POLITECNICO DI TORINO

Master’s degree in Engineering and Management

From internal control to external collaboration: Vendor Managed Inventory as a paradigm shift in procurement

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Academic Year 2024/2025

SUMMARY

Abstract

In recent years, the need to adopt collaborative models within the supply chain has become increasingly evident, with the goal of improving planning and reducing inefficiencies caused by uncertain and fluctuating demand. This thesis analyses the impact of adopting the Vendor Managed Inventory (VMI) model in supply chain management, comparing it with the traditional Material Requirements Planning (MRP) system. The objective is to assess the operational, managerial, and collaborative benefits resulting from the introduction of the VMI approach. The study examines the case of Lavazza, a company characterized by the absence of an internal warehouse and is based on a case study supported by two simulations: one in a single-supplier context and one in a multi-supplier context. Through the comparative analysis of the two models, the study evaluates inventory trends, average stock levels, and their economic implications. The results show that implementing the VMI model leads to a significant reduction in average stock levels (over 30% compared to the MRP model) and, consequently, in the working capital employed. The thesis also describes the managerial and collaborative benefits that encourage stronger cooperation between the company and its suppliers. Finally, the study highlights how adapting the VMI model to a context without an internal warehouse still represents an innovative approach to improve the efficiency and responsiveness of the supply chain.

1. Introduction

In an increasingly dynamic economic environment, characterized by growing demand variability, companies are required to manage their supply chains with high levels of efficiency, flexibility, and coordination. This complexity makes traditional planning models, such as Material Requirements Planning (MRP), less effective in highly interconnected environments and in markets that change rapidly.

To face these challenges, many companies have adopted collaborative models based on constant information sharing and strong relationships of trust with their suppliers. Among these, the Vendor Managed Inventory (VMI) model plays a particularly important role, as it helps to improve demand visibility, strengthen collaboration along the supply chain, and consequently reduce the bullwhip effect. With this approach, suppliers have access to real-time consumption data, which allows them to plan production more accurately and operate with greater flexibility.

The main objective of this thesis is to analyse the transition from the MRP model to the VMI model and to highlight its operational, managerial, and collaborative impacts. The work starts with an overview of the literature on supply chain management and the importance of collaboration among its actors and then focuses on the main principles and characteristics of the MRP and VMI systems.

The core of the thesis is a case study carried out at Lavazza, a leading Italian company in the coffee industry, where the transition from the MRP to the VMI model is analysed. The case is particularly interesting because the company operates without an internal warehouse, which makes this implementation different from the traditional VMI applications found in the literature. The analysis is supported by two simulations, one in a single-supplier context and one in a multi-supplier context, which allow the comparison of stock behaviour, average inventory levels, and the related economic implications of the two management models.

The results show that the adoption of the VMI model leads to a significant reduction in average stock levels and working capital, while simplifying planning activities and improving transparency and trust between the company and its suppliers. The thesis also identifies the conditions that make some material codes more suitable for VMI implementation than others.

The thesis is structured into six chapters. The first chapter introduces the work and the research objectives; the second chapter presents the theoretical framework related to supply chain management and the MRP and VMI planning models; the third chapter reviews the state of the art in the literature. The fourth and fifth chapters describe the Lavazza case study and present the simulations used to evaluate the impact of the VMI model on stock levels and economic performance. Finally, the sixth chapter summarizes the main findings, practical implications, and possible future developments.

2. Theoretical background

2.1 The supply chain

2.1.1 Supply chain definition

The concept of supply chain has evolved significantly over the last decades, reflecting the increasing complexity of global production and distribution systems.

The supply chain can be defined as a system made up of suppliers, manufacturers, distributors, and final customers, in which there is a flow from suppliers of individual raw materials to final customers of physical products (or services), and a reverse flow of information (generally in the form of orders).

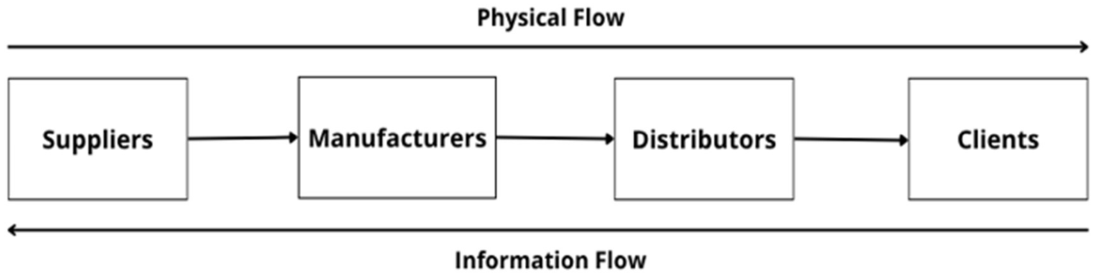

Figure 1: Physical flow and Information flow in supply chain

A supply chain is a dynamic system; it includes all activities involved in delivering a product from the stage of raw material to the customer. These activities include manufacturing, inventory control, distribution, warehousing, and customer service.

Supply chain management coordinates and integrates all these activities into a seamless process.

The core objective of supply chain management is to minimize system wide costs while satisfying service level requirements. *[1]*

2.1.2 Importance of collaboration in the supply chain

In the context of supply chains, collaboration is a broad concept that can be examined from multiple perspectives. Many scholars, when referring to “collaboration” within supply chains, emphasize elements such as the shared benefits it generates for the different parties involved, the distribution of risks, and the exchange of information.

Supply chain collaboration occurs when two or more companies share the responsibility of exchanging common planning, management, execution, and performance measurement information. Collaborative relationships transform how information is shared between companies and drive change to the underlying business processes. *[2]*

In the world of supply chains, cooperation can take many forms: it can be distinguished between internal cooperation, which develops among the various divisions of the same company, and external cooperation, which instead involves different companies. Collaborations between separate firms can take on different names, depending on their intended purpose.

In strategic alliances, a collaborative relationship is established, usually lasting over time, between two or more parties with the aim of pooling resources, skills, and expertise. The goal of these alliances is to increase the competitive strength of the partners or to enable access to new markets.

Joint ventures, on the other hand, are mostly cooperation agreements designed to explore new business opportunities. In these cases, one company provides products, services, marketing strategies, and capital, while the other contributes deep knowledge of the market, workforce, and relevant infrastructure.

In addition to these, there are cooperation agreements with other parties aimed at responding to rapid technological changes, increasingly competitive environments, and at expanding sourcing capabilities and organizational strategies. These collaborations make it possible to share both tangible and intangible resources, building long-lasting, trust-based relationships among partners.

Finally, collaborations can also be virtual, that is, temporary forms of integration between independent companies, implemented using telecommunications technologies.

Collaborations can be divided into vertical and horizontal types (*Figure 2*). Vertical collaborations involve customers, suppliers, or even internal partners (within the same function). Examples of vertical collaborations in supply chains include Vendor Managed Inventory (VMI), Efficient Customer Response (ECR), and Collaborative Planning, Forecasting and Replenishment (CPFR). In the next chapters I will focus on the study of VMI. Horizontal collaborations, on the other hand, involve competitors, non-competitors (companies producing complementary products or components of the same product), or internal partners (across multiple functions).

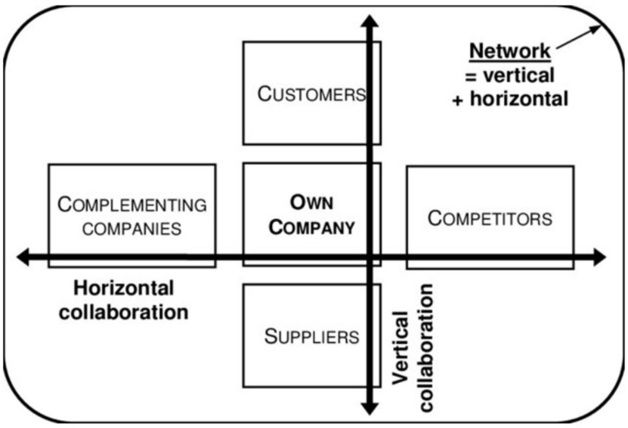

Figure 2: Illustration of vertical vs. horizontal collaboration [12]

Generally, the collaboration process between organizations involves four primary processes. *[3]*

- The first is the process of engaging organizations, which aims to identify the strategic collaboration needs in order to find the right partners with the required capabilities.
- The second process involves long-term planning for the management of resources, capabilities, and activities, taking into account possible changes in the environment and in resource availability.

- The third process is where the parties involved in the collaboration carry out day-to-day activities to pursue both short and long-term objectives
- The fourth process concerns the evaluation of the collaborative relationship, to decide whether to extend it or terminate it.

The willingness of two organizations within a supply chain to engage in a collaborative relationship does not automatically ensure the establishment of the key elements needed to guide the different members of the supply chain in making decisions that support the achievement of common goals. It is therefore essential to define these elements, which can influence the behavior of the individuals involved to achieve the outcomes expected from collaboration. *[3]*

- The first component is what the two authors refer to as Collaborative Performance System (CPS), which is a method of measuring the performance with metrics to guide supply chain participants in achieving both shared and individual goals. Goals must be stated in terms of outcomes (rather than activities), be measurable, quantifiable, and have a specific time horizon. They must be clearly defined and written, as well as challenging but attainable. Afterwards, they must be communicated to everyone involved. This allows all participants to be engaged, to understand what is truly expected from collaboration, and how they can contribute to the achievement of the stated objectives.
- The second component is information sharing, which enables monitoring and controlling how current performance compares to desired performance at any time. This gives each actor the necessary visibility of the process and allows them to make the right decisions. The most frequently exchanged information concerns: resource availability (production capacity, inventory levels), performance measures (time, quality, cost), and processes (forecasts, orders, deliveries). Technological advances allow to collect and transmit such information in real time.
- The third component is decision synchronization, which refers to the coordination and implementation of decisions among the various actors. The

need for coordination arises from the potential for greater returns (higher profits or lower costs) from joint actions compared to decisions taken independently.

- The fourth component is incentive alignment, which refers to the process of sharing costs, risks, and benefits among the actors involved in the collaboration. This enables the different members to make decisions that are optimal for the entire supply chain.
- Finally, the last component is about developing innovative processes within the supply chain. In other words, the various members of the supply chain strive to design and implement new processes that allow products (or services) to be delivered to the customer in the fastest and most cost-effective way.

However, achieving effective collaboration between organizations is not easy. Many collaborative projects fail or do not deliver the expected outcomes, which may be due to several factors.

- One cause may be the implementation of inadequate performance measures, like the use of metrics that evaluate individual performance but are irrelevant to maximizing the profit of the entire supply chain. Any action which maximizes individual performance is very likely to have negative consequences on the performance of another member of the supply chain. Goal misalignment, even across functions within the same organization, results in conflicting performance measures that create internal competition, which is counterproductive for the organization.
- Another factor may be asymmetric information sharing, arising from the fact that organizations are generally unwilling to share their private information with all supply chain partners. This incomplete sharing of information leads to decisions that are not optimal for the supply chain.
- Finally, a misalignment of incentives can also be a critical factor: this happens when a supply chain member makes decisions considering only their own rewards or penalties at the expense of others.

2.1.3 Effects of the lack of collaboration and coordination in the supply chain

Coordination in supply chains requires each tier of the chain to share its information and to be aware of the impact of its actions on other actors. If the objectives of the individuals involved are in conflict, or if there is no good flow of information across different levels, a lack of coordination arises.

When the various tiers of the supply chain pursue different objectives, they will aim to maximize their own profit as much as possible, but this may often result in actions that reduce the overall profit of the supply chain. *[4]*

One of the main effects of lack of coordination is the so-called Bullwhip Effect, a phenomenon in which orders placed by a certain level of a supply chain to its suppliers tend to have greater variance than the sales made by that level to its downstream customers. This demand distortion then propagates upstream along the supply chain in an even more amplified manner. This effect is clearly represented in *Figure 3*.

Figure 3: Increasing variability of orders up the supply chain [13]

Demand variability leads to an increase in safety stock, which results in higher storage costs and a greater need for warehouse space. Consequently, this also increases capital holding costs and the unit cost per item produced.

Greater demand variability also leads to longer procurement lead times and higher transportation costs. All these impacts product availability and can lead to a higher risk of stockouts.

Vendor Managed Inventory (VMI) is one of the methodologies that help improve coordination in a traditional supply chain and mitigate the Bullwhip Effect.

2.2 MRP System

One of the most widely used planning and procurement systems today is the MRP system.

