises, production can continue using the safety stock, provided it is replenished afterward.

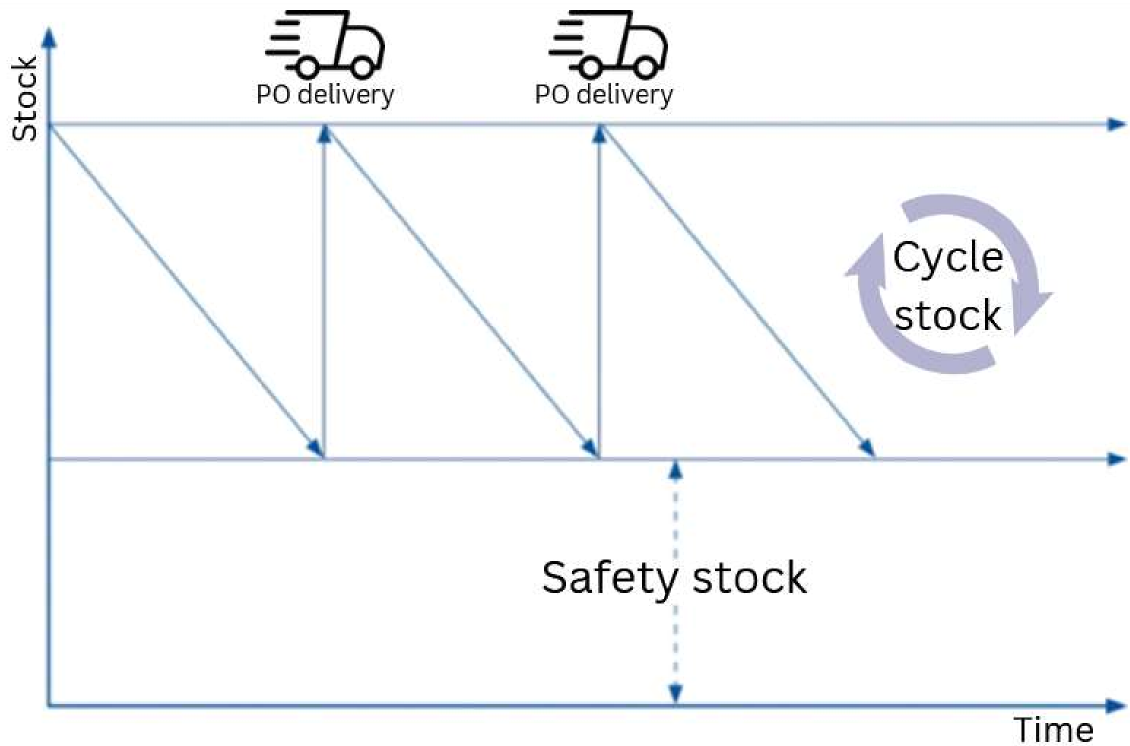

Figure 2. Safety stock in relation to cycle stock

Source: designed by author

Safety stock mitigates the risks and consequences of stockouts, ensuring that production processes remain uninterrupted and customer demands are consistently met. This buffer helps maintain service levels and protects against supply chain variability.

1.2.4 Distribution

Distribution involves the processes involved in transporting and storing a product from its supplier stage to its customer stage within the supply chain. It occurs between each pair of stages within the supply chain, with raw materials and components moving from suppliers to manufacturers, and finished products moving from manufacturers to end consumers. Distribution plays a crucial role in determining a firm's overall profitability as it directly impacts both supply chain costs and customer value. (Chopra et al., 2016). Authors argue that, The appropriate distribution network can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select different distribution networks.

Distribution systems differ depending on the number of intermediaries. Julian Dent (Dent, 2011) distinguishes these distribution structures:

- Direct – no intermediaries between supplier and customer.
- One-tier distribution – employing one set of intermediaries between supplier and customer to increase reach, provide special services, or position the product within established channels.
- Multiple-tiered distribution – for more complex markets that require more intermediaries who service customer segments a supplier is seeking to reach.

As you can see from the Figure 3, there can be an unlimited number of intermediaries, which in turn increase the final cost of product to the end consumer.

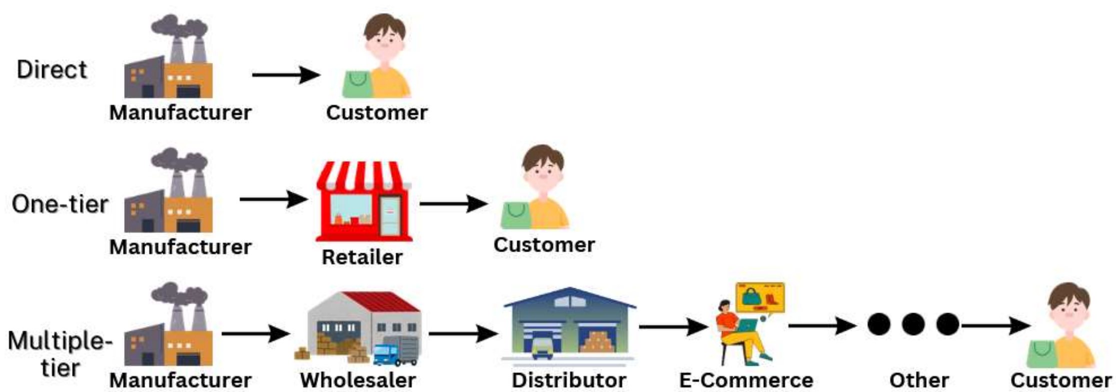

Figure 3. Distribution Channels

Source: designed by author

Distribution management brings substantial benefits to the business by delivering higher profits, eliminating waste by choosing a correct inventory management strategy, delivering added value conveniences to the end consumer. But choosing the right system is key to both – reaching more customers and keeping product price competitive.

1.2.5 End Consumer

It is debated if end consumer should be included into the supply chain. There are fundamental differences between the nature of supply chain and consumer. But most reviewed authors including S. Cohen (Cohen & Roussel, 2005), S. Chopra (Chopra et al, 2010) and Arnold T. (Arnold et al, 2008) in their respective books, consider consumers as part of supply chain. Consumers are providing financial flow and demand that is running the whole supply chain. It is the reason business exist. Businesses are shaped around consumer interests, try to tap into what appeals to the masses, try to create demand by arranging a creative appeal of a brand. In other words – the whole supply chain is changing to follow with the latest trends, pricing conditions and product expectations to increase customer value. If customer value is innovation (ex. Apple products), it drives research and innovation in the whole company. If value is determined by the price – strategic decisions must be made to save on costs, which goes through sourcing, manufacturing distribution – optimizing each step of the value process map.

On the other hand, the consumer is not part of the supply, it is the recipient of the end product. Supply chain adds value to the product – consumer depletes it. Supply chain is very specialized, while consumer is generally purchasing various types of products.

We could concede that the end consumer might not be a part of the supply chain, but it is the essence and main driver of it. A successful business is customer oriented, that listens and hears the requirements, follows the latest trends and takes one step forward by predicting user behavior.

1.3. Traditional supply chain model and just in time concept

In a traditional supply chain model many company managers primarily focused on internal issues within their organizations. While they acknowledged the importance of suppliers, customers, and distributors, these external entities were typically perceived merely as business counterparts. Specialists in purchasing, sales, and logistics were tasked with managing relationships with these external entities, often through formal contracts negotiated on a regular basis, representing short-term agreements. (Arnold et al, 2008)

In the APICS dictionary (APICS, 2016), the term “supply chain” is defined as a set involving all processes that connect producing firms and consumers. These processes start with supplying the raw materials and finish with final product delivery to consumer. Additionally, the term "supply chain" is defined as a compilation of both internal and external activities within an organization, enabling the value chain to offer services and products to clients. (Cox et al., 1995). “Supply chain is defined as a group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-consumers” (Lu, 2011). In other words – it is a flow of materials, information, finance and commercial from the extraction of raw materials to final product sold to end consumer. Active control strategies are often used for the management of supply chain systems, where nonlinear control synthesis is recommended (Xu et al., 2022). These authors emphasize that the use of System Dynamics Theory can be a potentially effective strategy to deal with chaotic supply chains with unpredictable behavior over time. Other authors (Wofuru-Nyenke et al., 2023) have explored recent trends in sustainable manufacturing supply chain modeling. These studies aimed to identify modeling approaches. Assessing the challenges posed by COVID-19 in adapting supply chains to function in suddenly changed conditions, significant research on strategy formation in crisis situations was analyzed (Durugbo & Al-Balushi, 2023). Such strategies are fundamentally different from conventional strategies that focus on the development of competitiveness. The COVID-19 epidemic has drawn the attention of companies to blockchain technology, which can help companies quickly gain competitiveness in the market. However, this technology also requires large financial investments. To solve this problem, an effective supply chain contract can be started with the adoption of blockchain technology in the supply chain (Liu, et al., 2023).

Often, companies concentrate on financial and material flows, that allow operations short term, not allocating enough resources to information, and commercial flows, which are crucial long term.

In past studies, several strategies were provided for supply chain, which can generally be divided into two categories: responsive/agile supply chain strategies, and efficient/lean supply chain strategies (Fisher, 1997). The first major change in that perspective for most companies can be traced to the explosive growth in just-in-time (JIT) concepts originally developed by Toyota and other Japanese companies in the 1970s. Supplier partnerships were felt to be a major aspect of successful JIT. With that concept, suppliers were viewed as partners as opposed to adversaries (Arnold et al., 2008). Authors further explain that Just-in-time manufacturing is described by the elimination of all forms of waste and the ongoing enhancement of productivity. Waste encompasses anything beyond the essential amount of equipment, parts, space, materials, and workers' time needed to contribute value to the product. This means there should be no surplus, there should be no safety stocks, and lead times should be minimal: “If you can’t use it now, don’t make it now.”

As M'Barek, Z., Fujii, H., & Ohtaki, Y. (1988) described in their paper - JIT is designed to produce and deliver materials, parts, and components just before they are needed. This strategy is well known to result in a considerable cost reduction and improvement in total productivity in many types of manufacturing companies. It is based on close relationship with the supplier, allowing accurate planning of materials avoiding inventory storage. Implementing JIT can lead to significant savings for companies that can meticulously establish their planning systems. JIT became a go-to strategy for many manufacturing companies seeking to optimize resources and achieve cost and cash savings. But in today's environment, not having any safety stock and relying on supply chains designed for a stable global market brings huge risks and potentially enormous costs if production must be stopped due to disrupted deliveries and lack of materials.

This is exactly what happened to Toyota after the earthquake in Japan in 2011. Most of Toyota's Japanese plants were closed for nearly two months. In addition, Toyota's north American production was cut to 30% for the subsequent 6 months due to a shortage of 150 different parts which should have been produced by Toyota's Japanese plants (Canis, 2011) Toyota had a 77% fall in profits in the second quarter of 2011, equivalent to $1,36 BN (MacKenzie et al, 2012). Toyota learned this painful lesson early and revised its operating strategy, while the rest of the world did so only in 2020 after experiencing disruptions in the supply chain due to Covid-19. That is why Toyota did relatively well during 2020-2021, while most of other companies struggled to get the needed materials and components for production.

Arnold T. and coauthors argue that the concept of having one department responsible for the flow of materials, from supplier through production to consumer, is relatively new. Although many companies have adopted this type of organization, there are still a number that have not. If companies wish to minimize total costs in this area and provide a better level of customer service, they will move in this direction. (Arnold et al, 2008).

1.4. Post pandemic supply chain trends

Competition is changed. Instead of competition between two companies, now we witness competing supply chains. Having a strategically optimized, aligned, and resilient supply chain is key for success. Covid-19 pandemic had a significant impact on the FMCG business. In addition to influencing consumer behavior towards e-commerce, people were spending more on FMCG overall. This meant that factories had to increase production, push to the maximum capacity while juggling lack of personnel due to sick leave.

Based on general news media during 2020-2022 inbound flows of raw materials and packaging were greatly impacted by:

- Suez canal blockage (BBC news, 2021)
- Snowstorm in Texas (Biggest Polymer producer) (CBS news, 2021)
- Avian Flu outbreak in EU (aviNews, 2022)
- Brexit (BBC news, 2021)
- Sea Freight container crisis (Globalia Logistics Network, 2020)
- Aluminum shortage (CNN Business, 2020)
- Covid 1;2 and 3rd waves (Business insider, 2020)
- Labor shortages (CNBC News, 2022)
- War in Ukraine (BBC News, 2022)
- Europe energy crisis (CNN News, 2022)
- Rising Fertilizer prices (World Bank Blogs, 2021)
- Inflation (Eurostat, 2024)
- Trade wars (Brookings, 2020)

These are just a couple of global events that shook up the industry and made it rethink and reshape the supply chain. Overall Supply chain agility became a long-term strategy of the business.

S. Harapko, (2023) working in Ernst & Young LLP (EY US), a global business consultancy company, conducted a survey of 200 senior-level supply chain executives in late 2020 and then in 2022 to determine how/if Covid-19 pandemic impacted global supply chains. 72% of respondents reported a negative effect. The results are depicted in Figure 4.

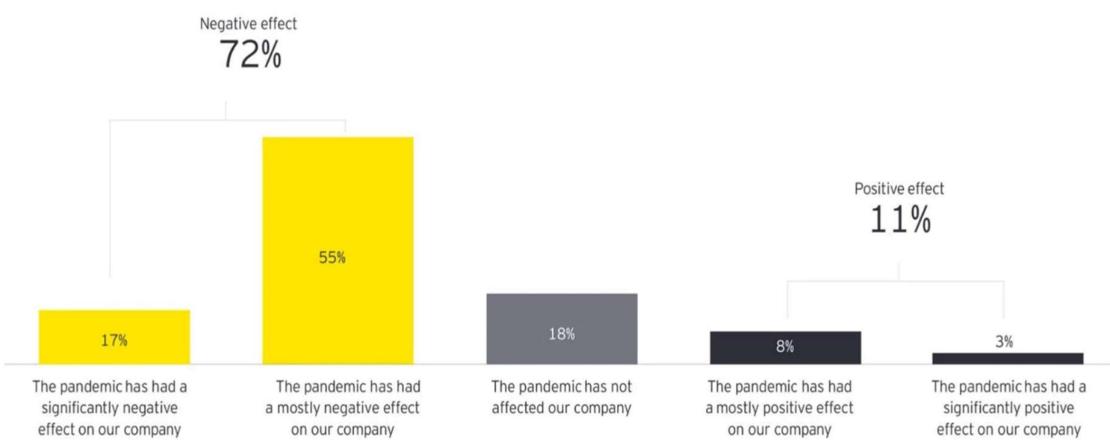

Figure 4. Survey results – pandemic effect on the business.