MRP is a computer-based system designed to organize the timing and ordering of the dependent demand products. The demand for the raw material and components of the final product are calculated by using the demand for the final product and it is determined how much to order from these components and raw material, considering the production and lead times and counting back from the delivery time of the product. Thus, the demand for the final product is used to calculate the demand for the components in lower levels. *[14]*

MRP is designed to answer three questions: What is needed? When is it needed? How much is it needed?

The inputs of an MRP system include a Bill of Materials (BOM), which lists all the components and subcomponents required to produce a finished product; a master production schedule, which indicates the timing and the quantity required of the final product; and an inventory records file, which shows how much inventory is currently available or already on order.

Using these inputs, the planner determines the material requirements for each planning period. The system then performs several actions: it starts from the production plan (how many finished products are needed and when), it breaks down these products into individual components based on the BOM, it considers current stock levels and open orders, it calculates the net material requirements and the corresponding lead times for procurement or production, and finally, it generates planned order releases (either purchase or production orders) to ensure that materials arrive in the right quantities at the right time.

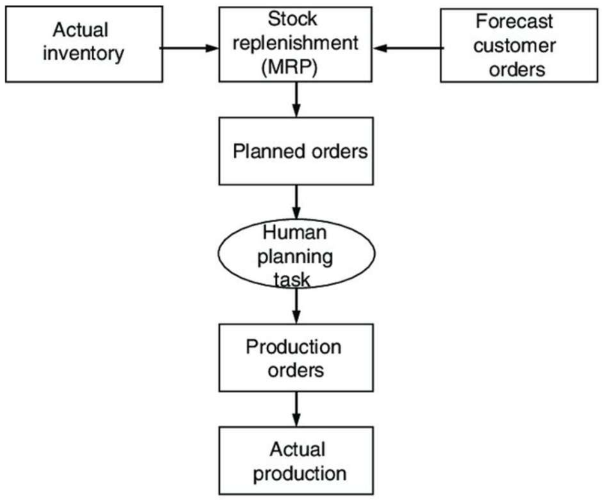

Figure 4: MRP Flow [15]

A key element in this procedure is choosing an appropriate lot size for each order or production batch, which plays a crucial role both for items with dependent demand (components and subassemblies) and for independent demand products (finished goods). Proper lot sizing helps balance inventory levels, minimize costs, and ensure a smooth production flow.

2.3 Vendor managed inventory (VMI)

2.3.1 Definition of VMI

Vendor-Managed Inventory (VMI), sometimes called supplier-managed inventory, is a supply chain management practice in which the supplier (vendor) takes responsibility for managing and replenishing inventory located at a customer's (retailer or distributor) premises. Under this arrangement, the supplier monitors inventory levels and uses demand or sales data shared by the customer to determine the appropriate order quantities and timing, effectively shifting the decision-making responsibility from the retailer to the supplier *(Figure 5*).

The vendor will therefore decide how and when to replenish the buyer's inventory, typically keeping stock levels within a predetermined range. For its part, the buyer will continuously update the vendor on inventory levels, product outflows, sales, forecasts, and any other information that may influence the replenishment process between the vendor and the buyer.

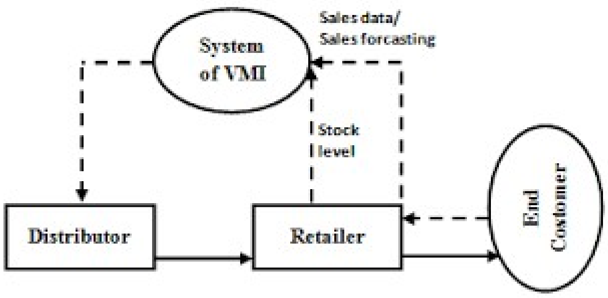

Figure 5: Material flow and supply chain information of VMI [11]

This continuous exchange of information between the buyer and the vendor is typically referred to as Collaborative Planning, Forecasting and Replenishment (CPFR). It is a concept often associated with VMI, serving as a program designed to encourage information sharing among the various partners within a supply chain. *[5]*

2.3.2 The origins of VMI

Procter & Gamble (P&G) and Walmart were among the first enterprises to adopt VMI successfully in 1985. This early implementation sought to reduce inventory costs and enhance supply chain efficiency through closer supplier-retailer collaboration.

Walmart, already in the 1990s, had strong information systems that collected point-of-sale (POS) data in real time. This data was shared with suppliers like P&G and thanks to this system, P&G could plan production and deliveries based directly on consumer demand, without waiting for Walmart to place an order. This was an innovation because it reduced the so-called "bullwhip effect," where small variations in customer demand create large fluctuations in the supply chain.

The factors that contributed to the success of the Walmart–P&G collaboration were distinct.

- First, reliable information sharing: Walmart was able to share accurate and frequent data on sales and stock levels.
- Second, strong technological systems: both companies used electronic data interchange and other IT tools to communicate efficiently. *[6]*
- Third, there was a trusting and long-term relationship between the two firms, which made it possible for Walmart to give P&G the responsibility of managing part of its supply chain. *[7]*

From a product perspective, Walmart's assortment can be divided into three main categories: food, daily necessities, and household appliances. The company's products are highly standardized, repeatable, and subject to auditable quality standards. Because customer expectations for such standardized products are relatively stable, this type of product environment is especially well suited for the Vendor-Managed Inventory (VMI) model. According to internal reports, Walmart developed innovative data prediction strategies covering over 100,000 different products across 4,700 Walmart stores in the United States. This advanced capability in data analytics was a key driver in supporting Walmart's adoption of VMI practices.

From the supplier perspective, Walmart collaborates with a vast network of vendors. The company maintains efficient communication with suppliers by sharing real-time inventory data. For instance, Procter & Gamble, one of Walmart's major suppliers, receives access to inventory and sales information directly from Walmart. Based on this data, P&G is able to make replenishment decisions, ensuring that stock levels are maintained efficiently. This practice has significantly increased sales under the VMI model.

2.3.3 Benefits of VMI

The adoption of Vendor Managed Inventory (VMI) entails significant benefits for both vendors and retailers. These advantages can be grouped into operational, management, and collaborative dimensions, and often emerge from the continuous exchange of information between supply chain partners. In fact, the forecasting accuracy which derives from this exchange of information is one of the most significant benefits.

One of the most important contributions of VMI is its ability to improve demand visibility across the supply chain. By sharing timely and accurate data on sales and inventory levels, the supplier gains a clearer view of final customer demand. *[8]* This allows the vendor to respond proactively to demand variability rather than reacting only after fluctuations occur. *[9]* As a result, forecasts become more accurate, stock distribution is more efficient, and customer service levels are improved. *[1]*

Moreover, for vendors, better access to information stabilizes production and improves resource utilization, avoiding inefficiencies caused by sudden fluctuations in orders. The vendor can adapt its production schedule more effectively to market needs without waiting for the buyer's mediation.

Retailers, on the other hand, benefit from the reduction of administrative and planning costs, as replenishment responsibilities are transferred to the supplier. Moreover, the buyer experiences improved service levels, since the supplier is now responsible for stock availability and aligns replenishments more closely with actual demand. The supplier assumes greater responsibility and the related risks in the event of stockouts, but the risk itself is reduced thanks to the accuracy of forecasts derived from shared information.

The system is also particularly effective in reducing shortages and overstocks. Since suppliers manage replenishment based on actual sales rather than orders, the mismatch between demand and supply is minimized. This also helps to mitigate the well-known bullwhip effect. By removing one layer of decision-making and eliminating delays in the flow of information, VMI reduces the uncertainty and distortion typically introduced by order batching and miscommunication. *[10]* The constant flow of data from buyer to vendor ensures that replenishments are aligned with real market conditions, rather than filtered or delayed by buyer intervention.

2.3.4 Challenges of VMI

VMI also involves several negative implications that can be critical for its practical implementation.

One of the main challenges of VMI is the sharing of highly sensitive information, such as inventory levels, sales data, and details of future promotions. This requires a strong relationship of mutual trust between the supplier and the buyer. Building such a relationship is often difficult, since suppliers may perceive the implementation of VMI as more beneficial to the buyer than to themselves. In fact, suppliers take full responsibility for product replenishment, including the costs associated with both stockouts and overstocking.

From the buyer's perspective, delegating inventory management to an external party can be seen as a loss of control over the supply chain. The importance of information sharing becomes even more critical in situations of demand uncertainty, where timely and accurate data are essential to avoid disruptions.

Furthermore, the implementation of VMI requires significant investments to achieve an integrated supply chain, both in terms of technology and organizational adaptation.

3. State of art

The study of the Vendor Managed Inventory (VMI) model has grown significantly over the last 25 years, especially between 2005 and 2010 (see *Figure* 6).

The purpose of this chapter is to provide a systematic review of the literature, highlighting the main areas of application, the results achieved, and the remaining research gaps.

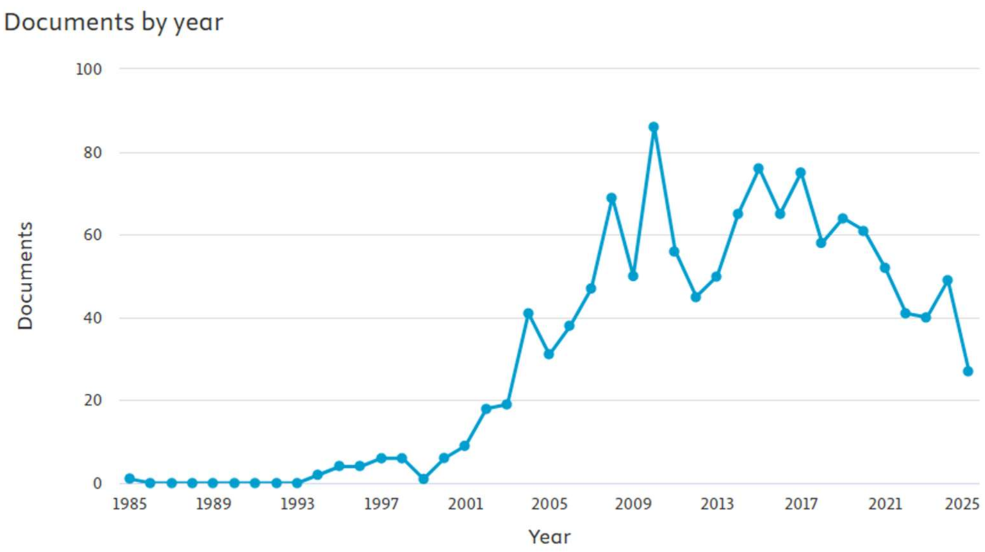

Figure 6: Temporal distribution of documents (by Scopus)

The bibliographic research was carried out using the Scopus database. Initially, the query "Vendor Managed Inventory" was used, resulting in about 1,200 documents. As shown in *Figure (6)*, most of the publications were released in the last 20 years. In fact, by selecting the period 2005–2025, around 1,100 documents were found only about 100 fewer than the total.

3.1 Vendor Managed Inventory in the manufacturing supply chain

Considering the broadness of the topic and the large number of documents, the research field was further narrowed to studies focused on the application of the VMI model in manufacturing supply chains. The query used for this second search was: ("vendor managed inventory" OR "VMI") AND manufacturing supply chain. This search produced 72 articles. The following figures show their distribution over time (*Figure 7*), subject area (*Figure 8*), and geographical distribution (*Figure 9*).