Source: Harapko, S. (2023). https://www.ey.com/en_gl/supply-chain/how-covid-19-impacted-supply-chains-and-what-comes-next

According to the executive supply chain survey, it is evident that top priorities include enhancing visibility, efficiency, and reskilling supply chain personnel. These results align with expectations, considering that cost optimization in the supply chain remains a consistent focus, even when bolstering resilience. Traditionally, cost reduction involved lean operations, extended lead times, and low-cost labor. Looking ahead, the emphasis shifts towards agility, visibility, automation, and upskilling the workforce. These factors not only contribute to cost reductions but also foster improved decision-making, standardized processes, and excellence throughout the supply chain and collaborative partners within the client's ecosystem.

The surveys highlight that supply chain visibility ranked among the top three priorities in late 2020 and claimed the top spot in 2022. Despite its prominence, achieving comprehensive supply chain visibility remains an ongoing endeavor.

Although Covid-19 was the first factor that shook up the global supply chains, now it is only one of many over the last 3 years. Executives acknowledge the heightened strategic significance of their supply chain due to the changing global trade environment. Consequently, businesses are forced to promptly establish a supply chain structure that aligns with the demands of the emerging digital and autonomous-focused era.

1.5. End to end supply chain concept

A supply chain architecture with an end-to-end focus identifies where integration—both internal and external—can create value for the company as a whole. By *integration,* we mean shared goals and alignment of the processes, systems, and organizations needed to achieve those goals. (Cohen & Roussel, 2005)

A traditional Supply Chain focuses on individual functions, with each step in the process being isolated and managed separately. Whereas End-to-End (E2E) is a holistic view of a Supply Chain that integrates all Supply Chain functions. This enhances visibility throughout the supply chain, leading to improved efficiency in processes and elevated levels of customer service.

A comprehensive End-to-End (E2E) supply model was presented by the company under further study. The fundamental differences between traditional and E2E supply chain models are illustrated in Table 1.

Table 1. Traditional vs. end-to-end supply chain

TRADITIONAL SUPPLY CHAIN		END-TO-END SUPPLY CHAIN
View of supply chain limited to departments	TRANSPARENCY	Complete view of Supply Chain
Information is delayed as it moves through each function	COMMUNICATION	Information available to all Supply Chain members simultaneously
Limited visibility of the entire chain, restricting meaningful collaboration and optimisation	COLLABORATION	Natural development of collaboration depth to capture intrinsic supply chain value
End customer demand is distorted as information flows through material path	FLEXIBILITY	End customer demand changes are rapidly assessed
Different planning cycles resulting in delays and unsynchronized responses across multiple tiers	RESPONSIVENESS	Real time response on planning and execution level

Source: Created by author, based on investigated company resources.

A well-managed Supply Chain can boost customer service and significantly reduce a company's operating expenses, driving profitability. Agility to react to changing requirements provides a competitive advantage, helping achieve business objectives related to service, cost, and cash.

End to End visibility is an important risk reduction factor, not only because it helps organizations to proactively track production and identify potential disruptions, but also its absence can create additional risks. Visibility can also facilitate efficient information exchange between partners. (Brandon–Jones et al., 2014). According to KPMG's global manufacturing outlook report (Gates et al., 2016), achieving cross functional and end to end supply chain visibility is the best way to minimize supply chain risk failure.

Building an agile and responsive end to end supply chain is the strategic focus of the analyzed corporation, which is deployed through enterprise planning.

1.6. People Process Technology framework

The People-Process-Technology (PPT) framework is a conceptual model commonly used in business management and organizational development to analyze and improve various aspects of operations. It recognizes that successful organizations depend on a balanced integration of three key components: people, processes, and technology. It originated from H. Leavitt's work where he concluded that any organizational analysis should include four components: task, technology, people and organizational structure. He saw one of management's key functions as maintaining a "dynamic equilibrium" among these four elements. Although Leavitt's main interest was in the individual and that person's fit with the organization, he too came up with the four factors of task, technology, people, and structure. (Rockart, 1987).

Lean manufacturing can be described as a set of tools (e.g., kanban, andon, poka yoke) that eliminates waste and creates flow of materials through a transformation process. You can describe lean product development the same way. But peel away another layer, and you discover the basis of both lean product development and lean manufacturing is the importance of appropriately integrating people, processes, tools, and technology to add value to the customer and society. (Morgan, 2006) Furthermore, Morgan J.M. explains, that People, processes, and technologies do not exist in isolation, insulated from each other and the outside world. Product development is an integrated evolving system, and the three subsystems interact, overlap, are interdependent, and work together to create a coherent whole. Changes to one subsystem will always have implications for the other two.

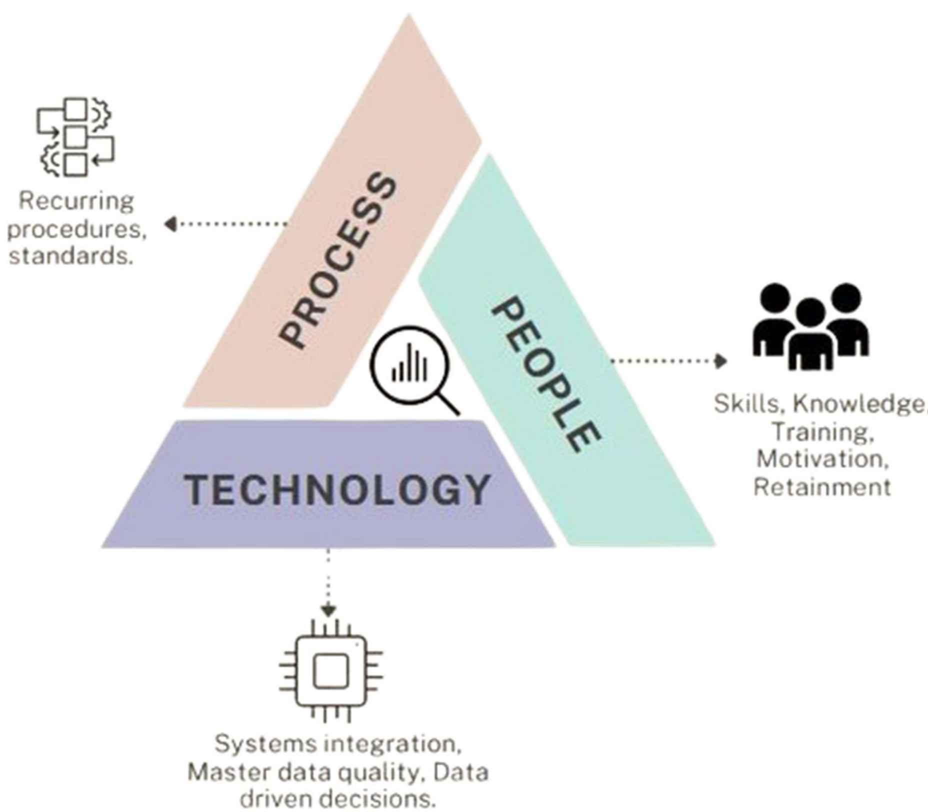

Figure 5. People, Process, Technology framework

Source: designed by author

As depicted in Figure 5, we observe the People, Process, Technology system illustrated, all of which are powered by data. Accurate data is essential to all operations in our supply chain and it is the driving force of all business.

2. EMPIRICAL RESEARCH ON FMCG INBOUND MATERIAL MANAGEMENT PRACTICES

The objective of this research is to determine the current level of maturity of a specific production site, pinpoint the obstacles that hinder its further progress, and develop an action plan to address those gaps and facilitate advancement.

The research adopted a mixed-methods approach, combining case study analysis of individual manufacturing facilities with qualitative research focusing on inbound logistics across 11 manufacturing facilities located in 7 different countries. While these facilities adhere to shared standards, systems, and centralized guidance, the study aims to uncover the diverse local practices and approaches to work that exist within each facility.

The purpose of this case study is to gain a comprehensive understanding of the manufacturing facility, providing a solid foundation for grasping the operational environment and challenges faced by the people within it. To achieve this, the study will involve gathering in-depth data through interviews with key personnel and conducting observations of the manufacturing processes and premises.

2.1. Research object

Analyzed corporation is producing and distributing FMCG mostly throughout continental Europe and globally. There are 11 factories that will be at the core of this research.

These factories have different technologies in the product itself and the way it is packaged. The variations in products necessitate differences in production technology, machinery, and outputs, although they generally follow similar systems, planning, and execution methods.

2.2. Research process and methodology

The research was conducted July-November 2023. Each production plant has been physically visited and audited. Qualitative research methodology was used – only matter experts considered. Interviews were carried out with factory raw/pack material planners, deep diving into their daily routines ordering materials for production. The planners were asked to describe their daily tasks step by step, making sure to cover all areas relevant to the research:

Master data maintenance, MRP runs, Requirements, Ordering procedure, Risk assessments and Risk management, Inventory assessment and management, new product development and other activity management, Supplier relations and Performance Management. The planners answered open questions in order to get the full overview, avoiding bias and predisposition.

Systems experts, scheduling and commercial specialists, logistics managers and factory leadership team were also interviewed to define their input to the factory supply chain.

Visual inspection and observation methodology was also used – in addition to the physical interviews in the factory office, a factory tour was also arranged to get to know the technologies, capacity constraints, systems integrations, infrastructure and accessibility, storage capabilities, etc. The factory tour is most valuable tool to witness each sites unique setup and understand why certain ways of working are applied.

Focus groups were created with relevant site team members to discuss first findings and preliminary risk factors, urgent actions (if any), and continuous improvement action plan.

The collected data is non numerical, it is detailed information on processes, systems, and people integration. Based on the collected data, each site will be evaluated following the same template, clearly indicating the current "as is" maturity level and stating the gaps. The template was prepared and created by the investigated company, following their enterprise planning guidelines.

2.3. Research data analysis

The findings of this review have already prompted the company to implement new KPIs, training programs, communication strategies and process change procedures. An ingrained continuous improvement mindset in the company is allowing for these changes to be implemented relatively smoothly – factory teams are engaged, understand the bigger picture and welcome positive change. There were several benchmarking opportunities identified, where some factories have very effective processes that could be deployed to others.

The first row in Table 2 consists of ID codes for different factories. Numbers 1 to 11 are randomly allocated to each visited factory.

Table 2. Example of research result table

	Factory ID	1	2	3	4	5	6	7	8	9	10	11		
Material planning process Score		3.5	4.5	3	6	5	4	2.5	6	5	4	4		**Factory compliance**
Basic	Planners have the basic understanding of material planning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	100%
	Planners ensure continuous flow of required materials according to manufacturing planning data.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	100%
	If Materials Planning is done outside of the system, inputs are maintained to track material deliveries.	Yes	Yes	Some	Yes	Yes	Yes	Some	Yes	Yes	Yes	Yes	10	91%
Capable	Materials Planning is done fully in the system with MD and parameters maintained.	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	5	46%
	PO changes are tracked manually, root caused, analyzed and actioned.	Some	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7.5	69%
	Exceptions management is tracked in system of record.	No	No	No	Yes	No	No	No	No	No	No	No	1	10%
	MRP run outages can be identified, corrected or escalated.	No	No	No	No	No	No	No	No	No	No	No	0	0%
Advanced	KPI reporting is available in automatic dashboards	No	No	No	No	No	No	No	No	No	No	No	0	0%
	PO changes are tracked automatically by the system, root caused and actioned.	No	No	No	No	No	No	No	No	No	No	No	0	0%
	Materials Planning is done with exceptions management and actioning by exception only.	No	No	No	No	No	No	No	Yes	No	No	No	1	10%
	Integrated Planning system with E2E visibility and exceptions/constraint management capability to optimize material supply	No	Some	Some	No	No	No	No	No	No	No	No	1	10%

Source: designed by author

Factory finding and comparison table is divided into 3 levels:

- Basic – essential skills, tasks, setups for the factory to be running continuously. Any gaps in this level is considered a serious risk to factory inbound supply.
- Capable –systems, people and processes in an optimized environment. Any gaps at this level are to be assessed and planned to be closed on a continuous improvement logic within a year.
- Advanced – features, that enable longer time planning, good visibility of E2E SC. They are not essential for the factories to run but are essential for an agile SC and ensuring business continuity and competitive advantage. There might be bigger challenges to close these gaps, such as system adaptability, overall strategic organizational approach, and the allocation of resources. They require investments, long term enterprise planning and should be addressed as separate projects centrally, rather than each factory solving them independently.

The factories were assessed, and research results were grouped in general themes:

- Material planning process
- Master Data Maintenance & Audit
- Risk Assessment & Management
- Inventory Management
- Supplier Management
- Training Solutions
- Cross Functional participation / collaboration
- Performance Management KPIs

In the next chapters each of them will be overviewed. Assigning 1 point if the answer to a statement is "Yes", 0 if the answer is "No". There was a need to recognize that the processes are very different for packaging materials and raw materials. Thus, in the result table there are answers "Pack", that mean the statement is true for packaging materials only. 0.5 point is assigned to such cases.

As we see in Figure 6, the flow of information initiates with the demand planning team, which forecasts sales volumes for the next 1.5 years in alignment with the overall strategic planning of the business. Subsequently, the commercial operations team procures the necessary materials and volumes by entering contracts for the upcoming year.

Figure 6. Information and Physical flows in Supply chain

Source: designed by author

The market sales teams then update the short-term demand forecast for the next 6 months. This information is utilized by the factory inbound schedulers to ensure timely delivery of raw materials and packaging. Additionally, short-term manufacturing scheduling takes place in the factories, typically one week in advance, in response to the specific market requirements. Once produced, the finished product is transported straight from the factory to the market warehouses, that in turn feed the customers on demand. In the manufacturing facility, none of the products remain stored for extended periods; they are typically stored for only a few hours. To facilitate efficient transportation, trucks are pre-ordered two days prior to production. The destinations of the trucks are determined based on the manufacturing plan, ensuring timely delivery of the products. All of the above is captured and actioned in SAP software used in all of the business units. Other software is used in the process, that are integrated into SAP - Warehouse management system, transport control tower, central planning tool, manufacturing recipe and machinery management, quality control system, hold and release.

Supply chain is a complex system of interdependencies between systems, departments, entities inside and outside of the organization. At its core, the system within the manufacturing facility relies heavily on the collaboration and interdependence of individuals. The successful completion of daily tasks is not solely reliant on the capabilities and knowledge of each individual, but also on the cooperation and support of others within the system.

2.4. Systems: Master Data Maintenance and Audit

Master data maintenance and regular audits are essential for ensuring accurate, consistent, and compliant information. Master data provides a foundational view of critical business information, enabling optimized inventory management, effective supplier relationships, and data-driven decision-making. Audits help maintain data integrity, mitigate risks, and ensure compliance with regulatory standards. Together, they form the backbone of efficient operations, enabling manufacturers to enhance competitiveness and deliver value to customers.

Table 3 displays the factory compliance results regarding master data maintenance, audit quality, processes, and knowledge. During the site visits a direct link was identified between inbound scheduler knowledge of systems and quality of master data. Therefore, more mature teams were also able to avoid manual practices and use systems the way they were designed.

Table 3. Factory compliance score on Master data maintenance and audit

Master Data Maintenance & Audit		Factory compliance
Basic	Master Data is maintained for some materials	100%
Capable	Master Data is present for key planning fields.	73%
	Master data is regularly collected and maintained.	37%
	Past due elements are cleaned weekly.	28%
	Obsolete materials are regularly cleaned from the system, process and responsibilities are defined and followed.	46%
	Planners understand master data impact on system functionality	55%
Advanced	Master data audit process is established and performed on quarterly basis.	0%
	Planners understand all parameters and optimize them in daily work.	37%
	Supplier SLA's actively influence MD and parameter definition.	0%

Source: designed by author

All of the sites were familiar with MRP master data and maintained at least some of it. But when we go to the “capable” section the results are more diverse. Only 3 sites had master data missing in key MRP areas, but when it comes to maintaining, only 4 sites had the process of regularly overviewing, confirming, and updating the master data. The consequences of not maintaining MRP master data can include production disruptions, inventory issues, resource wastage, quality control problems, compliance risks and supplier inconsistency.

Past due elements like Purchase requisitions, Purchase orders, production orders were also not followed up in the majority of the factories, which means that the supply, demand and stock data is inconsistent and inaccurate in the systems. On top of that obsolete materials were not closed and retired properly in more than half of the factories, meaning the system was overloaded with irrelevant data and in turn could be that the warehouse was also holding stock that will not be used anymore.

2.5. Process: Material planning

Although each visited factory is unique in their set up, the general rules and conditions to material planning are the same with some exceptions to accommodate distinct features or limitations. (see Figure 7.) Limiting factors could be bulk materials and silo capacity, overall factory storage capacity, expiry time limits for specific raw materials, processing speed, number of unloading docs and personnel available.

Material schedulers' day usually starts with cleaning the system – any errors (COGI, IDOCS) that need to be dealt with in order to see correct inventory in the system of record.

Figure 7. The main process buckets overlooked by the inbound material planner

Source: designed by author based on research data

Then to create a purchase order the scheduler needs to know three things: Demand, Stock, and orders in the pipeline. All this information is available in the system of record and is accurate if correctly maintained. Following the local rules on inventory level and supplier lead time, the scheduler then determines how many weeks of production they will cover and round it up to supplier lot size or pallet size.

After order is placed, it is sent to the supplier via email and a confirmation is required. Upon receipt of the goods, quality is being assessed and goods receipt is processed. This is a generalized process flow, there might be some differences in factories – having an external warehouse, supplier providing the order proposal (instead of scheduler calculating the order), systems approach, etc.

Table 4 depicts factory compliance results on Material planning process on Basic, Capable, Advanced levels. Only one factory was found not maintaining pack orders in the system of record so the Basic requirements for materials planning process is in good shape. The goal would be to use the system of record fully, so all stock, Purchase requisitions, purchase orders, quantities in transit and demand would be fully visible and the system could plan the inbound flows according to the master data and demand.

Table 4. Material Planning process factory compliance score

Material planning process		**Factory compliance**
Basic	Planners have the basic understanding of material planning	100%
	Planners ensure continuous flow of required materials according to manufacturing planning data.	100%
	If Materials Planning is done outside of the system, inputs are maintained to track material deliveries.	91%
Capable	Materials Planning is done fully in the system with MD and parameters maintained.	46%
	PO changes are tracked manually, root caused, analyzed and actioned.	69%
	Exceptions management is tracked in system of record.	10%
	MRP run outages can be identified, corrected or escalated.	0%
Advanced	KPI reporting is available in automatic dashboards	0%
	PO changes are tracked automatically by the system, root caused and actioned.	0%
	Materials Planning is done with exceptions management and actioning by exception only.	10%
	Integrated Planning system with E2E visibility and exceptions/constraint management capability to optimize material supply	10%

Source: designed by author based on research data

Following up from the previous MD chapter – if master data is not there, not maintained and not used – planning of inbound materials is manual. More than half of the factories are relying on scheduler experience, excel based tools, manual calculations to control inbound flows rather than letting the systems do it for them. This is mostly due to a gap in training and general systems knowledge. Figure 8 depicts the status of systems usage vs manual calculation in Pack, Protein, Additives planning processes in the 11 researched factories.

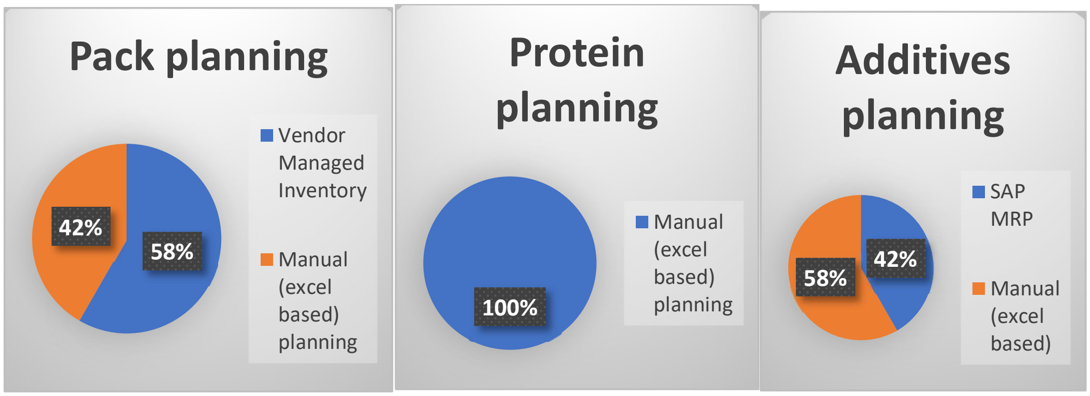

Figure 8. Factory planning methods based on material type.

Source: designed by author based on research data

System limitations was another factor that creates extra manual work for some raw materials with short expiration time or bulk deliveries with limited silo capacity. Because main systems were not adapted to the local factory setup, requirements and operations, workarounds had to be created to compensate. These manual excel based tools were used for material requirement planning and ordering, meanwhile interfering with data accuracy, material inventory visibility in the main operating systems. Only individuals employed in specific roles possess the expertise required to handle the excel based macros tools, which then causes a potential risk to supply should they leave the company unexpectedly. Additional features must be added to the software so the factories could bring all planning back to the main operating systems, stop any transactions being done outside of it and can have clean and reliable data to enable advanced technology adaptation and analytics.

2.6. Risk assessment and management

Factories were asked of supply disruptions during 2020-2022 and only 3 of them had to stop planned production for a number of days because of material shortages, which is surprisingly great result when compared to similar industries in EU, that had to completely shut down for months. But this has not been easy, logistics and commercial teams pointed out that their workload increased by 50% or more during this period, manual follow up of multiple materials were performed daily to ensure operations with very low stock, just in time deliveries, constant alignment with suppliers, sharing resources between factories and even prioritizing products to manufacture or cut.

If we look at the research for current status, among the most worrying findings was the risk visibility, which usually is limited to the supplier lead time, while the target should be at least 12 weeks. Figure 9 depicts the current risk visibility in the factories. If this lead time is less than 1-2 weeks, then the factory might not have enough time to implement any mitigation actions and end up stopping the production lines. Although there are some safeguards already in place – safety stock and avoiding single sourced materials, but this cannot be arranged for all inbound portfolios. Fresh raw materials cannot have any safety stock due to limited expiry time, which is 24-48 hours. In this case – close relationship, service level agreements and systems integration with key suppliers is essential to business continuity. It is important to inform suppliers of future demand, agree on risk management processes to allow more time to prepare for a material shortage.

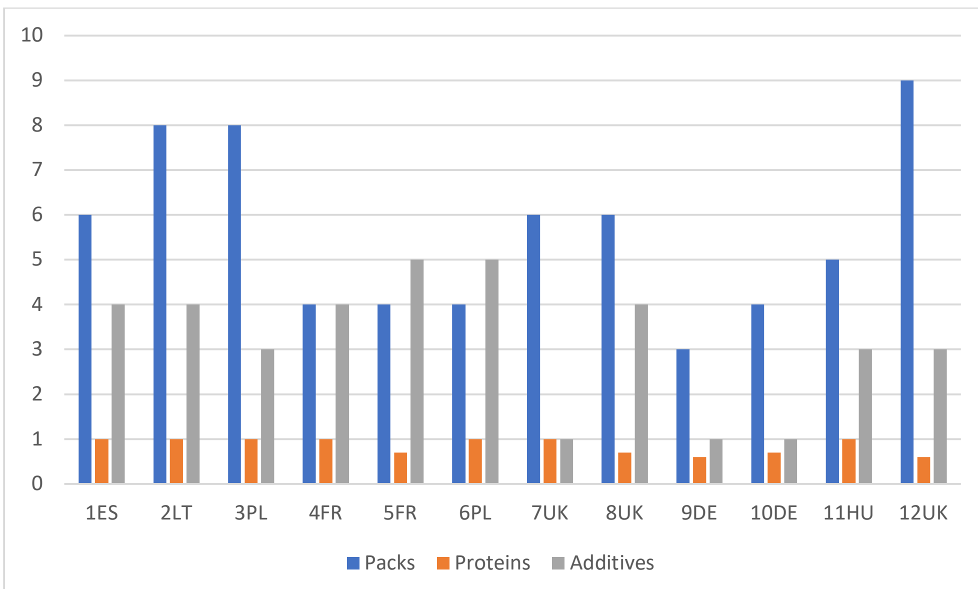

Figure 9. Risk visibility based on material type and lead time

Source: designed by author based on research data

Findings depicted in Table 5 also indicate a couple of critical gaps – in 5 of the factories daily material availability checks are not performed, and in one – a daily check is performed only for packaging materials, but not ingredients. For these factories checks are being done couple of times per week, but this might not be enough to prepare for any short term changes or issues. There might be quality incidents, inventory accuracy issues, urgent production plan modifications, that must be assessed daily to ensure materials are available for the next 72 hours of production.

Two factories also had a critical gap, where risk escalation was not done in a timely manner – material schedulers would be trying to solve the supply issue without asking for support or informing commercial operations, production planners or line managers. Such delay in escalation might limit risk mitigation options and lead to production line stops that are incredibly costly. Human factor could be causing this gap – either trying to solve the issue individually and not escalating at all or not escalating to a particular colleague where personal relationship is a barrier. An escalation matrix and triggers for each step was already created and deployed in the whole region, but some gaps were still there in practically using it.

Table 5. Risk Assessment and management factory compliance score

Risk Assessment & Management Score		**Factory compliance**
Basic	Material planner running daily checks to spot and manage risks in the next 72h.	50%
	Material planner is able to do scenario planning to define risk	100%
	Mitigation actions are escalated and delegated without delay.	82%
Capable	Escalation matrix and short term risk FMOS meeting structure established	37%
	Material planner is proactively assessing material risk impact 0-12 weeks	28%
	Material planner is able to do scenario planning, define actions to mitigate material outages and escalate risks to cross functional stakeholders in time.	73%
Advanced	Cross functional FMOS meeting structure established for 0-12weeks supply risk horizon	28%
	Material planner is able to spot and escalate risks on time to prevent high impact on business and engages other functions into mitigation actions. No line stoppage due to materials in the last year.	55%
	Requirements for 0-12months are shared with Suppliers automatically through the system.	37%
	Supplier portal is used for supplier collaboration.	32%

Source: designed by author based on research data

Overall pro-active approach on risk is a common gap in the assessed factories. There is no one unified way to approach risk and each site has their own standard process, but only 3 factories stated that they are assessing material risk impact to manufacturing for 12 weeks in advance. Very few factories had daily or weekly meetings to assess short- and medium-term risks, safety stocks and inventory levels, there were KPIs established but they we're not followed and analyzed on a regular basis.

Demand accuracy and production plan adherence is one more issue for the factories. While in FMCG industry manufacturing must be very reactive to fulfil ever changing customer needs, a balance is also necessary to have a steady fixed time horizon to prepare for production. Demand planning accuracy and bias must be assessed using new statistical, interpersonal and AI tools. If factories can achieve relatively accurate demand planning and factory output adherence to plan a reasonable amount of cash could be saved by lowering the safety stocks on finished product and materials.

Risk and risk management links closely to supplier management, the relationship and systems integration factor. Table 6 depicts the assessment results on supplier management, which might be satisfactory on Basic level, but show considerable gaps on higher levels.

The assessed company values strategic partnerships over short term benefits, which is evident in the ways of working, investments and solutions available for better co-operation. This could be one of the success factors that helped the company during the supply disruptions caused by Covid-19.

Table 6. Supplier management factory compliance

Supplier Management		**Factory compliance**
Basic	Material planner communicates with supplier on ad-hoc basis for order management	100%
	Supplier proactively informs change in delivery schedule or quantities. Material planner is tracking overdue POs in the system.	64%
Capable	Material planner participates in supplier onboarding to ways of working	0%
	SLA is part of contract and is maintained with all suppliers.	0%

	Manual supplier scorecard in place with root causing and actions to address gaps	0%
Advanced	KPI tracking automated via system	0%
	Automatic medium term (0-12 months) demand sharing with supplier weekly.	37%
	Firm horizon is aligned with supplier and documented in SLA	0%
	Supplier inventory levels are visible in the system	0%
	Material planner has access to supplier capacity outlook	19%

Source: designed by author based on research data

Keeping this in mind, material schedulers still highlighted several times where suppliers were not transparent with their production issues that were impacting material deliveries, that lead to unplanned changes in the production, safety stocks being used up or even certain production cuts and out of stocks in the markets. Additionally, not all schedulers are monitoring overdue purchase orders (POs) in the system, potentially indicating a risk that may not be identified promptly.