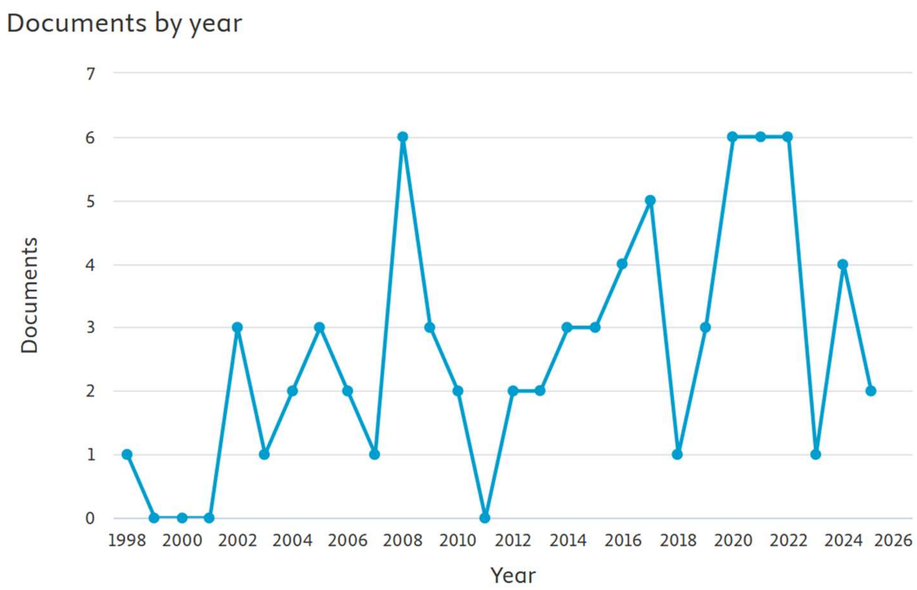

Figure 7: Temporal distribution of documents (by Scopus)

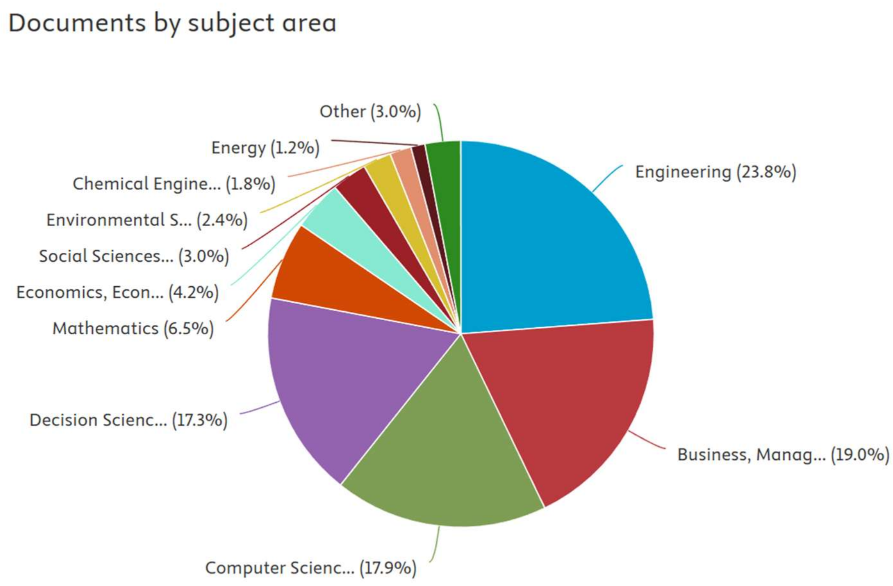

Figure 8: Documents by subject area (by Scopus)

The graph highlights that most publications are concentrated in the fields of Engineering (23.8%), Business, Management and Accounting (19.0%), Computer Science (17.9%), and Decision Sciences (17.3%). Together, these four areas account for over 78% of the total, indicating that the topic is primarily addressed from technical-engineering, managerial, and computational perspectives. The disciplines of Economics, Mathematics, and Social Sciences contribute to a lesser extent, but they suggest a multidisciplinary interest that combines analytical, economic, and social dimensions. Moreover, the categories Energy, Environmental Science, and Chemical Engineering, although representing smaller percentages, indicate specific industrial and sustainability-oriented applications of the topic.

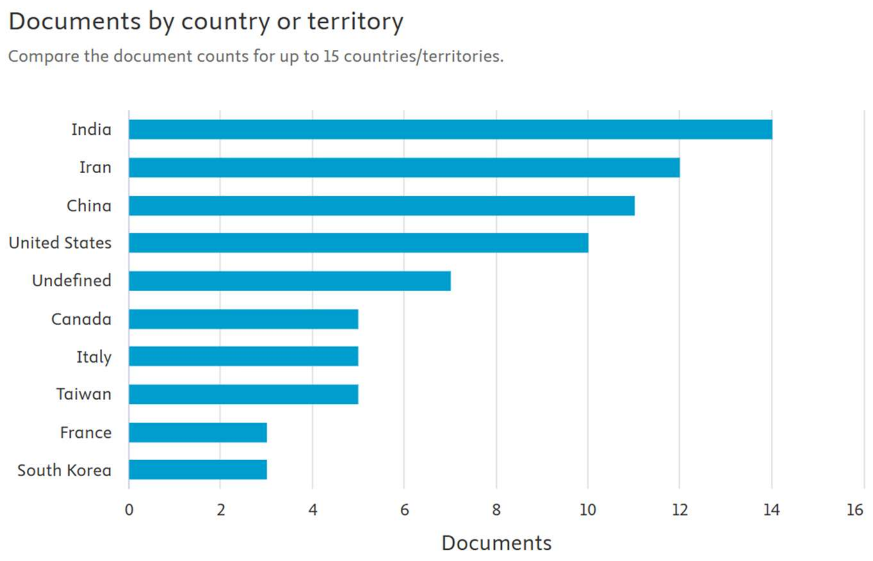

Figure 9: Geographical distribution of documents (by Scopus)

Among the 72 articles found, about fifteen were selected, using the number of citations as the main evaluation criterion. This method is useful to assess the scientific relevance and popularity of an article, although it inevitably excludes the most recent publications.

Consistent with the overall trend in publications (*Figure 7*), the most cited articles are mainly concentrated between 2006 and 2020. Below is a table listing the title, authors, and year of publication of the selected articles, together with a brief description of each one based on its abstract.

Title	**Authors**	**Year**	**Description**
The extended VMI for coordinating the whole supply network	Danese, P.	2006	Explores how extending vendor-managed inventory (VMI) across the entire supply network improves coordination, visibility, and efficiency among multiple tiers.
The inventory value of information sharing, continuous replenishment, and vendor-managed inventory	Yao, Y.; Dresner, M.	2008	Analyzes the inventory cost benefits of information sharing and VMI; shows that improved coordination reduces total costs but affects partners asymmetrically.
On the benefits of CPFR and VMI: A comparative simulation study	Sari, K.	2008	Compares VMI and CPFR models using simulation to assess performance in demand variability

			scenarios, identifying conditions where each performs best.
Ordering and pricing policies in a manufacturing and distribution supply chain for fashion products	Webster, S.; Weng, Z.K.	2008	Develops joint pricing and ordering policies for manufacturer–distributor chains, showing how coordination maximizes profits and minimizes inefficiencies.
A Stackelberg game and its improvement in a VMI system with a manufacturing vendor	Yu, Y.; Chu, F.; Chen, H.	2009	Proposes a Stackelberg game model for supplier–retailer VMI coordination and introduces contract improvements that increase overall channel efficiency.
A vendor managed inventory supply chain with deteriorating raw materials and products	Yu, Y.; Wang, Z.; Liang, L.	2012	Examines a VMI system considering perishable materials and products, optimizing replenishment and production schedules to minimize losses and costs.
Optimal selection of retailers for a manufacturing vendor in a vendor managed inventory system	Yu, Y.; Hong, Z.; Zhang, L.L.; Liang, L.; Chu, C.	2013	Develops an optimization framework to select retailer partners under VMI, balancing profit, capacity, and service-level considerations.
Lean versus green: The impact of lean logistics on greenhouse gas emissions in consumer goods supply chains	Ugarte, G.M.; Golden, J.S.; Dooley, K.J.	2016	Empirically explores whether lean logistics reduces GHG emissions; identifies cases where lean practices align, or conflict, with sustainability.
A green vendor-managed inventory analysis in supply chains under carbon emissions trading mechanism	Jiang, Y.; Li, B.; Qu, X.; Cheng, Y.	2016	Integrates carbon-emission trading into VMI models, analyzing how environmental policies influence replenishment and profit allocation.
Carbon emissions and energy effects on a two-level manufacturer-retailer closed-loop supply chain model with remanufacturing subject to different coordination mechanisms	Bazan, E.; Jaber, M.Y.; Zanoni, S.	2017	Develops a closed-loop supply-chain model linking production, remanufacturing, energy use, and emissions under various coordination mechanisms.
Robust bi-level optimization for green opportunistic supply chain network design problem against uncertainty and environmental risk	Golpîra, H.; Najafi, E.; Zandieh, M.; Sadi-Nezhad, S.	2017	Presents a bi-level optimization model for designing green, resilient supply chains under uncertainty and environmental risk.
Supply chain models with greenhouse gases emissions,	Marchi, B.; Zanoni, S.;	2019	Investigates the economic–environmental impacts of

energy usage, imperfect process under different coordination decisions	Zavanella, L.E.; Jaber, M.Y.		coordination contracts considering energy consumption and process imperfections.
UNISON data-driven intermittent demand forecast framework to empower supply chain resilience and an empirical study in electronics distribution	Fu, W.; Chien, C.-F.	2019	Introduces a data-driven framework combining machine learning for intermittent demand, improving forecasting and inventory resilience.
A consignment stock scheme for closed loop supply chain with imperfect manufacturing processes, lost sales, and quality dependent return: Multi Levels Structure	Taleizadeh, A.A.; Moshtagh, M.S.	2019	Analyzes consignment stock policies in closed-loop supply chains with returns of varying quality, optimizing pricing and replenishment strategies.
Deep reinforcement learning for selecting demand forecast models to empower Industry 3.5 and an empirical study for a semiconductor component distributor	Chien, C.-F.; Lin, Y.-S.; Lin, S.-K.	2020	Applies deep reinforcement learning to dynamically select forecasting models, improving inventory performance in industrial applications.

Table1: Selected Articles on Vendor Managed Inventory in the Manufacturing Supply Chain

It can be observed that:

- 2000–2010: research focused on the conceptual and mathematical foundations of the VMI model. The approach was mainly analytical and quantitative, often using simulations to represent power relationships within the supply chain. The main goals were to reduce inventory costs and improve collaboration between suppliers and distributors.
- 2011–2021: the theme of sustainability was introduced into supply chain studies. The VMI model began to be reinterpreted both as a tool to balance profit and environmental goals, and as a component of intelligent systems (such as machine learning and reinforcement learning) aimed at demand forecasting.

3.2 Vendor Managed Inventory under demand uncertainty

To better align this analysis with the case study discussed in Chapter 4, the literature related to VMI applications under conditions of demand variability was explored. A search was conducted on Scopus using the query: "vendor managed inventory" AND "demand uncertainty", which returned 26 articles. The figures below show their distribution over time (*Figure 10*), their subject area (*Figure 11*), and their geographical distribution (*Figure 12*).

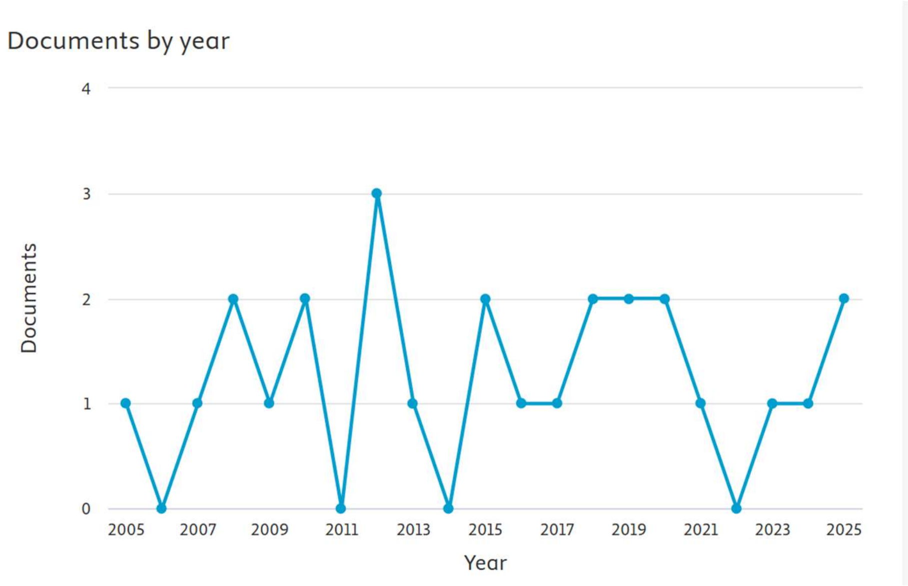

Figure 10: Temporal distribution of documents (by Scopus)

Although no temporal constraints were applied to the search, it can be observed that the topic has been addressed since the early 2000s.