2.7. Inventory Management

Effective inventory management is crucial for businesses to optimize their operations and maximize profitability. By accurately tracking and controlling inventory levels, companies can minimize stockouts, reduce carrying costs, and improve cash flow.

If we look at the research table 7, there are still gaps that need to be covered on the basic level. There are instances where not integrated external warehouses are used and schedulers are not able to see owned stock held there in the system of record. This means that they are relying on 3rd party to provide data.

Data reliability in system of record is another gap that is preventing factories to move forward. There are many reasons for the inaccuracies – unaccounted manufacturing over usage or scrap factor, inhouse rework operations, stock take or system error cleanup is not frequent enough, etc.

Table 7. Inventory management factory compliance score

Inventory Management		Factory compliance
Basic	Reactive approach to inventory management	100%
	Stock is visible in main planning system for all owned materials.	64%
	Stock data in systems is reliable. Stock take and quantity adjustments are done weekly.	55%
Capable	Consistent proactive approach to inventory management: inventory health check, obsolete materials, safety stock.	46%
	Safety stock calculation methodology is defined and used. SS is being maintained in main planning system MD and is updated on a regular basis.	46%
	Main inventory KPIs are in place and being tracked consistently.	0%
	Root causing and action plan is in place to close KPI gaps	0%
Advanced	All KPIs are in place & tracking is fully automated	0%
	Regular reviews with supplier to optimize inventory levels	10%
	Stock, materials in pipeline, consignment, external warehouse stock is visible in main planning system.	64%

Source: designed by author based on research data

Less than half of the factories have a consistent approach to their inventory management – they are all ordering enough materials to ensure business continuity, but when it comes to having a KPI that defines inventory health – each plant has their own approach, which is usually based on number of pallets (warehouse capacity driven) or financial limitations in sum of EUR. Both of these measures are needed, but they do not define if the factories are over/understocked and in the case of financial limits – inflation is influencing the final result.

When looking at safety stock and material inventory targets – there is still a lack of standard methodology that could cater for differences in factory set up – infrastructure, production capacity, warehousing space, material storage requirements. A standard safety stock calculation methodology could be applied region wide, but it is extremely important, that it would be adjusted to individual factory set up requirements. Currently factories have their own methodology to calculate safety stock. Usually, it is based on planner experience, supplier responsiveness, lead times and recommendations from commercial department highlighting any structural issues in the market.

2.8. People: Training Solutions

One more very important finding that needs to be addressed is people: proper recruitment, retention, development, proper handover and onboarding. A clear trend emerged where the factory supply team that exhibited experience, comprehensive training, and minimal staff turnover, resulted in fewer supply issues. In contrast, at other factories where knowledge was lost during handovers, we observed more issues with data accuracy, lower system usage and trust, underutilization of available tools. Table 8 depicts a specific gap - the lack of fully documented processes to support onboarding, along with the absence of training programs to develop essential knowledge of system functionality.

Table 8. Training solutions factory compliance score

Training Solutions		**Factory compliance**
Basic	Exist, but not used or not appropriate.	82%
	Documented role job instructions are created and maintained annually.	10%
Capable	Standard Company training exists appropriate to all stakeholders and is embedded into development plans where appropriate.	64%
	At least one local functional expert conducts a holistic annual maturity assessment.	0%
Advanced	Continuous improvement roadmap in place.	0%
	Local functional expert active in regional/global community practices.	19%

Source: designed by author

Only one factory had a documented job instructions for each role that were maintained. Such instructions are invaluable during holiday covers or unexpected changeovers in the team where proper handover cannot be ensured.

2.9. Inbound Material Planning's Impact on End-to-End Supply Chain Performance

Inbound material planning plays a critical role in optimizing end-to-end supply chain performance. If we examine Figure 11 below, we'll see a close correlation with three other supply chain silos, each of which significantly influences the others. So E2E supply departments cannot exist individually and make decisions without taking into account others.

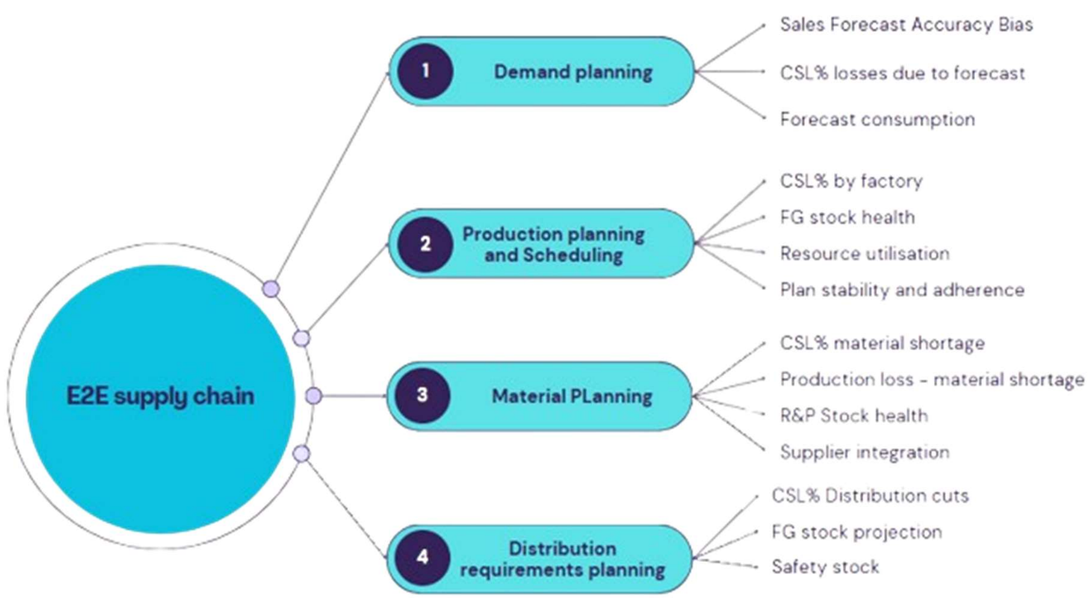

Figure 10. E2E Supply chain KPIs

Source: designed by author based on investigated company resources

Demand planning is mainly focused on accurately forecasting customer needs. For such businesses, where material lead times can be 12 weeks and contract quantities are agreed for a year in advance – demand must be planned at least for 36 months in advance to allow proper preparation for materials to be present when they are needed.

Production planning and scheduling is shorter term planning 1-36 weeks, where the factory can be flexible, but to a point of vendor fixed order timeline. Proper material planning directly impacts manufacturing and its output capacity. Adherence to production plan is also incredibly important. The more accurate and reliable factory production, less safety stock can be held in the form of finished product.

Precise manufacturing output plays an essential role in shaping distribution operations. By guaranteeing timely loading and delivery, in turn minimizing claims, it ensures that consumers receive their products on time and prevents instances of out-of-stock scenarios in the market.

3. PROPOSED SOLUTIONS: BRIDGING RESEARCH FINDINGS WITH PRACTICAL STRATEGIES

As previously mentioned, the research was conducted within the framework of People, Processes, and Systems. The synergies among these three components are crucial for ensuring the effective functioning of both the supply chain and the broader business. In the forthcoming chapters, I will present solutions aimed at addressing the identified process gaps, offering insights applicable to a wide range of manufacturing plants and industries.

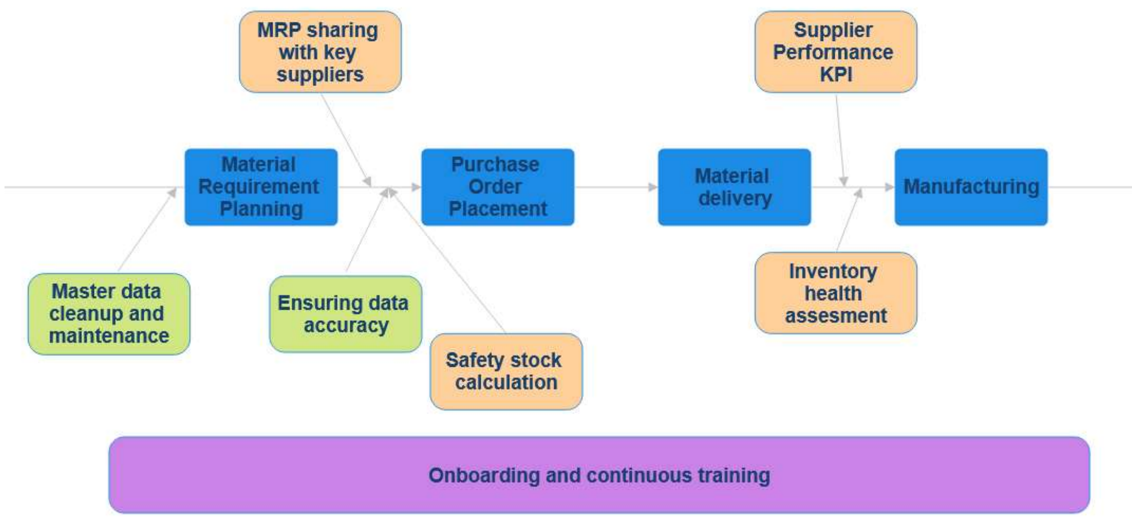

Figure 11. Proposed improvement of inbound material planning process.

Source: designed by author

Figure 11 depicted above is inbound material process chart (in blue) updated with suggested improvements, color coded by area: green – systems, orange – process, violet – people retention improvements. To maximize their benefits, each of these suggestions should be incorporated into specific stages of the material management process.

3.1. Systems

Functional systems within an Enterprise Resource Planning (ERP) framework are essential. They streamline and integrate various business processes, such as inventory management, procurement, production planning, and financial management, into a unified platform. This integration leads to improved efficiency and accuracy in operations by minimizing manual data entry and reducing errors. Functional systems facilitate standardization and automation of processes, leading to greater consistency and compliance with industry regulations and internal policies. Also, they enable real-time data visibility and analysis, providing decision-makers with timely and accurate information to make informed choices.

In order to keep inbound systems functional, precise and efficient it is necessary to maintain master data, have regular clean ups and maintain inventory accuracy.

3.1.1. Master data cleanup and maintenance

The first task for any systems assessment should be master data cleanup. Outdated master data can cause inefficiencies in procurement, production scheduling, and order fulfillment. By cleaning up obsolete materials and MRP elements, organizations can streamline processes, reduce lead times, and improve overall operational efficiency.

1. Past due MRP element list is downloaded, then closed or deleted. This could be outdated and locked purchase requisitions, overdue POs, other movements in the past that have not been completed and are no longer relevant. These elements disrupt system planning by being anticipated to arrive when in reality they won't.
2. Obsolete materials report downloaded, elements with no demand reviewed and cleaned up by deactivating code status to inactive, removing all master data behind (safety stock and MRP planning parameters), removing MRP elements and retiring. The obsolete material list should undergo validation, as there may be valid reasons for an organization to keep a code active despite not currently using it.
3. MRP master data review and update should happen at least annually. This ensures that any changes in parameters that could impact planning, such as supplier lead times or lot sizing, are promptly addressed and incorporated. Below is an example of SAP MRP master data fields that should be tracked for full functionality.

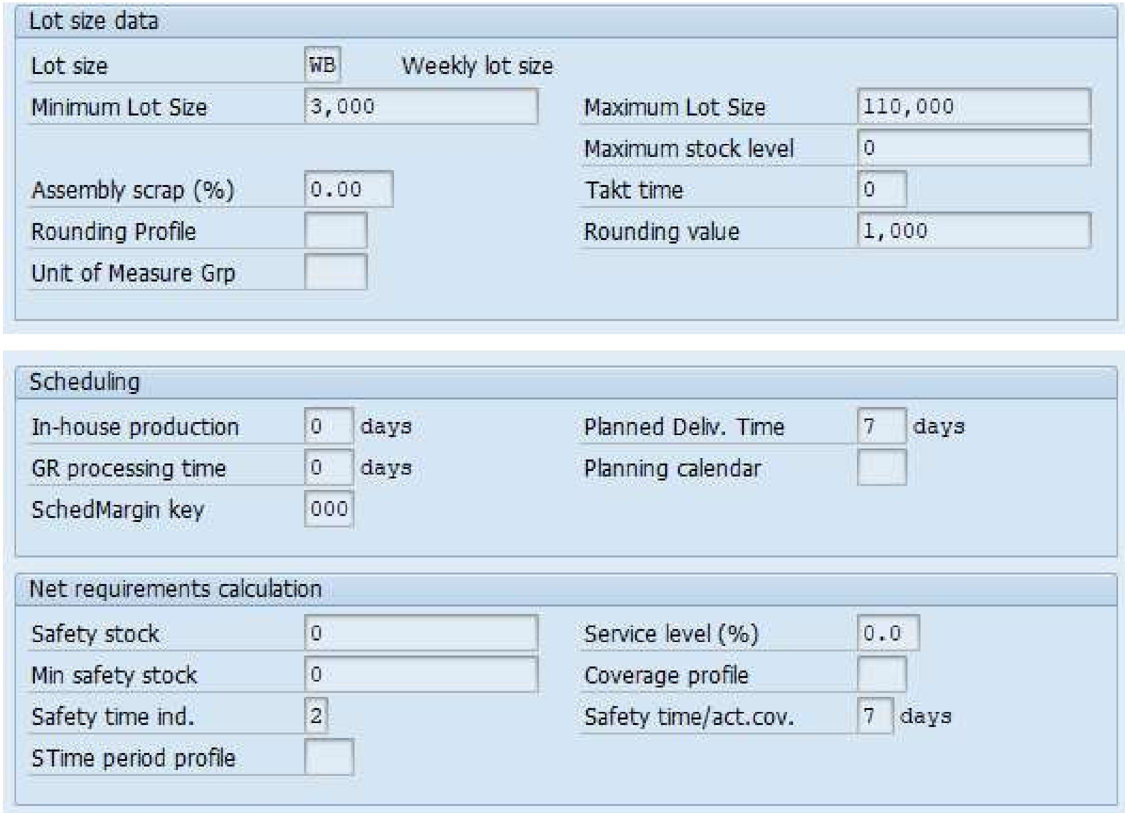

Figure 12. Main MRP master data fields in SAP ERP

Source: investigated company resources

Master data maintenance encompasses several key functions. Commercial operations are responsible for supplying market insights and supplier relations data, which may prompt updates to MRP fields. Logistics evaluates these fields based on experience, considering supplier performance and delivery issues. Operations and product/technology engineers contribute feedback on material processability and quality. Keeping Master data in good health is a joint effort, thus time and resources should be planned in advance for these activities, to ensure its completed.

3.1.2. Ensuring data accuracy

To fully leverage systems, we must have confidence in the accuracy of the data they contain. Processes, protocols and daily error checks must be in place to ensure data reliability. Material backflush and any errors it may contain should be assessed without delay.

On the other hand, to instill confidence in the accuracy of system data, regular inventory stock takes should be conducted to make sure physical stock and systems stock aligns. These changes usually come from manufacturing scrap or over usages, so regular inventory stock take process should be set up.

3.2. Processes

Defined processes ensure consistency in product quality and performance. When every step of manufacturing is clearly outlined and followed, there's less variation in the final output, leading to higher customer satisfaction and fewer defects. It also provides a baseline for continuous improvement initiatives. By analyzing existing procedures and identifying areas for optimization, manufacturers can streamline operations, reduce costs, and stay competitive in the market. Bellow I will suggest processes that will help with highlighted supply chain risk management gaps – supplier relations and inventory health assessment.

3.2.1 Risk management proposals

As seen in the research findings – risk visibility and risk management are most concerning. In order to improve transparency in the supply chain it is essential to build lasting, integrated and mutually beneficial relationships with suppliers. The market dynamics have shifted away from favoring buyers, where the cheapest solution would be chosen. Now it is more about being the preferred customer and long-term partner that brings benefits to both supplier and manufacturer.

To enhance risk visibility and expand it beyond supplier lead times, companies must supply the relevant data. One suggestion is to integrate systems through API links, share access to non-confidential manufacturing planning modules, or establish automated reports detailing material demand. Implementing any combination of these measures can significantly boost risk assessment and management efforts. Sharing material requirement forecast short to mid-term with key suppliers empowers them in making their own decisions on capacity planning, securing raw materials and planning optimal production runs. See Table 9 as an example of such shared data. Integrated and informed suppliers can provide valuable feedback when they are unable to fulfill future demand, leaving plenty of time to find alternative solutions and also save costs due to better planning opportunities.

Table 9. Example of material demand forecast file.

Material	current stock	orders in pipeline	Demand							
			W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
X1	100	0	20	30	20	15	0	30	10	20
X2	30	50	10	10	20	10	0	15	20	10
X3	20	75	10	20	5	10	0	5	20	0
X4	300	500	120	100	80	130	0	150	70	0
X5	285	0	25	25	25	25	0	25	25	25
X6	75	0	10	15	5	20	0	15	10	5

Source: created by author

Supplier performance tracking and regular reviews should also be introduced at least annually for well performing suppliers and more regularly depending on service levels. Material planner should be tracking supplier performance KPI (preferably automated and integrated into local systems). Below is the list of the most essential KPIs in the industry, that should be introduced to supplier performance scorecard:

- On time delivery
- Delivery in full (quantity/volume)
- Quality performance
- Contract compliance

All of these points should be discussed while during performance reviews and before renewing contracts.

3.2.2. Inventory health analysis proposal.

To have a healthy stock first it is essential to analyze it and identify safety stock, obsoletes, and assess overstock.

3.2.3. Proposed Safety stock calculation methodology.

The size of safety stock is unique to each factory. There are a lot of factors that need to be taken into consideration while calculating it:

- Material demand quantity (per chosen time period)
- Lead time (from the point of order placing to delivery at site)
- Supplier Error (% of delivery not in full and/or not on time)
- Delivery frequency
- Scrap factor (manufacturing unaccounted over usage)
- Single/multi sourced material (is there a backup or emergency supply options?)
- Quality rejection probability (% of deliveries that are rejected)
- Quality check time (in days)
- Criticality of material (is this material main ingredient, is it used in all products, is it interchangeable with other materials?)
- Material usage standard deviation
- Other safety time requirements (in days)

Table 10 contains an example calculation of SS model. It assesses various factors that cause a risk to the supply chain and proposes a recommendation on the SS. This model can be assessed and changed depending on each industry standards. It could give more weight to each of the factors by adding a coefficient to the formula.

Table 10. Safety Stock calculation example model

Input												Calculation				
Material	Weekly Demand, t	Lead time, days	Supplier Error, %	Frequent delivery, yes=0/no =1	Scrap factor, %	Single sourced, yes=1/no =0	Quality rejection probability, %	Quality check, days	Criticality, yes=1/no =0	other, days	Material usage st.dev, %	Reaction time	Risk factor	combined error St.Dev, %	Recommended SS, Days	Recommended SS, t
x1	20	4	5	0	1	0	1	0	1	0	33	4	1.1	33.4	1.4	4.0
x2	33	14	2	0	3	0	2	0	1	0	60	14	1.0	60.1	8.8	41.3
x3	2	7	20	1	5	1	4	0	1	0	0	7	3.2	20.6	4.7	1.3
x4	15	5	25	1	10	0	5	1	1	0	35	6	2.3	44.2	6.1	13.1
x5	6	2	20	0	5	0	4	0	0	1	78	3	0.2	80.7	0.6	0.5
x6	1	45	15	1	2	1	1	0	1	0	70	45	3.2	71.6	101.8	14.5
x7	105	7	10	0	4	0	3	0	1	0	50	7	1.1	51.1	4.0	60.7
x8	60	30	5	1	6	0	5	0	1	0	44	30	2.1	44.7	28.2	241.3
x9	45	14	40	1	8	0	2	3	0	0	37	17	1.4	55.1	13.3	85.5
x10	4	60	18	0	5	0	3	0	1	0	25	60	1.2	31.2	22.7	12.9
x11	0.5	21	23	0	9	0	5	0	0	0	16	21	0.3	29.4	1.7	0.1
x12	124	7	3	0	2	1	4	0	1	1	76	8	2.1	76.1	12.6	223.2
x13	16	5	5	0	3	0	6	5	1	0	81	10	1.1	81.2	9.0	20.6
x14	85	5	26	0	4	1	2	0	1	0	11	5	2.3	28.5	3.3	39.5
x15	90	7	8	0	11	0	7	0	0	1	16	8	0.2	21.0	0.3	3.2
x16	68	30	26	1	4	0	2	2	0	1	37	33	1.3	45.4	19.2	186.3
x17	5	21	15	1	2	0	3	0	1	0	25	21	2.2	29.2	13.4	9.6
x18	23	3	3	0	7	0	7	1	0	0	13	4	0.1	15.1	0.1	0.2

Source: created by author

The inputs in the table have to be provided by experienced material planners. While the calculation goes forward as follows:

Reaction time (RT) is calculated by adding Lead time (LT), Quality check (QC) and other days (OD):

$$RT = LT + QC + OD \tag{1}$$

Risk Factor (RF) takes into account all variables that could potentially increase risk such as:

- Supplier reliability (SR) (how often the supplier is delivering in full and on time),
- delivery frequency (FD) (frequent deliveries lower the risk, but each site has to define what is “frequent”),
- single sourced (SSo) materials naturally have more risk in case the supplier has issues
- quality rejection probability (QRP)
- Criticality (C) (sites also have to define which materials are critical for production)

$$RF = \frac{SE}{100} + FD + SSo + \frac{QRP}{100} + C \tag{2}$$

Combined Error standard deviation (CE) is calculated by taking into account supplier error (SE), Scrap Factor (SF) and material usage standard deviation (MU)

$$CE = \sqrt{SE^2 + SF^2 + MU^2} \tag{3}$$

Recommended SS in days coverage (SSd) and SS in quantity (SSq)is calculated with the formulas bellow, where D=demand, n= number of days in a period for demand considered:

$$SSd = RT * RF * \frac{CE}{100} \tag{4}$$

$$SSq = SSt * \frac{D}{n} \tag{5}$$

3.2.4. Obsolete materials clean up.

Obsolete materials need to be removed both in systems and physically. Obsolete materials are materials that:

1. Have no future demand for consumption.
2. Are old materials, that have been retired (ex. after pack design or component change)
3. Have not been used for a pre-defined time. (each industry should assess how much time is necessary to fully retire and close unused items)

In Table 11, there is an example of obsolescence assessment and the comparison ratio in value.

Table 11. Example of obsolete materials value ratio assessment

Plant	Sum of SOH.	Sum of Obsolete €	Sum of % Used
1	€ 2 000 000	€ 20 000	99.0%
2	€ 3 200 000	€ 40 000	98.8%
3	€ 9 100 000	€ 150 000	98.4%
4	€ 4 000 000	€ 200 000	95.0%
5	€ 8 000 000	€ 450 000	94.4%
6	€ 3 500 000	€ 290 000	91.7%
7	€ 7 800 000	€ 900 000	88.5%
8	€ 2 400 000	€ 300 000	87.5%
9	€ 10 000 000	€ 1 200 000	88.0%
10	€ 3 000 000	€ 500 000	83.3%
11	€ 4 000 000	€ 850 000	78.8%
Grand Total	**€ 57 000 000**	**€ 4 900 000**	**91.4%**

Source: created by author

After obsolete materials are identified they should be checked if indeed they will no longer be used and if so – scrapped from the system and physically removed. Such materials are using up space in the warehouses influencing cost, and are slowing down systems. So a standard approach should be implemented and regularly completed. Depending on the industry, such cleanups should be performed at least once per quarter to make sure materials are not taking space without usage.

After identifying and removing obsoletes from reporting, the slow-moving and healthy inventory can be analyzed. Stock coverage in days could be a good indication for this analysis (See Table 12). The essence of this calculation is how long the available quantity of stock will cover the planned demand. This analysis should be done for each material used in production. Most of the ERP systems are able to provide this data.

Table 12. Example of material stock coverage in days calculation

Date	Stock	Demand	Stock coverage
2024-04-24	100	50	2.5
2024-04-25	50	20	1.5
2024-04-26	30	60	0.5
2024-04-27	-30	30	0

Source: created by author

Each factory in any industry should define what is their acceptable stock coverage in days – it could vary factory to factory/ industry to industry. Slow moving inventory are materials that are used up much slower than most other items. This is usually caused by low demand, high minimum order quantity (MOQ) from the supplier, or both. The general approach would be 80-20 (see Table 13), for example, if 80% of materials are used up within 10 days and the remaining 20% take on average 31 days to be used. The indicated 20% of materials need to be assessed and determine if following solutions would be feasible to lower stock:

1. Lower the MOQ, without impacting cost.
2. Consignment buys possibility.
3. Increase production rates.
4. Assess BBD expiry and scrap possibility and what would that account to.

Table 13. Example of materials coverage in days analysis using 80/20 approach.

Material no.	days coverage	average 80/20
x1	3	7
x2	5	
x3	5	
x4	6	
x5	7	
x6	8	
x7	9	
x8	9	
x9	11	
x10	12	14
x11	15	
x12	15	

Source: created by author

Not all solutions might be feasible, but it is important to do the analysis and determine if this coverage is acceptable or can be modified to secure the needed materials for production and on the other hand to freeze as little assets as possible.

3.3. People

People are at the heart of every business, serving as its most valuable asset and driving force. Collective efforts and collaboration of people within an organization determine its ability to adapt to change, overcome challenges, and thrive in competitive markets. Thus, recognizing the importance of people and investing in their development, well-being, and engagement is essential for building a strong and sustainable business foundation.

This chapter discusses proposals for knowledge retention and effective collaboration strategies.

3.3.1. Training plan, certification, and documented roles

Factory research findings confirm, when the logistics teams are experienced and knowledgeable overall their supply chains are more resilient and better managed. So training, talent retention and knowledge retention is key. Of course, people in the organization will change, move up the career steps and will eventually leave their current positions, but proper training, certification programs and proper process documentation will ensure knowledge retention in the team. We're all familiar with scenarios where training is rushed or nonexistent, leaving new colleagues to navigate high stress levels and lack of support. Figure 13 below depicts a proposed knowledge retention strategy that would ensure each member of the team is equipped with the tools necessary to succeed in their role.

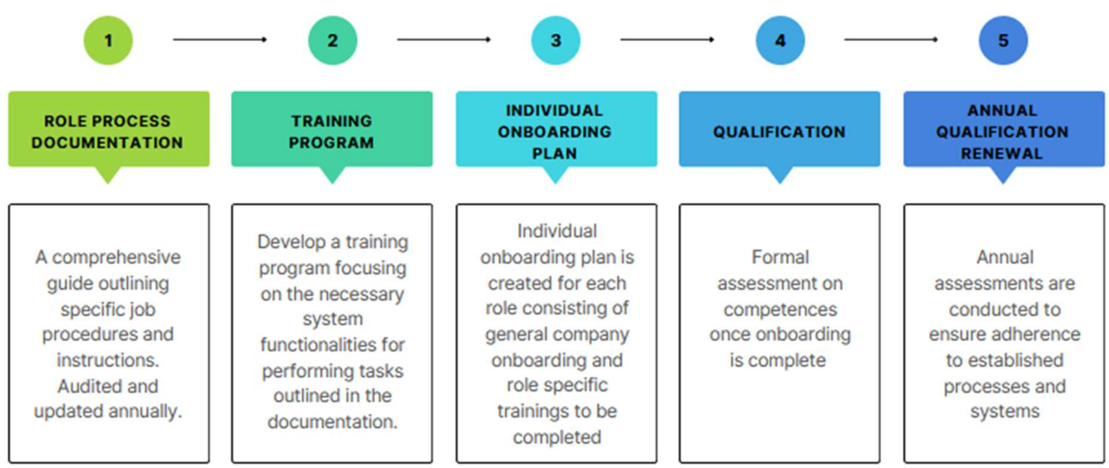

Figure 13. Knowledge retention strategy. Source: designed by author

It is essential that each work position has a documented detailed steps for any processes under their responsibilities with as much detail as possible – screenshots, explanations, links to required systems. Such documentation also should be audited at least annually to update on any changes in the process. Once this documentation is available and precise it is much easier to train new colleagues and support holiday covers.

It is always best option for the new employee to be trained by the same person that had this role before, but unfortunately it is not always possible. So having a functional training that goes through the main processes mentioned in the role documentation and systems that back the process up is essential for knowledge retention. This training could be used each time the employee needs to doublecheck the process, thus must be pre recorded and stored in an easily accessible location.