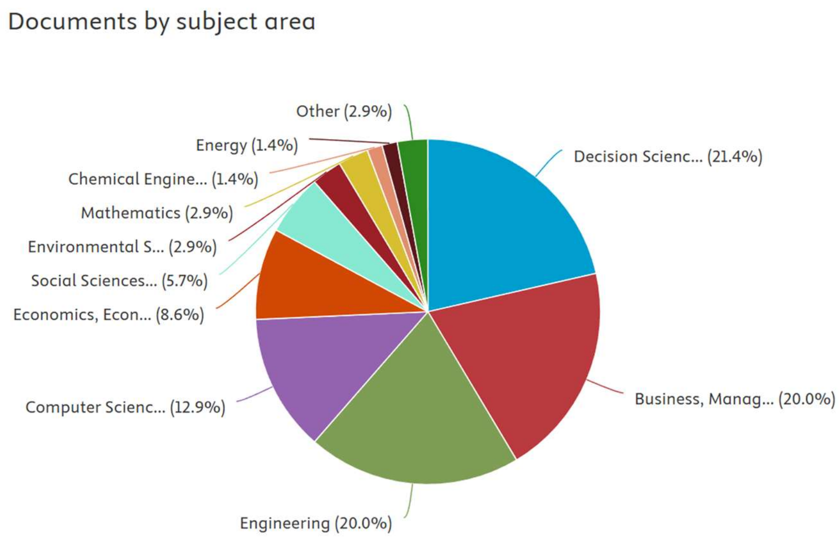

Figure 11: Documents by subject area (by Scopus)

The publications, as in the previous search, mainly belong to the fields of Decision Science (21.4%), Business Management and Accounting (20%), Engineering (20%), and Computer Science (12.9%). In this case, however, a more balanced distribution can be observed among Decision Science, Business Management and Accounting, and Engineering, while the Computer Science area appears to be less represented.

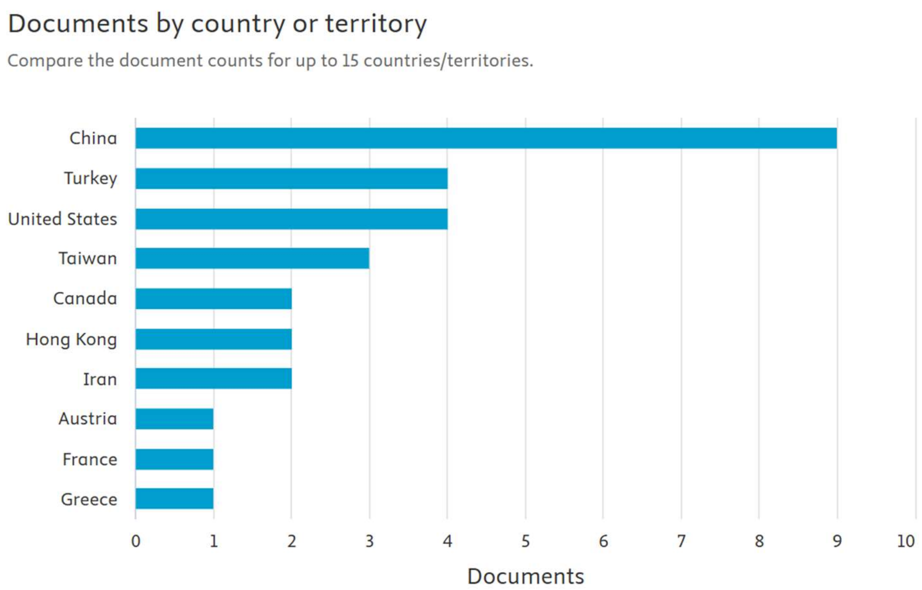

Figure 12: Geographical distribution of documents (by Scopus)

All 26 articles identified are listed below (Table 2):

Title	Authors	Year	Description
Who should control inventory in a supply chain?	Lee, C.C.; Chu, W.H.J.	2005	Compares inventory control models between supplier and retailer, showing that transferring responsibility can enhance efficiency when supported by proper risk-sharing mechanisms.
Exploring the benefits of vendor managed inventory	Sari, K.	2007	Analyses, through simulation, the performance of VMI under different capacity, uncertainty, and lead time conditions, highlighting how supply and demand variability affect achievable benefits.
Inventory inaccuracy and performance of collaborative supply chain practices	Sari, K.	2008	Examines the impact of inventory data errors on collaborative practices, showing that inaccuracy significantly reduces performance, especially in highly integrated supply chains.
Component procurement strategies in decentralized assembly systems with demand learning	Fang, X.; So, K.C.; Wang, Y.	2008	Models procurement strategies in assemble-to-order systems using VMCI to coordinate independent suppliers and optimize cost and lead time under demand uncertainty.
Pricing and allocation of retail space with one radio frequency identification enabled supplier and one non-RFID enabled supplier	Szmerekovsky, J.G.; Tilson, V.; Zhang, J.	2009	Analyses competition between RFID and non-RFID suppliers in a VMI setting, showing that RFID technology strengthens competitiveness through more efficient shelf-space management.
Vendor managed inventory for environments with stochastic product usage	Hemmelmayr, V.; Doerner, K.F.; Hartl, R.F.; Savelsbergh, M.W.P.	2010	Models a VMI system in environments with stochastic product consumption, balancing inventory and uncertainty to improve service levels.
Twice producing and ordering mode under vendor managed inventory	Cai, J.; Wang, L.-P.; Han, Y.	2010	Analyses a VMI model with dual production and ordering modes, optimizing quantities and timing to minimize total supply chain costs.
A supply chain performance analysis of a pull inspired supply strategy faced to	Marquès, G.; Lamothe, J.; Thierry, C.; Gourc, D.	2012	Assesses the performance of a pull-based supply strategy under demand uncertainty, highlighting VMI's efficiency compared to traditional models.

demand uncertainties			
The impact of demand variability and transshipment on vendor's distribution policies under vendor managed inventory strategy	Chen, X.; Hao, G.; Li, X.; Yiu, K.F.C.	2012	Examines how demand variability and transshipments among retailers affect vendor distribution policies within a VMI framework.
Manufacturing Intelligence to Forecast the Customer Order Behavior for Vendor Managed Inventory	Chien, C.-F.; Hsu, C.-Y.; Lin, S.-C.	2012	Applies manufacturing intelligence tools to forecast customer ordering behaviour, enhancing the accuracy of VMI management.
The role of spot market in a decentralised supply chain under random yield	Ma, S.; Yin, Z.; Guan, X.	2013	Investigates the influence of spot markets in decentralized supply chains with random yields, showing how integration and coordination mitigate production risk.
Service failure recovery and prevention: Managing stockouts in distribution channels	Dong, Y.; Xu, K.; Cui, T.H.; Yao, Y.	2015	Analyses service failure recovery and prevention strategies, showing how proactive stockout management improves customer satisfaction and retention.
How much does VMI better than RMI in a global environment?	Yu, H.; Tang, L.; Xu, Y.; Wang, Y.	2015	Compares VMI and RMI models in global contexts, demonstrating that VMI provides greater efficiency and coordination through enhanced information sharing and reduced uncertainty.
Closed-loop Inventory Routing Problem for returnable transport items	Soysal, M.	2016	Models a closed-loop inventory routing problem for reusable containers, optimizing deliveries and returns to minimize logistics costs and environmental impact.
Economic model predictive inventory routing and control	Nikolakopoulos, A.; Ganas, I.	2017	Integrates model predictive control into the inventory routing problem, enabling dynamic supply and transport decisions to minimize operational costs.
Combining variable neighborhood search with simulation for the inventory routing problem with stochastic demands and stock-outs	Gruler, A.; Panadero, J.; De Armas, J.; Moreno Pérez, J.A.; Juan, A.A.	2018	Combines variable neighbourhood search with simulation to solve the IRP under stochastic demand, enhancing solution robustness under stock-out conditions.

Evaluating supply chain flexibility under demand uncertainty with smoothing approach and VMI considerations	Bodaghi, G.; Jolai, F.; Rabbani, M.	2018	Evaluates supply chain flexibility using smoothing and VMI-based approaches, proposing a method to adapt production and supply to demand fluctuations.
Improving sustainability in a two-level pharmaceutical supply chain through Vendor-Managed Inventory system	Weraikat, D.; Zanjani, M.K.; Lehoux, N.	2019	Enhances sustainability in pharmaceutical supply chains by adopting a VMI system that optimizes drug inventory levels and minimizes waste due to expiration.
Optimal input quantity decisions considering commitment order contracts under yield uncertainty	Cai, J.; Hu, X.; Wu, F.; Zhou, Q.; Zhang, X.; Xuan, L.	2019	Determines optimal input quantities in a two-echelon supply chain under yield uncertainty using commitment order contracts to balance risk and profit.
Deep reinforcement learning for selecting demand forecast models ... semiconductor distributor	Chien, C.-F.; Lin, Y.-S.; Lin, S.-K.	2020	Applies deep reinforcement learning to select optimal demand forecasting models for a semiconductor distributor, improving VMI-based inventory accuracy and resilience.
Simultaneous inventory competition and transshipment between retailers	Zhang, P.; Xu, X.; Shi, V.; Zhu, J.	2020	Analyses how competing retailers coordinate inventory and transshipment decisions, showing that cooperation can reduce stockouts and improve supply chain efficiency.
Inventory decision and coordination contract design for two-echelon supply chain considering delivery time uncertainty	Cai, J.; Zhang, Y.; Xu, F.; Huang, W.	2021	Designs coordination contracts for two-echelon supply chains under delivery time uncertainty, improving synchronization and reducing delays under VMI and RMI models.
Managing returnable transport items in a vendor managed inventory system	Soysal, M.; Koç, Ç.; Çimen, M.; İbiş, M.	2023	Addresses a closed-loop inventory routing problem managing deliveries and returns of reusable transport items, optimizing routes and costs under demand uncertainty.
Robust inventory routing problem under uncertain demand and risk-averse criterion	Feng, Y.; Che, A.; Tian, N.	2024	Develops a distributionally robust IRP model under uncertain demand using the M-CVaR criterion to minimize risk and improve delivery reliability.
Robust optimal model of green vendor-managed	Zhang, X.; Liu, Q.; Dong, Y.;	2025	Constructs a robust multi-objective green VMI model integrating carbon emission trading and visibility mechanisms to

inventory for carbon emission reduction and supply chain visibility	Wen, Y.; Yang, H.		enhance sustainability and operational efficiency.
A New Vendor Managed Inventory for Perishable Products Considering Supplier Selection	Modares, A.; Motahari Farimani, N.M.; Dehghanian, F.	2025	Proposes a hybrid VMI model for perishable products integrating blockchain, TOPSIS, and chance-constrained programming to optimize supplier selection and minimize waste and costs.

Table 2: Articles on Vendor Managed Inventory under demand uncertainty

- 2005–2010: As already outlined in Analysis 1, during this period research focused on the conceptual and mathematical foundations of the VMI model. The dominant goal was to reduce inventory costs and improve coordination between suppliers and distributors through mathematical modelling.
- 2011-2018: research moved toward optimization and coordination mechanisms. In this period, VMI was reinterpreted as an optimization framework for supply chain efficiency under stochastic demand and complex logistics scenarios.
- 2019-2021: sustainability and artificial intelligence became central themes in VMI research. The VMI thus evolved into a tool to balance economic and environmental goals, while also enhancing predictive and adaptive capabilities within intelligent supply chains.
- 2023-2025: research has focused on robust, green, and digital supply chain systems. It can be observed that there is a transition toward smart, data-driven, and environmentally responsible VMI frameworks capable of managing uncertainty and risk in global networks.

3.3 Vendor Managed Inventory in a multi-vendor environment

After that, an even more detailed analysis was carried out. All the articles related to the application of the VMI model in contexts involving multiple suppliers were searched. The query used for this search was: ("multi-vendor" OR "multiple suppliers") AND "vendor managed inventory", which returned 9 documents, including 7 journal articles.

Since the dataset was relatively small, it was not possible to generate graphs showing the trend of publications over time or their subject area distribution.

The table below (*Table 3*) presents the title, authors, publication year, and a brief description derived from the abstract for each of the 7 selected articles.

Title	Authors	Year	Description
Nash game model for optimizing market strategies and configuration of platform products in a VMI supply chain for a product family	Yu, Y.; Huang, G.Q.	2010	Introduces a dual Nash game model between manufacturer and retailers in a multi-supplier VMI system, coordinating product design, pricing, and advertising strategies to reach a profit-maximizing equilibrium.
Optimizing a multi-vendor multi-retailer vendor managed inventory problem: Two tuned meta-heuristic algorithms	Sadeghi, J.; Mousavi, S.M.; Niaki, S.T.A.; Sadeghi, S.	2013	Develops a multi-vendor, multi-retailer, single-warehouse VMI model and optimizes it using hybrid PSO–GA algorithms, minimizing total inventory cost and demonstrating algorithmic performance through Taguchi calibration.
Cyclic consumption and replenishment decisions for vendor-managed inventory of multisourced parts in Dell’s supply chain	Katariya, A.P.; Çetinkaya, S.; Tekin, E.	2014	Proposes a pull-based VMI framework for multisourced components at Dell, optimizing demand allocation among suppliers and replenishment cycles to reduce costs and support leaner operations.
Modeling the inventory routing problem (IRP) with multiple depots with genetic algorithms	Arango Serna, M.D.; Zapata Cortes, J.A.; Gutierrez Sepulveda, D.	2015	Formulates a multi-supplier, multi-client IRP integrating VMI collaboration and uses a genetic algorithm to reduce transportation and inventory costs in distributed networks.

Vendor managed inventory for multi-vendor single-manufacturer supply chain: A case study of instant noodle industry	Phong, H.T.; Yenradee, P.	2020	Presents a multi-vendor single-manufacturer VMI model considering realistic truck sizes and transportation costs; applies a genetic algorithm to minimize total logistics cost and validate with a case study in the instant noodle industry.
Collaborative vendor managed inventory model by using multi-agent system and continuous review (R, Q) replenishment policy	Kusuma, P.D.; Kallista, M.	2022	Develops a multi-vendor, multi-customer, multi-product VMI based on a multi-agent system, showing that collaboration reduces lost sales and improves efficiency compared to traditional single-vendor models.
Vendor managed inventory system considering deteriorating items and probabilistic demand for a three-layer supply chain	Salas-Navarro, K.; Romero-Montes, J.M.; Acevedo-Chedid, J.; Florez, W.F.; Cárdenas-Barrón, L.E.	2023	Proposes a VMI model for a three-tier supply chain with multiple suppliers, manufacturers, and retailers, accounting for deteriorating items and probabilistic demand to maximize joint profit through collaborative coordination.

Table 3: Articles on Vendor Managed Inventory in a Multi-Vendor Environment

- 2010–2015: The first relevant studies, such as Yu and Huang (2010), introduced a game-theoretic approach, where manufacturers and retailers interact in a multi-supplier context to optimize pricing, advertising, and product configuration strategies. The VMI model thus evolved into a strategic coordination tool, rather than a purely operational one. Later, Sadeghi et al. (2013) and Katariya et al. (2014) proposed more quantitative optimization models. The first developed a multi-vendor, multi-retailer model to minimize total inventory costs, while the second focused on an industrial case (Dell), proposing a model that improves synchronization between suppliers and distribution centers. Both studies demonstrate that adopting collaborative VMI logics can reduce the bullwhip effect and enhance system responsiveness. Finally, Arango Serna et al. (2015) introduced the Inventory Routing Problem (IRP) in a multi-depot context, aiming to simultaneously optimize delivery routes and inventory levels, highlighting how integrated planning of transport and inventory is essential to reduce costs and lead times.

- 2016–2020: Phong and Yenradee (2020) applied the multi-vendor VMI model to a real case study in the food industry, using genetic algorithms to minimize transportation and procurement costs.
- 2021–present: Kusuma and Kallista (2022) introduced a collaborative model based on multi-agent systems, enabling dynamic and automated management among multiple suppliers, customers, and products, leading to improved overall efficiency compared to traditional models. Finally, Salas-Navarro et al. (2023) proposed a three-tier VMI model (suppliers, manufacturers, and retailers) that considers perishable products, probabilistic demand, and quality imperfections, with the aim of maximizing total supply chain profit and reducing waste.

Analysing the literature, a research gap emerges regarding the adoption of the Vendor Managed Inventory (VMI) model in business contexts without an internal warehouse. Although this configuration differs from the traditional model, studying its applicability and possible adaptations represents an interesting topic for further investigation and a promising direction for future research.

4. Lavazza case study: from MRP system to VMI

4.1 Current Business context

Lavazza is an Italian multinational company founded in 1895 in Turin and operating in the coffee sector. The company has over 5.500 employees, 9 production plants located in 5 different countries, and sells its products in more than 140 nations. Originally established as a small coffee roastery, over time it has expanded its product range to include various types of coffee (beans, ground, capsules, and pods) and coffee preparation systems, targeting both the domestic and professional markets. Lavazza owns several brands (including Carte Noire, Merrild) which are part of the Lavazza Group.

From a supply chain perspective, Lavazza manages a complex and highly integrated network that connects coffee-producing countries with global distribution and retail markets. The company's operations involve the coordination of numerous suppliers, logistics partners, and production sites, making efficient planning and inventory management essential to maintaining product quality and service levels.

During my internship at Lavazza, I worked as a Non-Food Central Planning Intern within the team responsible for packaging planning. In particular, I supported the planner in charge of managing paper-based packaging materials, such as non-printed cartons, printed cartons, folding boxes, paperboard inserts and honeycombs to be placed inside the boxes, labels, and displays.

Among these types, printed packaging plays a particularly delicate role: not only do they serve to protect and contain the product, but they are also designed to present it to the end customer, enhancing its image and encouraging its purchase. Moreover, they display a series of mandatory food product information (ingredients, allergens, storage instructions, expiry date, etc.), which are strictly regulated and subject to frequent updates. The graphic elements related to marketing also change regularly, making this type of packaging particularly complex to manage: each regulatory or graphic change requires the creation of a new item code. As a result, printed packaging involves managing a very high number of codes, with frequent updates and greater operational complexity.

Currently, Lavazza uses, and continues to use, an MRP (Material Requirements Planning) system for the planning and procurement of materials from suppliers. Within the company system, packaging materials are grouped into different categories called “MRP Controllers” depending on their product family. For example, all Flexo cartons are assigned to the MRP controller FLX, while folding boxes are assigned to the MRP controller C10, and so on for all other types of packaging. This classification by MRP controller allows the entire portfolio of materials to be organized in an orderly way, facilitating planning, demand analysis, and operational flow management.

The planning process follows a well-defined monthly cycle (*Figure 13*). In the first week of the month (week 1), the finished product planners develop the production plan, called Tactical Plan, for the following six months based on the sales forecasts which arrive from the Demand department. The forecasted volumes are distributed across all the lines of the various Lavazza production plants and based on this scheduling the company system automatically “explodes” the material requirements, calculating for each packaging code the quantities needed and the dates by which they must be available. In the second week of the month (week 2), the packaging planners (the team in which I carried out my internship) analyse the proposals and the schedules generated by the system, if something needs to be correct or modify the planners modify it and then the forecast and the orders are published to suppliers. The forecasts made available to suppliers cover a period of 6 months, while orders are sent with a coverage of one or two months depending on the packaging lead time.

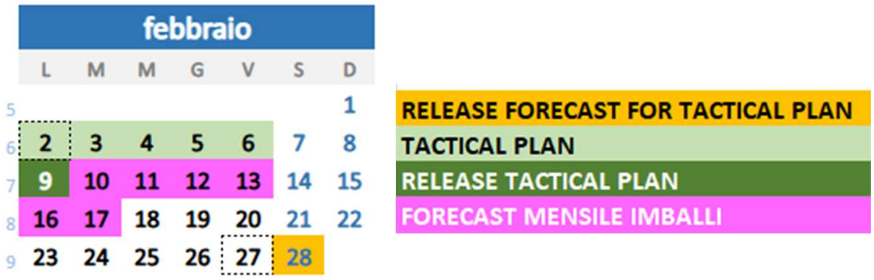

Figure 13: Example of a monthly cycle with MRP scheduling

The reorder proposals generated by the system (Planpurch) are calculated by considering the stock on hand for that specific code, the consumption (in terms of production), and the coverage in days of the available pieces. Each code has a safety margin (in days), and once the coverage reaches or falls below this safety margin, a new reorder is proposed. However, the system does not take into account the orders already issued to suppliers (purchorder) with scheduled delivery within the considered period but not yet received in the warehouse. This aspect requires a manual check by the planners, who each month analyse the proposals to decide which orders should actually be issued and which should be discarded.

TOTDMD	-	3.038	-	-	2.633	-	-	2.633	-	2.633	-
INVENTORY	3.460	-	-	-	-	-	-	-	-	-	-
SCHEDRCPTS	-	-	-	-	-	-	-	-	-	-	-
PLANORDERS	-	-	-	-	-	-	-	-	-	-	-
FIRMPLANORDER	-	-	-	-	-	-	-	-	-	-	-
PLANPURCH	-	-	-	-	-	-	8.000	-	-	-	-
PURCHORDER	8.800	-	-	-	-	-	-	8.000	-	-	-
PROJOH	12.260	9.222	9.222	9.222	6.590	6.590	14.590	19.957	19.957	17.325	17.325
COVDUR	70	63	56	49	42	35	84	119	112	105	98

Figure 14: Example of system proposal for a single code

The *Figure 14* represents the layout used by the packaging planners to analyse the system proposals. Each column represents a week, and the rows of interest are:

- Consumptions (TOTDMD)
- Current stock (inventory)
- System reorder proposals (planpurch)
- Already issued orders (purchorder)
- Projoh, which is the stock calculated as: (inventory + planpurch + purchorder – totdmd)
- Covdur (which is the coverage in days of the stock on hand).

In this scheduling method, the safety margin is very high, about 5 weeks (which corresponds to 35 days). As shown in the example, the system proposes a planpurch as soon as the coverage reaches the 35-day safety margin, ignoring the fact that there is already a scheduled order (purchorder) arriving the following week. In situations like this, the planner intervenes manually, modifying the proposals and updating the forecasts and orders to be sent to suppliers.

Each month, forecasts for the following 6 months are sent to every supplier, while actual orders are issued within a shorter time frame, which also varies depending on the MRP controller involved.

Each packaging code can be associated with one or more suppliers: planners always analyse the aggregated situation, and only afterwards the system split the quantities among the different approved suppliers according to predetermined quotas. However, the system does not perform this allocation proportionally and linearly: for example, if a code is assigned to two suppliers at 50% each and 100 units need to be reordered, the system will not necessarily propose 50 units for each supplier. It is more likely that, in order to respect the minimum order lots, a full order will be placed with one supplier, and the next time with the alternative one. This approach can generate fluctuations in the volumes ordered from individual suppliers, who end up receiving alternately very large or very small orders, making their internal planning more complex. As a consequence, there are risks of extended lead times due to a lack of raw materials, or of having excess unused material to dispose of.

In addition, each code is characterized by a minimum order lot, which limits the possibility of ordering exactly the desired quantity to cover the estimated consumption. This can create situations in which a slow-moving code still requires ordering a large quantity, resulting in stock coverage that is much higher than the actual demand.

The combination of the safety margin time constraint and the minimum order lot requirement often forces the company to place large orders for certain codes several months before the actual consumption takes place. During this period, sales forecasts may change significantly, increasing the risk that the material will remain unused in stock.

This model only works properly if the bills of materials (BOM), lead times, stock levels, and production plan are accurate and constantly updated. Incorrect data lead to wrongly calculated requirements and to unnecessary or delayed orders. Moreover, it is not very responsive to sudden changes in demand or in supply lead times. Small variations in the inputs can trigger the so-called "nervousness effect": frequent changes to the planned orders that destabilize production and the supply chain.

Once the planning phase is completed by Lavazza, the suppliers receive the orders and make the materials available on the required dates. Lavazza does not have its own warehouse, so each supplier stores the produced materials in their own facility. The materials are then transferred to Lavazza's plants when needed for production, following a call-off request.

The overall flow is shown below:

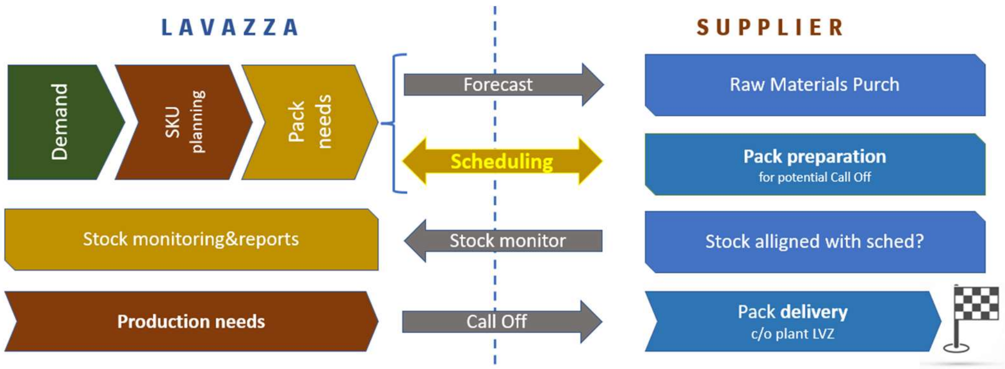

Figure 15: Today's packing re-order (scheduling)

Since there is no internal warehouse, the material kept in stock by suppliers is constantly monitored, and Lavazza ensures that it matches the quantity expected to be available. Each week, it is checked whether suppliers have updated the stock levels of their items; if at least 90% of the item codes have been uploaded, the supplier is considered OK, otherwise KO. This monitoring activity is important because it contributes to the calculation of the KPIs for each supplier.