When hiring a new employee, an onboarding plan should be prepared for each individual. It should consist of two parts:

1. General Company Onboarding (finalized on the first day):
    a. Administrative Tasks (contracts, taxes, benefits, confidentiality agreements, etc)
    b. Safety Policies and Procedures
    c. Company Policies and Guidelines
    d. Company Culture Introduction
2. Role Specific (finalized within 3-12 months in role):
    a. Role Description, Responsibilities and Accountability
    b. Performance Expectations and Quality Control KPI
    c. Functional Training
    d. Qualification

Qualification is a formal assessment that follows the training program. The new employee can be assessed either by a functional expert in the team or by passing a test.

Annual qualification renewal is also recommended to retain adherence to established process, ensure systems knowledge, master data importance and various transaction and reporting options.

CONCLUSIONS AND PROPOSALS

1. Having overviewed traditional supply chains it was determined that traditional supply chain methods need reassessment to accommodate the new global trade reality. Three key areas businesses need to consider are processes, technology, and people. Advanced technology solutions can enhance supply chain efficiency by enabling predictive analytics that enable risk visibility and support decision making.
2. Having revealed that recent supply chain disruptions caused by climate change derived disasters including COVID-19 and animal disease can immediately destroy prior developed and implemented manufacturing and distribution plans. Implementing JIT can lead to significant savings for companies that can meticulously establish their planning systems. But all those benefits can be taken only in predictable conditions.
3. Having gathered data from research objects supply chain weaknesses have been identified. One of the most worrying findings was the risk visibility, which usually is limited to the supplier lead time. Risk assessment and management process compliance ranged from 20% to 80% across different factories. Another relevant finding is about safety stock and material inventory targets – there is still a lack of standard methodology that could cater for differences in factory set up, while Inventory management process compliance ranged from 10% to 60% between the 11 sites. Master data quality and maintenance (compliance score between 11% to 78%) was also one of the main reasons that limits full usage of system capabilities, together with limited knowledge retention and training strategies in organizations.
4. Using People, Process, Technology framework proposals have been created to increase supply chain reliability and close the identified gaps. An improved inbound supply chain model has been introduced to close the gaps in the process and improve SC resilience.

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APPENDIX

1. Questionnaire and Research data

	Factory	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Material planning process score		3.5	4.5	3	6	5	4	2.5	6	5	4	4	
Basic	Planners have the basic understanding of material planning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
	Planners ensure continuous flow of required materials according to manufacturing planning data.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
	If Materials Planning is done outside of the system, inputs are maintained to track material deliveries.	Yes	Yes	Pack	Yes	Yes	Yes	Pack	Yes	Yes	Yes	Yes	10
Capable	Materials Planning is done fully in the system with MD and parameters maintained.	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	5
	PO changes are tracked manually, root caused, analysed and actioned.	Pack	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7.5
	Exceptions management is tracked in system of record.	No	No	No	Yes	No	No	No	No	No	No	No	1
	MRP run outages can be identified, corrected or escalated.	No	No	No	No	No	No	No	No	No	No	No	0
Advanced	KPI reporting is available in automatic dashboards	No	No	No	No	No	No	No	No	No	No	No	0
	PO changes are tracked automatically by the system, root caused and actioned.	No	No	No	No	No	No	No	No	No	No	No	0
	Materials Planning is done with exceptions management and actioning by exception only.	No	No	No	No	No	No	No	Yes	No	No	No	1
	Integrated Planning system with E2E visibility and exceptions/constraint management capability to optimize material supply	No	Pack	Pack	No	No	No	No	No	No	No	No	1
Master Data Maintenance & Audit score		3	3	1	7	6	1	2	7	4	5	2	0
Basic	Master Data is maintained for Pack materials	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Capable	Master Data is present for key planning fields.	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
	Master data is regularly collected and maintained.	No	No	No	Yes	No	No	No	Yes	Yes	Yes	No	4
	Past due elements are cleaned weekly.	No	No	No	Yes	Yes	No	No	Yes	No	No	No	3
	Obsolete materials are regularly cleaned from the system, process and responsibilities are defined and followed.	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No	No	5
	Planners understand master data impact on system functionality	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	6
Advanced	Master data audit process is established and performed on quarterly basis.	No	No	No	No	No	No	No	No	No	No	No	0
	Planners understand all parameters and optimize them in daily work.	No	No	No	Yes	Yes	No	No	Yes	No	Yes	No	4
	Supplier SLA's actively influence MD and parameter definition.	No	No	No	No	No	No	No	No	No	No	No	0

Risk Assessment & Management Score		6	6.5	6	8	5	4	4.5	2.5	6.5	4	4	0
Basic	Material planner running daily checks to spot and manage risks in the next 72h.	Yes	No	No	Yes	Yes	No	Pack	Yes	Yes	No	No	5.5
	Material planner is able to do scenario planning to define risk	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
	Mitigation actions are escalated and delegated without delay.	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	9
Capable	Escalation matrix and short term risk FMOS meeting structure established	No	No	Yes	Yes	Yes	No	No	No	Yes	No	No	4
	Material planner is proactively assessing material risk impact 0-12 weeks	No	Pack	Pack	Yes	Yes	No	No	No	No	No	No	3
	Material planner is able to do scenario planning, define actions to mitigate material outages and escalate risks to cross functional stakeholders in time.	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	8
Advanced	Cross functional FMOS meeting structure established for 0-12weeks supply risk horizon	No	Yes	Yes	No	No	No	No	No	No	No	Yes	3
	Material planner is able to spot and escalate risks on time to prevent high impact on business and engages other functions into mitigation actions. No line stoppage due to materials in the last year.	Yes	Yes	No	Yes	No	Yes	No	No	Yes	Yes	No	6
	Requirements for 0-12months are shared with Suppliers	Pack	Pack	Pack	Pack	Pack	No	Pack	No	Pack	Pack	No	4
	Supplier portal is used for supplier collaboration.	Pack	Pack	No	Pack	Pack	No	Pack	Pack	No	Pack	No	3.5

Inventory Management		5	5	1	5	5	2	1	6	5	5	2	0
Basic	Reactive approach to inventory management	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
	Stock is visible in main planning system for all owned materials.	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	No	7
	Stock data in systems is reliable. Stocktake and quantity adjustments are done weekly.	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	No	6
Capable	Consistent proactive approach to inventory management: inventory health check, obsolete materials, safety stock.	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	5
	Safety stock calculation methodology is defined and used. SS is being maintained in main planning system MD and is updated on a regular basis.	Yes	Yes	No	Yes	No	No	No	Yes	No	No	Yes	5
	Main inventory KPIs are in place and being tracked consistently.	No	No	No	No	No	No	No	No	No	No	No	0
	Root causing and action plan is in place to close KPI gaps	No	No	No	No	No	No	No	No	No	No	No	0
Advanced	All KPIs are in place & tracking is fully automated	No	No	No	No	No	No	No	No	No	No	No	0
	Regular reviews with supplier to optimise inventory levels	No	No	No	Yes	No	No	No	No	No	No	No	1
	Stock, materials in pipeline, consignment, external warehouse stock is visible in main planning system.	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	7

Supplier Management Score		3	3	2	2.5	3	1	1.5	2	2.5	2.5	1	0
Basic	Material planner communicates with supplier on ad-hoc basis for order management	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
	Supplier proactively informs change in delivery schedule or quantities. Material planner is tracking overdue POs in the system.	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	7
Capable	Material planner participates in supplier onboarding to ways of working	No	No	No	No	No	No	No	No	No	No	No	0
	SLA is part of contract and is maintained with all suppliers.	No	No	No	No	No	No	No	No	No	No	No	0
	Manual supplier scorecard in place with root causing and actions to adress gaps	No	No	No	No	No	No	No	No	No	No	No	0
Advanced	KPI tracking automated via system	No	No	No	No	No	No	No	No	No	No	No	0
	Automatic medium term (0-12 months) demand sharing with supplier weekly.	Pack	Pack	Pack	Pack	Pack	No	Pack	No	Pack	Pack	No	4
	Firm horizon is aligned with supplier and documented in SLA	No	No	No	No	No	No	No	No	No	No	No	0
	Supplier inventory levels are visible in the system	No	No	No	No	No	No	No	No	No	No	No	0
	Material planner has acces to supplier capacity outlook	Pack	Pack	Pack	No	Pack	No	No	No	No	No	No	2
Training Solutions Score		3	2	2	2	3	2	1	0	2	1	1	0
Basic	Exist, but not used or not appropriate.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	9
	Documented role job instructions are created and maintained annualy.	No	No	No	No	Yes	No	No	No	No	No	No	1
Capable	Standart Company training exists appropriate to all stakeholders and is embedded into PDP where appropriate.	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	7
	At least one local functional expert conducts a holistic annual maturity assessment.	No	No	No	No	No	No	No	No	No	No	No	0
Advanced	Continuous improvement roadmap in place.	No	No	No	No	No	No	No	No	No	No	No	0
	Local functional expert active in regional/global community practices.	Yes	No	No	No	No	No	No	No	No	Yes	No	2
Cross Functional participation / collaboration Score		2	3	2	2	2	2	2	2	2	2	2	0
Basic	Collaboration with commercial, production planning and scheduling on ad hoc basis.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Capable	Material planning, commercial, production planning, production scheduling collaborate in managing constraints	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Advanced	All supply chain functions have an active role to play with right share of voice in managing materials through KPIs and formal sessions led by meeting structure	No	Yes	No	No	No	No	No	No	No	No	No	1
Performance Management KPIs Score		4	4	3	4	2.5	1	2	3	3	3	3	0
Basic	Not all KPIs are in place and tracking is fully manual. Understanding of KPIs and how they are measured differs between functional teams.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Capable	Key KPIs are in place and tracking is partially automated	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	10
	Root causing and action plan is in place to close KPI gaps	Yes	Yes	Yes	Yes	Pack	No	No	No	Yes	No	No	5.5
	Pack understanding of inter-dependencies between functional and organizational KPI	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	6
Advanced	KPIs are on track consistently for min 6 months.	No	No	No	No	No	No	No	No	No	No	No	0
	Strong understanding of inter-dependencies between functional and organizational KPI	No	No	No	No	No	No	No	No	No	No	No	0
Total maturity evaluation		29.5	31	20	36.5	31.5	17	16.5	28.5	30	26.5	19	0
Compliance		60%	63%	41%	74%	64%	35%	34%	58%	61%	54%	39%	0

2. Article to be published in Prof. Vladas Gronskas International Scientific Conference Vol. 37 (2023) https://www.journals.vu.lt/proceedings/issue/view/2375

ENHANCING SUPPLY CHAIN SYNCHRONISATION IN THE FAST MOVING CONSUMER GOODS INDUSTRY

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Abstract. In 2021-2022, a decade's worth of disruptions hit material supply chains and they are becoming a permanent factor. COVID-19 caused labour shortages, rising fertilizer costs altered farming, Europe faced energy crises, USA-China tensions grew, and Ukraine-Russia war escalated. Extreme weather and policy shifts worsened global supply chains, leading to bare shelves and crippled businesses. Just-in-time delivery failed, and traditional supply chains no longer ensure business continuity. The purpose of this article is to prove the inefficiencies of traditional supply chains and offer an approach to create an end-to-end model with better visibility, service, and cost control for Fast-Moving Consumer Goods (FMCG) manufacturing plants. During the research phase 12 European Pet food production plants were visited analysing their supply chains via People/Systems/Process lenses. Risks, synchronization needs, system requirements and training gaps were identified. Preliminary research findings are presented in this article.

Key words: *Supply Chain disruption, Manufacturing, Fast-moving consumer goods, Continuous improvement.*

Introduction

Relevance of the article

The global supply chains have been shaken during the last few years. Covid-19, wars, extreme weather events, economic and political instability unprecedentedly shook the global trade, and it seems that such events will continue and become the new normal. Research is needed to help organisations become resilient and continue operations while facing these new challenges.

Problem investigation level

There are a lot of resources available that recommend a lean supply, just in time deliveries, inventory control. All those papers were right for the time they were written in. Unfortunately, the circumstances business operate in have changed and there are very few papers that would stress agility and resilience more than immediate cash benefits, while stopping the factory due to lack of materials is extremely expensive.

Scientific problem

How to strengthen and adapt the global supply chains to compensate for unpredictable force majeure that is more common than expected? How to increase supply chain risk visibility and transparency?

Object of the article – Fast-Moving Consumer Goods (FMCG) manufacturing sites and their global supply chains.

Aim of the article – to research and define the inefficiencies of traditional supply chains in the changing global environment and argue this model can no longer ensure business continuity. An end to end supply chain visibility and proper enterprise planning must take place in order to avoid losses due to missed deliveries.

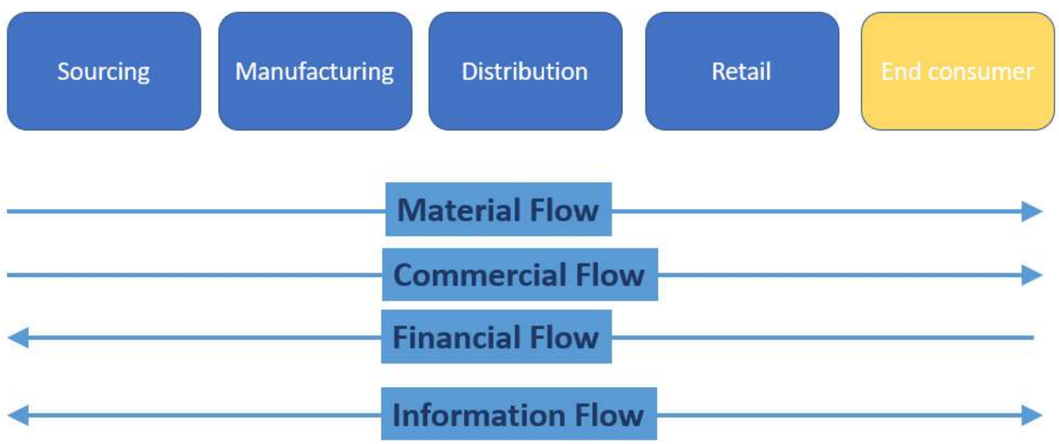
Objectives of the article:

1. To overview traditional supply chains.

2. To reveal recent supply chain disruptions.
3. To clarify findings of research done in 12 FMCG factories.

1. Traditional supply chain model and just in time concept

In the APICS dictionary (Pittman & Atwater, 2016), the term “supply chain” is defined as a set involving all processes that connect producing firms and consumers. These processes start with supplying the raw materials and finish with final product delivery to consumer. Additionally, the term "supply chain" is defined as a compilation of both internal and external activities within an organization, enabling the value chain to offer services and products to clients. (Cox et al., 1995). “Supply chain is defined as a group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-consumers” (Lu, 2011). In other words – it is a flow of materials, information, finance and commercial from the extraction of raw materials to final product sold to end consumer. Active control strategies are often used for the management of supply chain systems, where nonlinear control synthesis is recommended (Xu et al., 2022). These authors emphasize that the use of System Dynamics Theory can be a potentially effective strategy to deal with chaotic supply chains with unpredictable behavior over time. Other authors (Wofuru-Nyenke et al., 2023) have explored recent trends in sustainable manufacturing supply chain modeling. These studies aimed to identify modeling approaches. Assessing the challenges posed by COVID-19 in adapting supply chains to function in suddenly changed conditions, significant research on strategy formation in crisis situations was analyzed (Durugbo & Al-Balushi, 2023). Such strategies are fundamentally different from conventional strategies that focus on the development of competitiveness. The COVID-19 epidemic has drawn the attention of companies to blockchain technology, which can help companies quickly gain competitiveness in the market. However, this technology also requires large financial investments. To solve this problem, an effective supply chain contract can be started with the adoption of blockchain technology in the supply chain (Liu et al., 2023).