4.2 VMI application in the company

In this complex context of packaging, Lavazza has decided to introduce a Vendor Managed Inventory approach as a method to address the critical issues of the current situation and to better integrate its suppliers along the supply chain.

To manage this new procurement approach, the same portal the company uses to interact with suppliers through the MRP logic is utilized. However, a new section dedicated to VMI has been created within the portal.

Below is the schematic representation of the VMI process flow (*Figure 16*). It can be immediately observed, even visually, that it is simplified compared to the process flow under the MRP logic shown above in *Figure 15*.

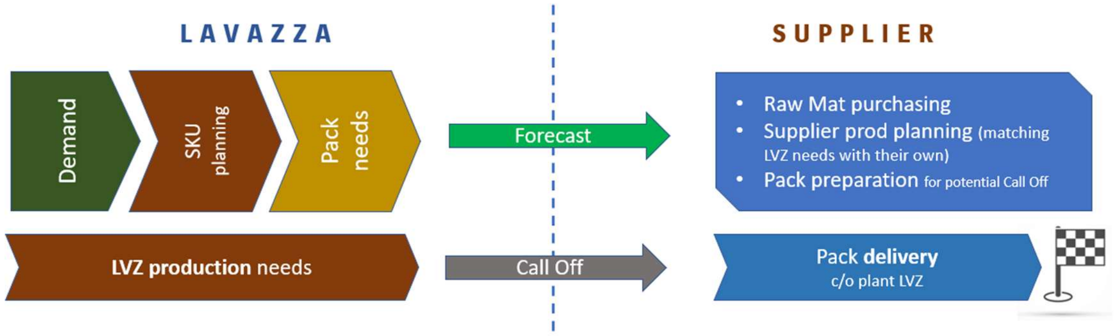

Figure 16: VMI workflow

Before examining the process in detail, a preliminary clarification is necessary. As mentioned earlier, Lavazza does not have an internal warehouse of its own. The VMI model has therefore been adapted to the company's specific organizational structure. This adaptation required considerable study and effort, as no similar cases are documented in the existing literature. The resulting framework is outlined below (*Figure 17*).

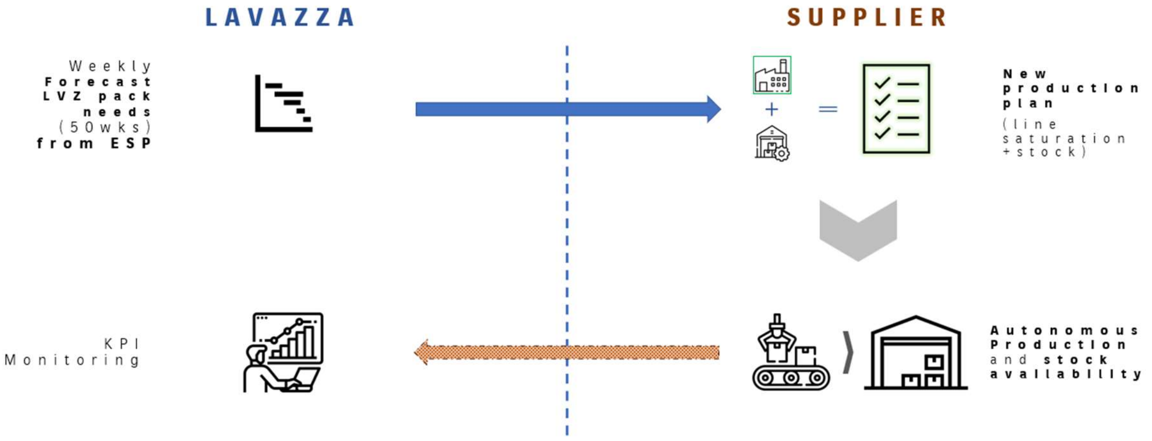

Figure 17: VMI - how it works

The planning process for finished products remains unchanged, while the work of the packaging planners is modified with the introduction of the VMI model. According to this approach, packaging planners download the packaging demand forecasts from the system once a week. These forecasts are made directly visible to the suppliers, without any intermediate analysis by the planners. This allows suppliers to consult, on a weekly basis, the material consumption forecasts and the available stock levels. Based on this information, they can autonomously calculate the quantities to be produced and plan the corresponding production dates.

The main difference compared to the traditional MRP model lies in the visibility of demand: with the VMI system, suppliers have direct access to consumption trends, enabling them to plan production more accurately and responsively. In contrast, under the MRP logic, suppliers could only see the reorder quantities sent by the planner. Since these quantities were often constrained by predefined lot sizes, they did not always reflect the actual consumption trend.

In the VMI model as well, a single code can be supplied by multiple suppliers. To manage this situation, supply quotas have been defined to distribute the overall demand among the different suppliers. Each code–supplier pair is therefore assigned a quota (not disclosed to the supplier) that represents the percentage of the total demand for which that supplier is responsible.

Consequently, each supplier can view only the consumption data corresponding to their assigned quota and plans production based on this information. In this scenario, the difference compared to the MRP model becomes even more evident: the supplier no longer receives large and infrequent orders but must instead plan more frequent productions of smaller quantities, in line with the actual consumption trend. This system contributes to mitigate the Bullwhip Effect.

It is important to highlight that this method works only if the plants also adjust the material call-offs to suppliers according to the quotas assigned to each of them.

Each material code is characterized by a maximum stock level, a minimum stock level, and a dynamic stock level. The maximum stock is variable and is defined as the sum of the rolling sales over a certain number of weeks (which varies depending on the type of code) following the current week. The minimum stock is static and is calculated based on an average coverage period that also varies according to the code. The dynamic stock, on the other hand, represents the quantity of material that the supplier currently has in stock. The screen through which the supplier can analyse this situation is shown in *Figure 18*:

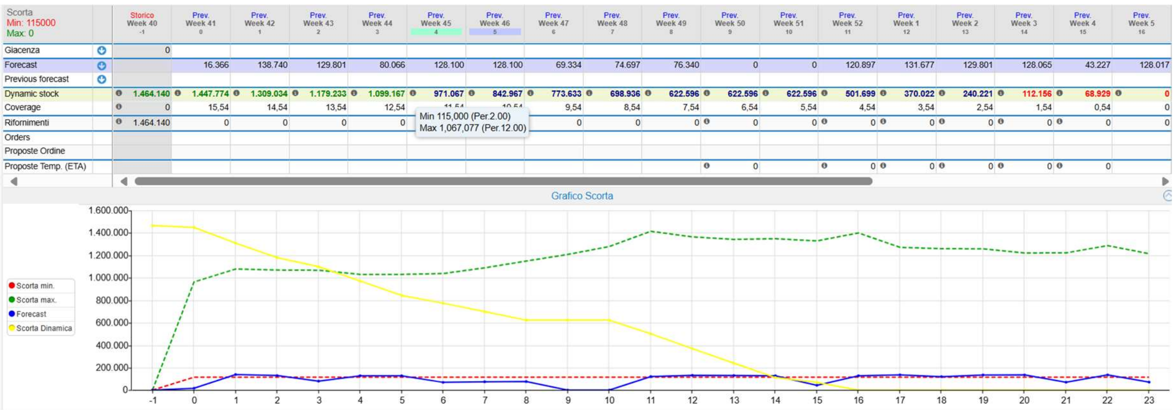

Figure 18: Stock and requirements view of a material code

The chart shows the maximum stock curve (green), the dynamic stock curve (yellow), and the minimum stock level (red), which, as mentioned earlier, is static. The blue line represents the trend of material consumption (forecast).

The table above the chart in *Figure 18* is divided by weeks, with each column corresponding to a specific week. It starts from week -1, which shows the open schedule, that is the quantity that Lavazza expects the supplier to have in stock. In the following weeks, the dynamic stock is shown, calculated as (initial stock – consumption forecast + orders). If the dynamic stock is within the defined limits, the corresponding number in the table is displayed in blue; if it exceeds the maximum level, it is shown in green; and if it falls below the minimum level, it is shown in red. Moreover, week 45 (or week 4) has a light blue header, while week 46 (or week 5) is marked in purple. These two colours respectively indicate the frozen period and the lead time of the code for a specific supplier. The system does not allow the supplier to enter any scheduling before the lead time.

The supplier can use this screen to understand when and how much needs to be produced in order to avoid the risk of having a stock level lower than the minimum. By entering a scheduling proposal in the “proposte temp” (temporary proposals) row, it is immediately possible to see a change in the dynamic stock curve on the chart and, consequently, to assess whether the proposal is reasonable or not. Furthermore, by placing the cursor on the curves, two numbers appear corresponding to the maximum and minimum stock levels, providing additional support in determining how to size the new schedule. Anything entered as a temporary proposal can be deleted without making any changes to the current situation. If, on the other hand, the supplier wants to confirm a temporary proposal, it must be saved and then validated and confirmed on a different page (*Figure 19*).

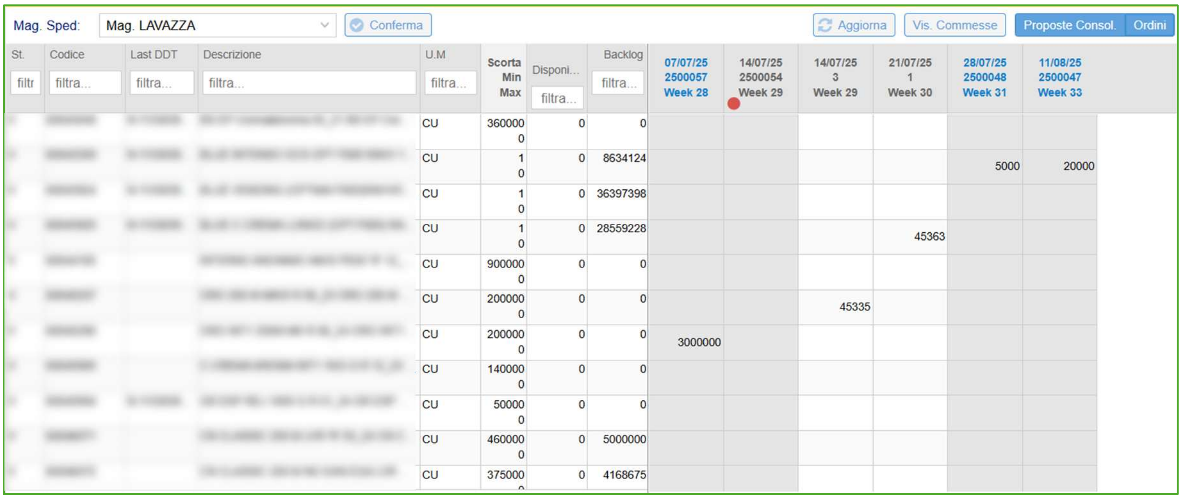

Figure 19: Proposals confirmation and validation

The white column identifies the temporary proposals that are still pending confirmation, while the grey column with a blue header represents the confirmed schedules that have been converted into orders. The fully grey column indicates the proposals that did not pass the validity check. The validity check can have three possible outputs:

- Green label: the proposal can be confirmed because it falls within the defined limits.
- Red label: the proposal did not pass the validity check because the dynamic stock exceeds the minimum or maximum limits.
- Black label: the proposal exceeds the time limits within which the supplier is allowed to submit a scheduling proposal.

The red signal acts as an alert but is not binding for the confirmation of the proposal. The proposal can still be confirmed; however, it must be considered that any excess quantity will not be acknowledged by Lavazza in case it is not used. Lavazza commits to recognizing only up to 5% above the maximum quantity. Therefore, if the proposal exceeds the maximum by more than 5%, it is automatically confirmed; otherwise, it requires manual confirmation by the Lavazza planner. The black signal, on the other hand, indicates that the proposal has been made too far in advance and cannot be confirmed.

Once the material is stored in the suppliers' warehouses, Lavazza plants can call off the material and receive from the supplier the quantity needed for production.

4.2.1 Implementation of the VMI logic

The transition to the VMI logic within the company is taking place gradually. Specific "waves" have been defined, representing dates on which groups of codes are progressively transferred from management under the MRP logic to management based on the VMI logic.