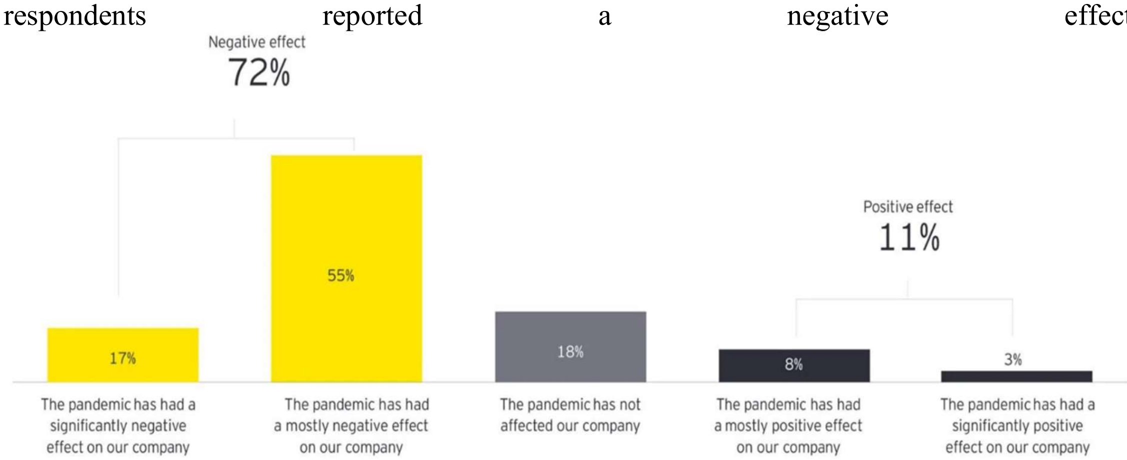
Source: created by the author.

Fig. 1. Supply Chain flows

Often, companies concentrate on financial and material flows, that allow operations short term, not allocating enough resources to information, and commercial flows, which are crucial long term. In past studies, several strategies were provided for supply chain, which can generally be divided into two categories: responsive/agile supply chain strategies, and efficient/lean supply chain strategies (Fisher, 1997). Toyota, a leader in innovative Lean manufacturing strategies, introduced its Just-in-Time (JIT) strategy. As M'Barek, Fujii and Ohtaki (1988) described in their paper - it is designed to produce and deliver materials, parts, and components just before they are needed. This strategy is well known to result in a considerable cost reduction and improvement in total productivity in many types of manufacturing companies. It is based on close relationship with the supplier, allowing accurate planning of materials avoiding inventory storage. Implementing JIT can lead to significant savings for companies that can meticulously establish their planning systems. JIT became a go-to strategy for many manufacturing companies seeking to optimize resources and achieve cost and cash savings. But in today's environment, not having any safety stock and relying on supply chains designed for a stable global market brings huge risks and potentially enormous costs if production must be stopped due to disrupted deliveries and lack of materials. This is exactly what happened to Toyota after the earthquake in Japan in 2011. Most of Toyota's Japanese plants were closed for nearly two months. In addition, Toyota's north American production was cut to 30% for the subsequent 6 months due to a shortage of 150 different parts which should have been produced by Toyota's Japanese plants (Canis, 2011) Toyota had a 77% fall in profits in the second quarter of 2011, equivalent to $1,36 BN (MacKenzie et al., 2012). Toyota learned this painful lesson early and revised its operating strategy, while the rest of the world did so only in 2020 after experiencing disruptions in the supply chain due to Covid-19. That is why Toyota did relatively well during 2020-2021, while most of other companies struggled to get the needed materials and components for production.

2. Post pandemic supply chain trends

Harapko (2023) working in Ernst & Young LLP (EY US), a global business consultancy company, conducted a survey of 200 senior-level supply chain executives in late 2020 and then in 2022 to determine how/if Covid-19 pandemic impacted global supply chains. 72% of respondents reported a negative effect.



Source: Harapko, S. (2023).

Fig. 2. Survey results – pandemic effect on the business

According to the executive supply chain survey, it is evident that top priorities include enhancing visibility, efficiency, and reskilling supply chain personnel. These results align with expectations, considering that cost optimization in the supply chain remains a consistent focus, even when bolstering resilience. Traditionally, cost reduction involved lean operations, extended lead times, and low-cost labour. Looking ahead, the emphasis shifts towards agility, visibility, automation, and upskilling the workforce. These factors not only contribute to cost reductions but also foster improved decision-making, standardized processes, and excellence throughout the supply chain and collaborative partners within the ecosystem. The surveys highlight that supply chain visibility ranked among the top three priorities in late 2020 and claimed the top spot in 2022. Despite its prominence, achieving comprehensive supply chain visibility remains an ongoing effort. Although Covid-19 was the first factor that shook up the global supply chains, now it is only one of many over the last 3 years. Executives acknowledge the heightened strategic significance of their supply chain due to the changing global trade environment. Consequently, businesses are forced to promptly establish a supply chain structure that aligns with the demands of the emerging digital and autonomous-focused era. To sum up, we can observe a trend where supply chains require adaptation to enhance agility and transparency, that is crucial for supporting business operations. Technological innovation plays a pivotal role in facilitating data analytics, thereby furnishing a foundation for strategic decision-making within organizations. To analyze this problem further and identify the specific challenges confronting businesses, a case study was conducted.

3. Optimizing FMCG Supply Chains: A Comprehensive Analysis of 12 Case Studies

Research methodology

Aim of the research – Define "as is" material management process, identify supply chain weak points and gaps, propose solutions.

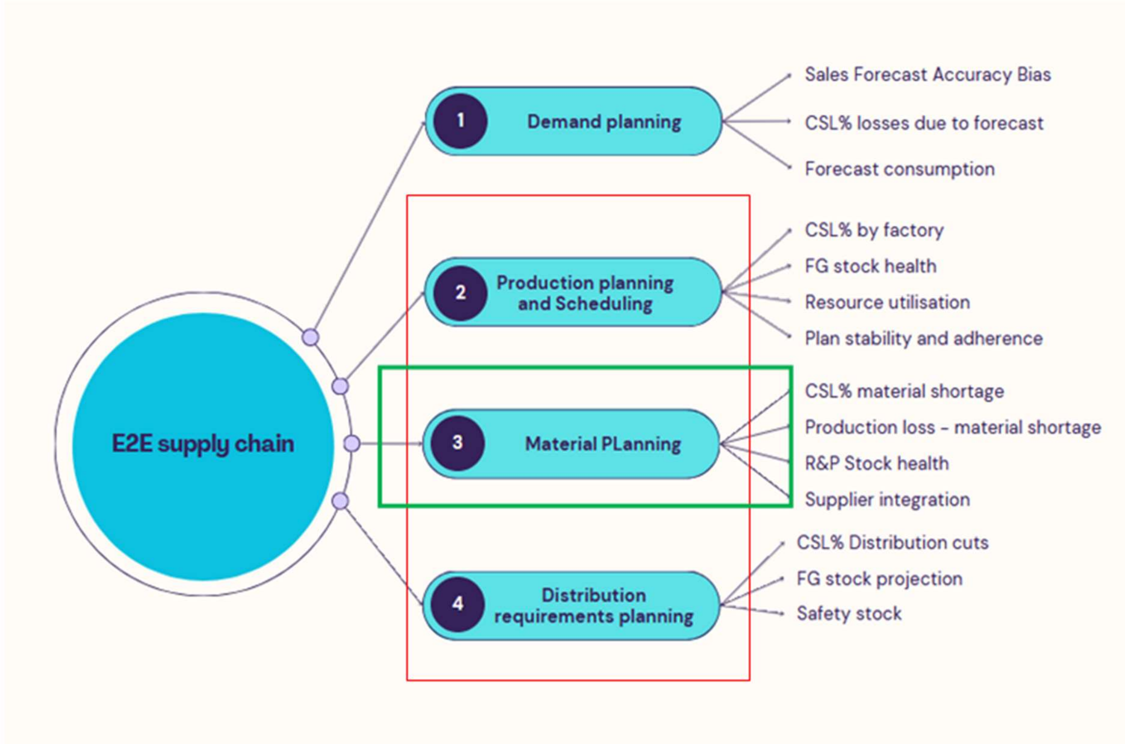
Objectives of the research:

1. Define "as is" material management process.
2. Identify supply chain weak points and gaps.
3. Propose solutions and methodology for continuous improvement.

Selective Sample. 12 EU and UK Pet Food manufacturing plants.

Research methods

The research was conducted July-November 2023. Each production plant has been physically visited and audited. Qualitative research methodology was used – only matter experts considered. Interviews were carried out with factory raw/pack material planners, deep diving into their daily routines ordering materials for production. The planners were asked to describe their daily tasks step by step, making sure to cover all areas relevant to the research: Master data maintenance, MRP runs, Requirements, Ordering procedure, Risk assessments and Risk management, Inventory assessment and management, new product development and other activity management, Supplier relations and Performance Management. The planners answered open questions to get the full overview, avoiding bias and predisposition.



Source: Company inner resources.

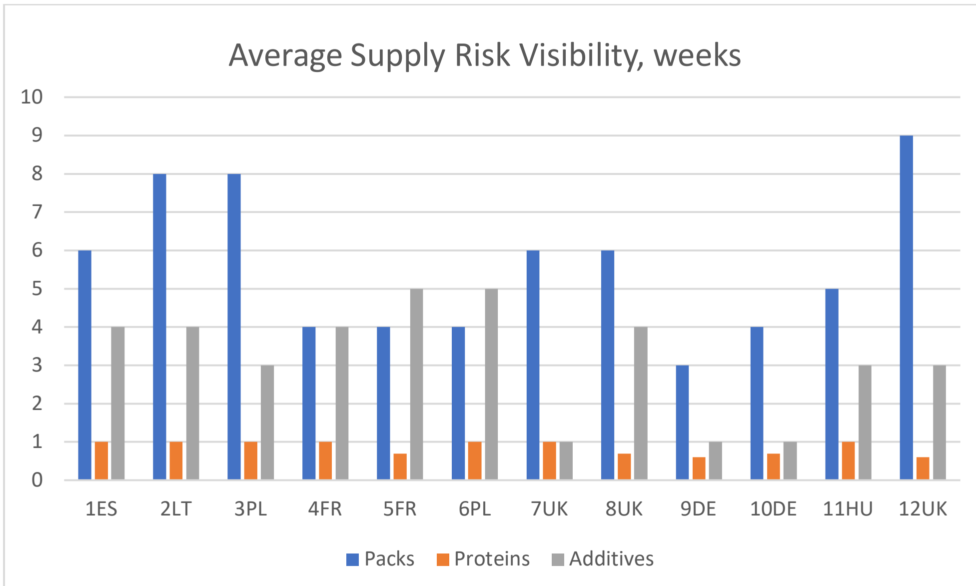
Fig. 3. End to end supply chain components and their KPIs

Systems experts, scheduling and commercial specialists, logistics managers and factory leadership team were also interviewed to define their input to the factory supply chain. Visual inspection and observation methodology was also used – in addition to the physical interviews in the factory office, a factory tour was also arranged to get to know the technologies, capacity constraints, systems integrations, infrastructure and accessibility, storage capabilities, etc. The factory tour is most valuable tool to witness each sites unique setup and understand why certain ways of working are applied. Focus groups were created with relevant site team members to discuss first findings and preliminary risk factors, urgent actions (if any), and continuous improvement action plan. The collected data is non numerical, it is detailed information on processes, systems, and people integration. Based on the collected data, each site will be evaluated following the same template, clearly indicating the current "as is" maturity level, stating the gaps and defining the maturity level – basic, capable, advanced or enterprise. The template was prepared and created by the investigated company, following their enterprise planning guidelines.

Research data analysis and discussion of the results

The analysis and comparison of research data is still ongoing, but the preliminary findings have already prompted the company to implement new KPIs, training programs, communication strategies and process change procedures. An ingrained continuous improvement mindset in the company is allowing for these changes to be implemented relatively smoothly – factory teams are engaged, understand the bigger picture and welcome positive change. There were several benchmarking opportunities identified, where some factories have very effective processes that could be deployed to others.

Among the most worrying findings was the risk visibility, which usually is limited to the supplier lead time, while the target should be at least 12 weeks. If this lead time is less than 1-2 weeks, then the factory might not have enough time to implement any mitigation actions and end up stopping the production lines. Although there are some safeguards already in place – safety stock and avoiding single sourced materials, but this cannot be arranged for all inbound portfolio. Fresh raw materials cannot have any safety stock due to limited expiry time, which is 24-48 hours. In this case – close relationship, service level agreements and systems integration with key suppliers is essential to business continuity. It is important to inform suppliers of future demand, agree on risk management processes to allow more time to prepare for a material shortage.



Source: Research data

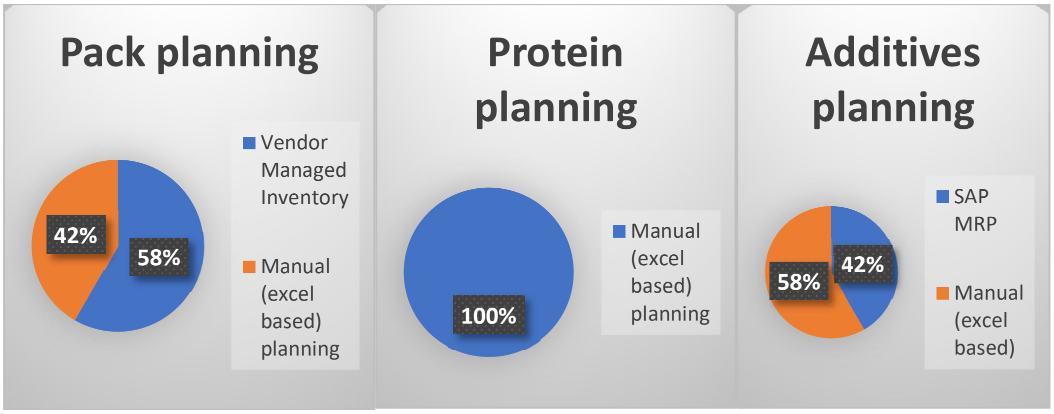
Fig. 4. Risk visibility based on material type and lead time

When looking at safety stock and material inventory targets – there is still a lack of standart methodology that could cater for differences in factory set up – infrastructure, production capacity, warehousing space, material storage requirements. A standart safety stock calculation methodology could be applied region wide, but it is extremely important, that it would be adjusted to individual factory set up requirements.

Demand accuracy and production plan adherence is one more issue for the factories. While in FMCG industry manufacturing must be very reactive to fulfil ever changing customer needs, a balance is also necessary to have a steady fixed time horizon to prepare for production. Demand planning accuracy and bias must be assessed using new statistical, interpersonal and AI tools. If factories can achieve relatively accurate demand planning and factory output adherence to plan a reasonable amount of cash could be saved by lowering the safety stocks on finished product and materials.

System limitations was another factor that adds extra manual work. Because main systems were not adapted to the local factory setup, requirements and operations, workarounds had to be created to compensate. These manual excel based tools were used for material requirement planning and ordering, meanwhile interfering with data accuracy, material inventory visibility in the main operating systems. Only individuals employed in specific roles possess the expertise required to handle the excel based macros tools, which then causes a potential risk to supply should they leave the company unexpectedly.

Additional features must be added to the software so the factories could bring all planning back to the main operating systems, stop any transactions being done outside of it and can have clean and reliable data to enable advanced technology adaptation and analytics.



Source: Research data

Fig. 5. Factory planning methods based on material type

One more very important finding should be mentioned is people: proper recruitment, retention, development, proper handover and onboarding. A clear trend emerged where the factory supply team exhibited experience, comprehensive training, and minimal staff turnover, resulting in fewer supply issues. In contrast, at other factories where knowledge was lost during handovers, there was observed more issues with data accuracy, lower system usage and trust, underutilization of available tools. A specific gap identified here was the lack of fully documented processes to support onboarding, along with the absence of training programs to develop essential knowledge of system functionality.

Conclusions

1. Having overviewed traditional supply chains it was determined, that traditional supply chain methods need reassessment to accommodate the new global trade reality. Three key areas businesses need to consider are processes, technology, and people. Advanced technology solutions can enhance supply chain efficiency by enabling predictive analytics that enable risk visibility and support decision making.
2. Having revealed recent supply chain disruptions, that earthquakes, COVID-19 and other serious natural disasters and uncertainties can immediately destroy prior developed and implemented manufacturing and distribution plans. Implementing JIT can lead to significant savings for companies that can meticulously establish their planning systems. But all those benefits can be taken only in predictable conditions. COVID-19 extremely painful impacted into disruption of such thoroughly balanced supply chains.
3. Having clarified findings of research done in 12 FMCG factories, that several benchmarking opportunities identified that could be deployed to other factories for relevant processes improvements. As one of the most worrying findings was the risk visibility, which usually is limited to the supplier lead time. It is important to inform suppliers of future demand, agree on risk management processes to allow more time to prepare for a material shortage. Another relevant finding is about safety stock and material inventory targets – there is still a lack of standard methodology that could

cater for differences in factory set up – infrastructure, production capacity, warehousing space, material storage requirements. Demand accuracy and production plan adherence is one more issue for the factories. System limitations was another factor that adds extra manual work. Additional features must be added to the software so the factories could bring all planning back to the main operating systems, stop any transactions being done outside of it. One more very important finding should be mentioned is people: proper recruitment, retention, development, proper handover and onboarding.

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Traditional vs E2E Supply Chain

TRADITIONAL SUPPLY CHAIN		END-TO-END
View of supply chain limited to departments	TRANSPARENT	Complete view of Supply Chain
Information is delayed as it moves through each function	COMMUNICATION	Information available to all Supply Chain members simultaneously
Limited visibility of the entire chain, restricting meaningful collaboration and optimisation	COLABORATIVE	Natural development of collaboration depth to capture intrinsic supply chain value
End customer demand is distorted as information flows through material path	FLEXIBLE	End customer demand changes are rapidly assessed
Different planning cycles resulting in delays and unsynchronized responses across multiple tiers	RESPONSIVE	Real time response on planning and execution level

Just-In-Time delivery concept

Originated in Toyota 1970s

1. **Cost Reduction** - by minimizing inventory
2. **Increased Efficiency** – streamlined production
3. **Waste Reduction** – by ordering only needed quantities
4. **Flexibility** – system is designed to be responsive

1. **Supply Chain Vulnerability** – JIT is based on reliable Supply chain
2. **Dependency on Suppliers** – delivery on time in full
3. **Increased Risk** – little room for error
4. **Higher Transportation/Material Costs** – frequent deliveries, smaller batches
5. **Limited Redundancy** – little to no inventory

A Toyota dealership devastated after earthquake and tsunami in 2011, Japan.
Photo credit: CARLOS BARRIA / Reuters

Problem of Research

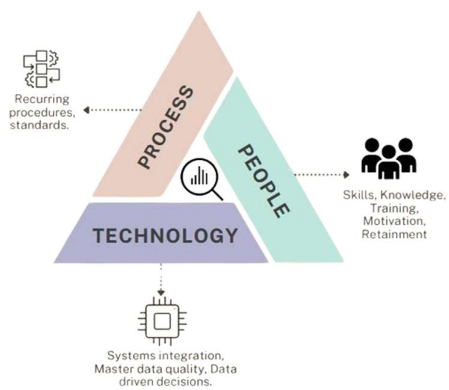
Supply chain disruptions due to recent global events. The need to strengthen SC for business continuity and continued material/information flow.

Supply chain disruptions in 2021/2022:		
Transportation	Container Crisis; Suez Canal crisis; Driver shortage in EU	Record high price on sea freight Critical container unbalance (Asia vs EU)
Climate change	Extreme weather events; Epidemics and Pandemics	Raw materials shortage (Plastic, adhesive, metals, etc) Human and farm animal populations affected by disease.
Demand instability	Explosion of e-commerce; electronic devices	Increase of demand creates competition for resources in the market.
Political instability	Russian/Ukraine War escalation; US/Chinese trade wars	Certain goods and services are limited due to the political turmoil

Research Object

11 FMCG production plants:

Focus on Inbound material management via the lens of process/people/technology framework



Research Aim

Identify inbound material flow supply weakness and impact on End-2-End supply chain, propose solutions and implementation of new processes/tools.

Tasks:

1. Inbound flow analysis
2. Systems integration and master data health.
3. Identify Supply chain weaknesses.
4. Provide proposals for Supply chain improvement.

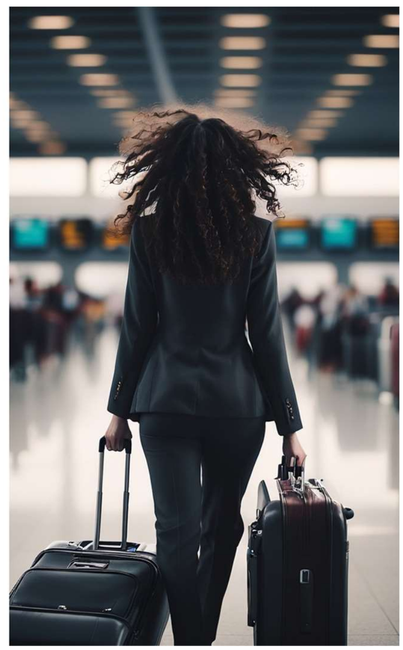
Research methodology

VILNIUS TECH

- **Qualitative research** methodology – only matter experts considered.
- **Visual inspection/Observation**– physical visits to sites
- **Interviews**– site supply chain team, commercial operations, quality and leadership team.
- **Focus groups**– to approach and discuss site specifics, findings.
- **Data** – non numerical, detailed information on process, systems and people integration
- **Selective Sampling**– 11 Manufacturing plants.

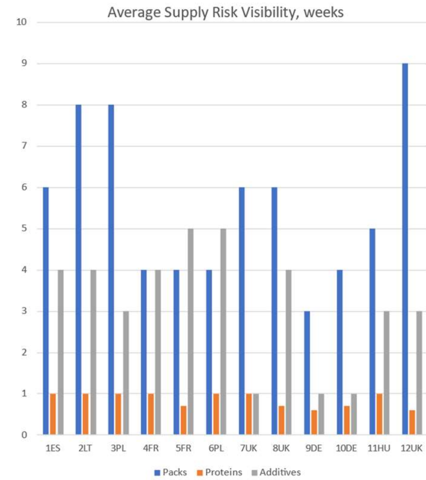
Research process

- 11 Pet Food manufacturing plants
- 7 European countries
- Physical visits July-November 2023
- Total of 176 hours spent on sites
- Focus on:
  - Raw and pack material planning; inventory
  - supplier relations;
  - manufacturing operations;
  - site specifications;
  - Information flow and escalation structure
- 49 statements with YES/NO answers for each factory defining inbound planning maturity level
- Master data quality, Material planning process, Risk assesment, inventory management, training and retention is reviewed in thesis.



Risk visibility = Lead time

- Suppliers proactively inform of supply issues in 7/11 factories
- Supplier service level agreement not in contracts.
- No Supplier scorecard or performance KPI tracking.
- Fostering mutually beneficial relationships with suppliers.
- Establishing an automated system to send weekly long term demand files to key suppliers.



Risk assesment process

Risk Assessment & Management Score		Factory compliance
Basic	Material planner running daily checks to spot and manage risks in the next 72h.	50%
	Material planner is able to do scenario planning to define risk	100%
	Mitigation actions are escalated and delegated without delay.	82%
Capable	Escalation matrix and short -term risk FMOS meeting structure established	37%
	Material planner is proactively assessing material risk impact 0 -12 weeks	28%
	Material planner can do scenario planning, define actions to mitigate material outages and escalate risks to cross functional stakeholders in time.	73%
Advanced	Cross functional FMOS meeting structure established for 0 -12weeks supply risk horizon	28%
	Material planner is able to spot and escalate risks on time to prevent high impact on business and engages other functions into mitigation actions. No line stoppage due to materials in the last year.	55%
	Requirements for 0-12months are shared with Suppliers automatically through the system.	37%
	Supplier portal is used for supplier collaboration.	32%

Inventory health assessment

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Remove obsolete

Sum of SOH.		Sum of Obsolete €		Sum of % Used
€	2 138 567	€	22 815	98.9%
€	3 269 169	€	48 408	98.5%
€	9 173 607	€	173 240	98.1%
€	4 177 686	€	205 518	95.1%
€	8 023 751	€	463 800	94.2%
€	3 528 591	€	289 861	91.8%
€	7 801 414	€	894 751	88.5%
€	2 427 214	€	297 887	87.7%
€	9 323 109	€	1 204 990	87.1%
€	3 381 833	€	532 976	84.2%
€	4 203 724	€	880 565	79.1%
€	**57 448 665**	**€**	**5 014 812**	**91.3%**

Safety stock calculation methodology

Input												Calculation				
Material	Weekly Demand, t	Lead time, days	Supplier Error, %	Frequent delivery, yes=0/no =1	Scrap factor, %	Single sourced, yes=1/no =0	Quality rejection probability, %	Quality check, days	Criticality, yes=1/no =0	other, days	Material usage st.dev, %	Reaction time	Risk factor	combined error St.Dev, %	Recommended SS, Days	Recommended SS, t
x1	20	4	5	0	1	0	1	0	1	0	33	4	1.1	33.4	1.4	4.0
x2	33	14	2	0	3	0	2	0	1	0	60	14	1.0	60.1	8.8	41.3
x3	2	7	20	1	5	1	4	0	1	0	0	7	3.2	20.6	4.7	1.3
x4	15	5	25	1	10	0	5	1	1	0	35	6	2.3	44.2	6.1	13.1
x5	6	2	20	0	5	0	4	0	0	1	78	3	0.2	80.7	0.6	0.5
x6	1	45	15	1	2	1	1	0	1	0	70	45	3.2	71.6	101.8	14.5
x7	105	7	10	0	4	0	3	0	1	0	50	7	1.1	51.1	4.0	60.7
x8	60	30	5	1	6	0	5	0	1	0	44	30	2.1	44.7	28.2	241.3
x9	45	14	40	1	8	0	2	3	0	0	37	17	1.4	55.1	13.3	85.5
x10	4	60	18	0	5	0	3	0	1	0	25	60	1.2	31.2	22.7	12.9
x11	0.5	21	23	0	9	0	5	0	0	0	16	21	0.3	29.4	1.7	0.1
x12	124	7	3	0	2	1	4	0	1	1	76	8	2.1	76.1	12.6	223.2
x13	16	5	5	0	3	0	6	5	1	0	81	10	1.1	81.2	9.0	20.6

Stock coverage in days assessment

Date	Stock	Demand	Stock coverage
2024-04-24	100	50	2.5
2024-04-25	50	20	1.5
2024-04-26	30	60	0.5
2024-04-27	-30	30	0

How long the available quantity of stock will cover the planned demand

- Slow movers must be assessed: demand, MOQ, NQC vs Sales return.

Conclusions

- Traditional supply chains no longer ensure business continuity
- Recent SC disruptions signal for an urgent need for resilience and flexibility.
- Research in 11 FMCG industry production plants highlighted serious gaps, that could be closed using digital tools, specific training and adjusting processes.

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