From an operational point of view, this gradual introduction is necessary both for the suppliers, who can become familiar with the new method by starting with a limited number of codes, and for the Lavazza planners, who also need to adapt to a different approach to planning and control.

From a more theoretical point of view, this gradual implementation is necessary because not all codes are equally suitable for this model. The most appropriate ones are high-turnover codes, meaning those with relatively high and steady consumption volumes. Forecasts based on actual data for these codes are more reliable, as their variability is lower compared to low-volume codes, and consequently, the margin of error is smaller.

This volume-related constraint makes it impossible to apply the VMI logic to all codes. Considering that packaging planners currently manage around 1,500 codes, the goal is to progressively extend the VMI model to about one thousands of them, specifically to those codes that, due to their turnover rate and demand stability, are most suitable for this type of management.

5. Analysis of the Impacts and Benefits of VMI on Lavazza’s Supply Chain

The benefits that VMI brings to Lavazza’s Supply Chain can be divided into three levels: operational level, management level, and collaborative level.

5.1 Operational-level impacts and benefits

The VMI offers significant advantages in terms of reduction of the material stock levels. Below, I compare through a simulation the stock behaviour of a material code in a traditional scheduling scenario and under VMI management, both in a single-supplier and a multi-supplier case.

I decided to perform a simulation because, since VMI management for the selected material codes only started in July, I did not have enough real data available to show their stock behaviour over time.

It is important to note that the simulations were carried out assuming a static Total Demand, not subject to daily updates but fixed according to the initial planning.

5.1.1 Single-supplier simulation

The simulation analyses the stock trend of material code 600xxxx, supplied by a single supplier (“Supplier A”), over the period from week 43 of 2025 to week 39 of 2026 (a total of 49 weeks).

The data used for the simulation were extracted from the company systems and include:

- Total Demand: weekly material requirement for the entire analysis period
- Stock (Open Schedule): available inventory at the reference week (wk43 2025)
- Schedule Proposal: proposed scheduling of new orders
- Reorder lot: 50.000.000 pieces (used only for the traditional scheduling method)

The “projected available quantity” of the material was calculated week by week according to the following logic:

- Week 0:
  Projected available quantity (0) = *Stock (open schedule)* + *Future schedule (0)* + *Schedule proposal (0) – Total demand (0)*
- Subsequent weeks (x):
  Projected available quantity (x) = *Projected available quantity (x-1)* + *Future schedule (x)* + *Schedule proposal (x) – Total demand (x)*

Subsequently, the average stock and days of coverage were derived from the projected available quantity.

The average stock is the arithmetic mean of the projected available quantity over the entire analysis period (49 weeks) and represents the expected average inventory level:

$$\text{Average Stock} = \frac{\sum_{i=1}^{49} Projected\ available\ quantity_{\ i}}{49}$$

The days of coverage quantify the duration of the available stock in days. The formula used in Excel counts the number of weeks covered by the stock, and this value is then converted into days.

In the simulation, the frozen period and lead time are also specified. These correspond respectively to the time window during which orders can no longer be modified and the minimum time required by the supplier to make the material available. The lead time for the material under analysis is 8 weeks, of which 2 are part of the frozen period.

5.1.1.1 Traditional Scheduling scenario

The scenario under traditional scheduling is shown in *Table 4*:

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total Demand				2.181.000	5.257.093	8.211.558	2.181.000	7.205.517	2.181.000	7.898.629	7.898.629
Stock (open sched)	10.150.000										
Future Schedule	50000000										
Schedule Proposal									50000000		
Projected Available Quantity	60.150.000	60.150.000	60.150.000	57.969.000	52.711.907	44.500.349	42.319.349	35.113.832	82.932.832	75.034.203	67.135.574
Average Stock	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888	54.515.888
Days of Coverage	84G	77G	70G	63G	56G	49G	42G	35G	98G	91G	84G

Table 4: Partial view of the traditional scenario (10 of 49 weeks shown)

It was not possible to display all the weeks in the table, so only 10 weeks are shown which correspond to the number of weeks in the "monitoring period".

One of the main characteristics of traditional scheduling is the high safety margin; indeed, in this case, it can be observed that replenishments are proposed 35 days before stock depletion, which corresponds to 5 weeks in advance.

The first replenishment occurs in week 0, and over the following 48 weeks, five additional orders are proposed. The orders must comply with a fixed reorder lot, which for this material code amounts to 50.000.000 pieces.

Figure 20 shows the trend of the stock (Projected available quantity) and indicates the average stock level.

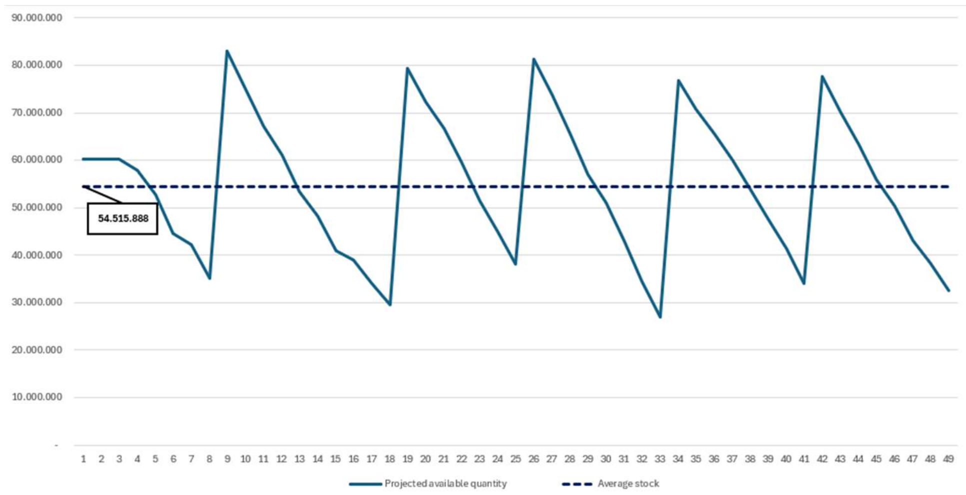

Figure 20: Stock and Average Stock – Traditional Scheduling Model

The peaks correspond to the replenishment schedules, while the average stock (dashed line) amounts to 54.515.888 pieces.

5.1.1.2 VMI scenario

In *Table 5*, the scenario based on the VMI logic is shown:

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	0	1	2	3	4	5	6	7	8	9	10
Total Demand				2.181.000	5.257.093	8.211.558	2.181.000	7.205.517	2.181.000	7.898.629	7.898.629
Stock (open sched)	10.150.000										
Future Schedule											
Schedule Proposal			45.000.000								
Projected Available Quantity	10.150.000	10.150.000	55.150.000	52.969.000	47.711.907	39.500.349	37.319.349	30.113.832	27.932.832	20.034.203	12.135.574
Average Stock	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317	33.087.317
Days of Coverage	28G	21G	63G	56G	49G	42G	35G	28G	21G	14G	7G
Min Stock Level	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000	10.000.000
Max Stock Level	43.015.000	49.005.000	56.720.000	59.825.000	61.700.000	55.500.000	58.235.000	55.670.000	53.490.000	52.775.000	50.440.000

Table 5: Partial view of the VMI scenario (15 of 48 weeks shown)

By definition, the VMI model includes a maximum (dynamic) stock level and a minimum (static) stock level. These are parameters that can vary depending on the specific characteristics of the material code considered. The maximum stock is recalculated week by week, and in this case, it is set to provide 10 weeks of coverage, while the minimum stock is fixed and has been calculated based on an average coverage of 2 weeks.

The maximum stock was calculated as follows:

- i = current week
- TD_x = Total demand in week x
- MS_i = Max stock level in week i

MS_i = *Round* ($\sum_{x=i+1}^{i+10} TD_x$ *, 5000)*

The VMI allows for a much lower safety margin compared to scheduling based on the MRP model. In fact, the supplier has visibility of consumption forecasts on a weekly rather than a monthly basis, which means that replenishment proposals can be made with less advance notice and more consistently with actual demand.

Moreover, there is no longer a fixed reorder lot, the supplier can decide the quantity to produce, with the only constraint being that the dynamic stock curve remains within the defined maximum and minimum limits. This results in a lower average stock quantity (as illustrated in *Figure 23*)

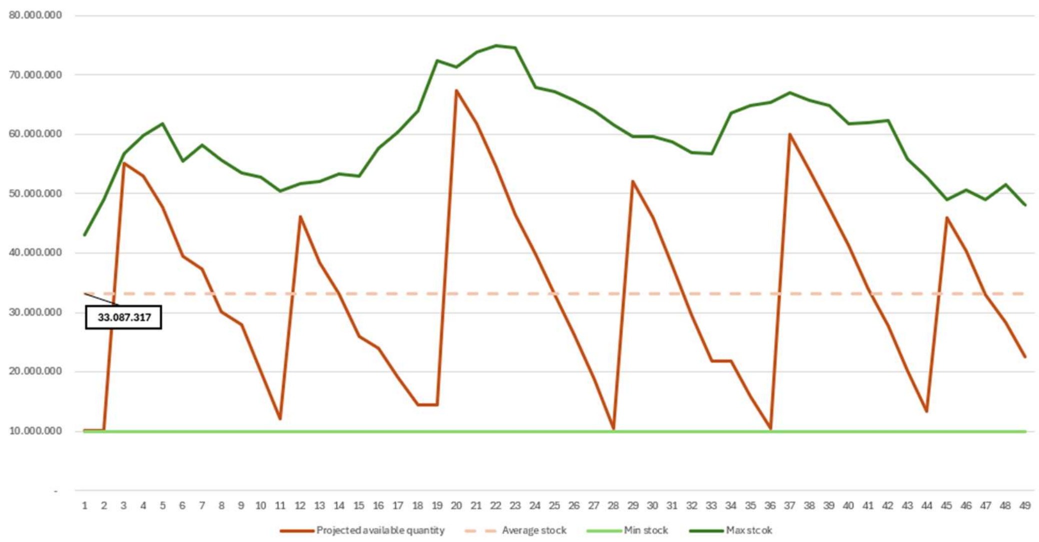

Figure 23: Stock and Average Stock – VMI Model

In this case, the average stock amounts to 33.087.317 pieces.

5.1.1.3 Comparison between traditional scheduling scenario and VMI scenario

By comparing the two scenarios, the result is as follows:

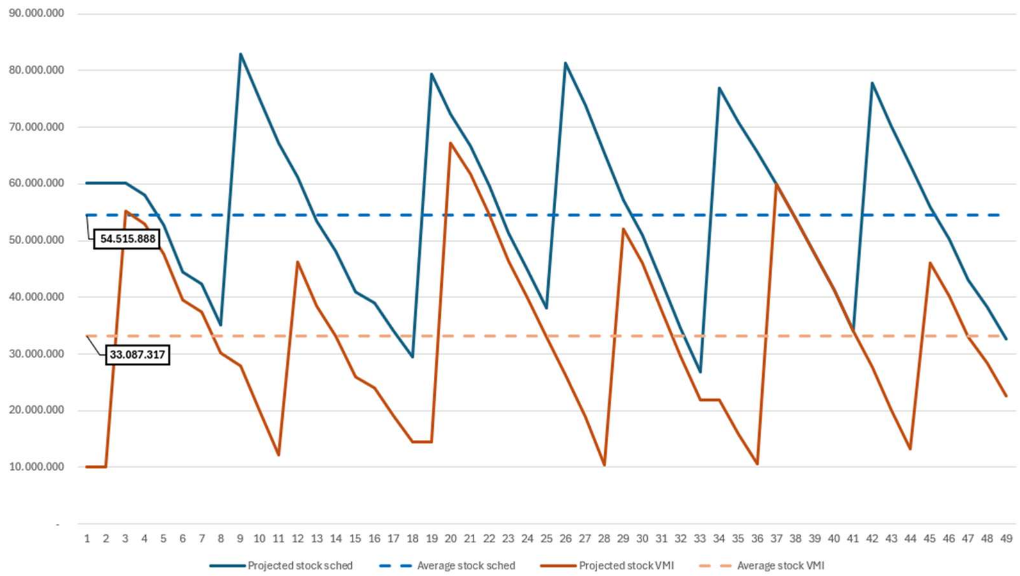

Figure 24: stock in traditional scheduling VS stock with VMI

In blue are shown the Projected available quantity and the average stock for the traditional scheduling, while in orange are the data related to the VMI-based replenishment.

It is evident that even if the number of replenishments remains unchanged between the two models, the traditional scheduling requires a much higher stock level due to the fixed reorder lot and the high safety margin.

The difference between the two average stock levels is approximately 21.500.000 pieces.

5.1.1.4 Economic evaluation of single-supplier scenario

The reduction in average stock levels achieved through the VMI model translates into a significant economic benefit, resulting from the decrease in working capital tied up in inventory.

For each of the 49 weeks, the difference between the stock level generated by the traditional model and the stock level resulting from the adoption of the VMI model was calculated. The average deviation was then determined as the arithmetic mean of the weekly differences.

The following assumptions were applied:

- Unit material cost = 0,00235€ per piece
- Cost of capital or opportunity cost (annual) = 7%. It represents the implicit return obtained by avoiding the capital investment associated with production.

Based on these parameters, the production savings and the financial savings were computed (*Table 6*).

The production savings correspond to the avoided cost for the supplier, since a certain quantity of items is not produced. It is obtained by multiplying the average stock deviation by the unit material cost:

Production savings = *Average* $(\sum_{i=1}^{49}(Proj\ Qty\ VMI_{\ i} - \ Proj\ Qty\ sched_i))$

The financial savings represent the economic benefit deriving from the reduced amount of capital tied up in inventory during the analysis period. It is calculated by applying the cost of capital to the production s avings:

Financial savings (49 weeks) = $Production\ savings \times Cost\ of\ capital\ \times (\frac{49}{52})$

Cost of Capital or Opportunity Cost		7%									
Cost per Piece		0,00235	€/piece								
Wk	**W43**	**W44**	**W45**	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W01**
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Proj Qty VMI – Proj Qty Sched	-50.000.000	-50.000.000	-5.000.000	-5.000.000	-5.000.000	-5.000.000	-5.000.000	-5.000.000	-55.000.000	-55.000.000	-55.000.000
Average	-21.428.571	Pieces									
Production Savings	50.357	€/week									
Financial Savings	3.322	€									

Table 6: Stock difference VMI vs. MRP (10 out of 49 weeks) and potential savings

The average stock deviation between the traditional model and the VMI approach is equal to 21.428.571 pieces per week. This reduction corresponds to an average production savings of 50.357€ per week (21.428.571 pieces × 0,00235 €/piece).

Considering the opportunity cost of capital, this results in an average financial saving of 3.322 € over the 49-week analysis period (50.357 € × 7% × 49/52).

5.1.2 Multi-supplier simulation

The simulation considers material code 600xxxx, which is supplied by two suppliers (A and B), each with a 50% allocation. Similarly to the single-supplier case, the data were extracted from the company systems, and the calculations were carried out in the same way.

5.1.2.1 Traditional Schedulig scenario

The analysis was structured into three distinct scenarios:

- stock and replenishment trends related to Supplier A (*Table7*),
- the same analysis carried out for Supplier B (*Table 8*),
- evaluation of the aggregated situation (*Table 9*).

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	0	1	2	3	4	5	6	7	8	9	10
Supplier Demand			1.052.460	1.475.550		2.518.500	1.859.400	1.506.000	376.945	1.627.000	1.806.200
Stock (open sched)	7.200.000										
Future Schedule											
Schedule Proposal					12.000.000						
Projected Available Quantity	7.200.000	7.200.000	6.147.540	4.671.990	16.671.990	14.153.490	12.294.090	10.788.090	10.411.145	8.784.145	6.977.945
Average Stock	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841	8.637.841
Days of Coverage	42G	35G	28G	21G	>110G	>110G	110G	105G	98G	91G	84G

Table 7: Partial view of Traditional sched scenario -supplier A

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	0	1	2	3	4	5	6	7	8	9	10
Supplier Demand			1.052.460	1.475.550	2.097.800				376.945		
Stock (open sched)	6.400.000										
Future Schedule											
Schedule Proposal											12.000.000
Projected Available Quantity	6.400.000	6.400.000	5.347.540	3.871.990	1.774.190	1.774.190	1.774.190	1.774.190	1.397.245	1.397.245	13.397.245
Average Stock	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054	5.786.054
Days of Coverage	98G	91G	84G	77G	70G	63G	56G	49G	42G	35G	105G

Table 8: Partial view of Traditional sched scenario -supplier B

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	0	1	2	3	4	5	6	7	8	9	10
Total Demand			2.104.920	2.951.100	2.097.800	2.518.500	1.859.400	1.506.000	753.890	1.627.000	1.806.200
Stock (open sched)	13.600.000										
Future Schedule											
Schedule Proposal					12.000.000						12.000.000
Projected Available Quantity	13.600.000	13.600.000	11.495.080	8.543.980	18.446.180	15.927.680	14.068.280	12.562.280	11.808.390	10.181.390	20.375.190
Average Stock	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895	14.423.895
Days of Coverage	49G	42G	35G	28G	77G	70G	63G	56G	49G	42G	84G

Table 9: Partial view of Aggregate sched scenario (A+B)

In a multi-sourcing supply context, as discussed in Chapter 4, the MRP system does not ensure a proportional allocation of demand among the involved suppliers. This behavior is clearly visible in the example provided: in weeks 2 and 3, the Total Demand is split equally between the two suppliers (50/50), while in the following weeks, the system assigns the entire requirement alternately to Supplier A or Supplier B, without continuity or linear balancing. As a result, order patterns become highly discontinuous, with alternating weeks of very large order volumes and weeks with no orders at all. This forces the supplier to maintain a high stock level, leading to increased working capital.

The fixed reorder lot of 12.000.000 pieces, combined with a high safety margin, results in significantly high coverage levels and stock quantities.

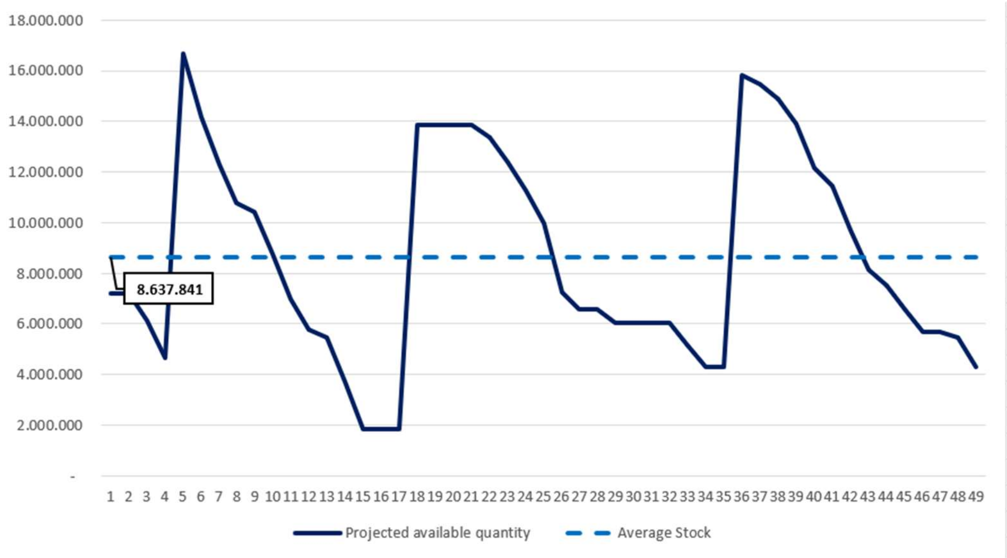

Figure 29: Stock and Average Stock – Traditional Scheduling Model (A)

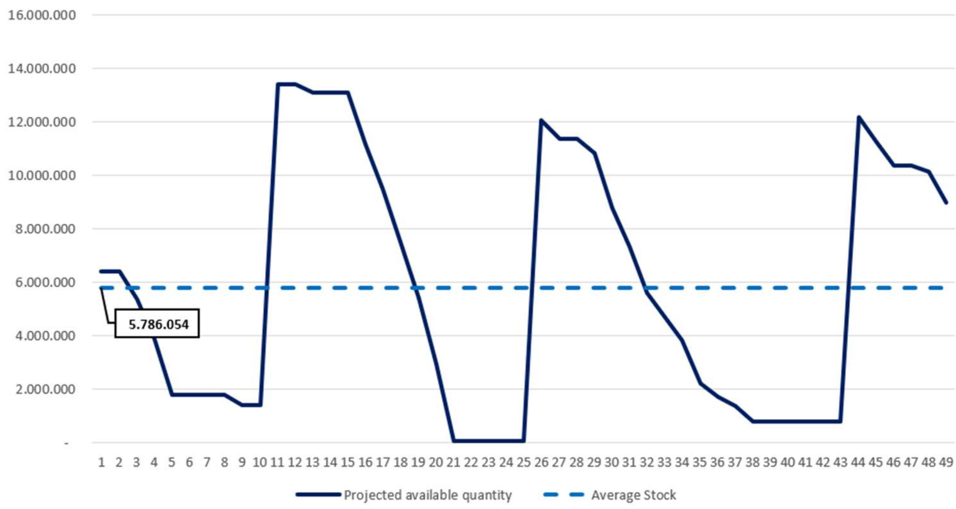

Figure 30: Stock and Average Stock – Traditional Scheduling Model (B)

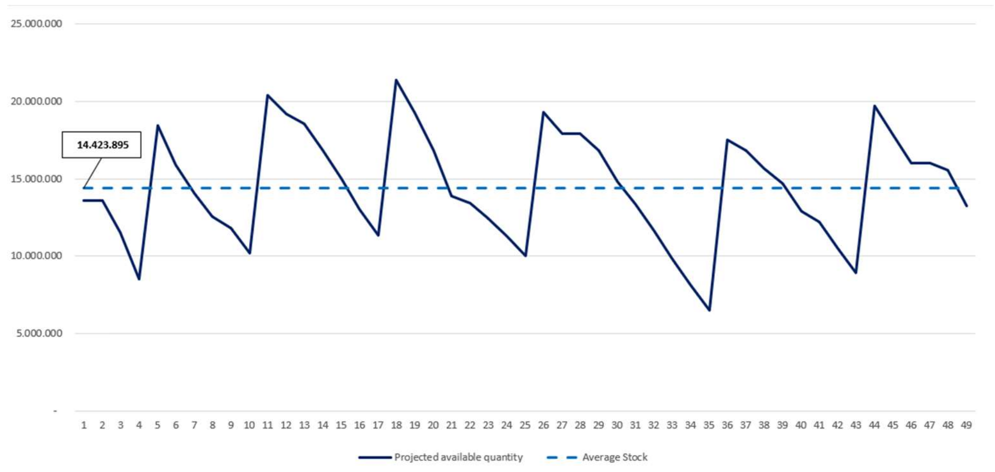

Figure 31: Stock and Average Stock – Traditional Scheduling Model (A+B)

From the analysis of the charts (*Figure 29* and *Figure 30*), it emerges that each supplier receives three replenishment orders over the 49-week period considered; consequently, at an overall level, the total number of orders amounts to six. Since the system does not allocate demand linearly between suppliers, different average stock levels are observed: Supplier A: 8.637.841 pieces, Supplier B: 5.786.054 pieces. This results in an aggregated average stock of 14.423.895 pieces (*Figure 31*).

5.1.2.2 VMI scenario

In the scenario where the VMI logic is applied, the situation for Supplier A is identical to that of Supplier B (*Table10*).

Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total Demand			1.052.460	1.475.550	1.048.900	1.259.250	929.700	753.000	376.945	813.500	903.100
Stock (open sched)	7.268.000										
Future Schedule											
Schedule Proposal								7.000.000			
Projected Available Quantity	7.268.000	7.268.000	6.215.540	4.739.990	3.691.090	2.431.840	1.502.140	7.749.140	7.372.195	6.558.695	5.655.595
Average Stock	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764	4.720.764
Days of Coverage	56G	49G	42G	35G	28G	21G	14G	70G	63G	56G	49G
Min Stock Level	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000
Max Stock Level	8.610.000	9.210.000	8.465.000	7.870.000	7.750.000	7.455.000	7.370.000	7.600.000	8.270.000	8.685.000	9.235.000

Table 10: Partial view of VMI scenario – Supplier A and Supplier B

The weekly demand each supplier receives is directly proportional to the assigned allocation share. In the case analysed, with a 50% split for both suppliers, the total requirement is equally distributed between the two.
In the same way, the initial stock (open schedule) is identical for each supplier.

It can be observed again that, in the VMI model, there is no longer a fixed reorder lot of 12.000.000 pieces. Instead, the supplier has the flexibility to independently define the quantities to produce, as long as the stock level remains within the defined minimum and maximum limits.

The minimum stock level for this material code has been set to 1.000.000 pieces per supplier, while the maximum stock level corresponds to 10 weeks of coverage.

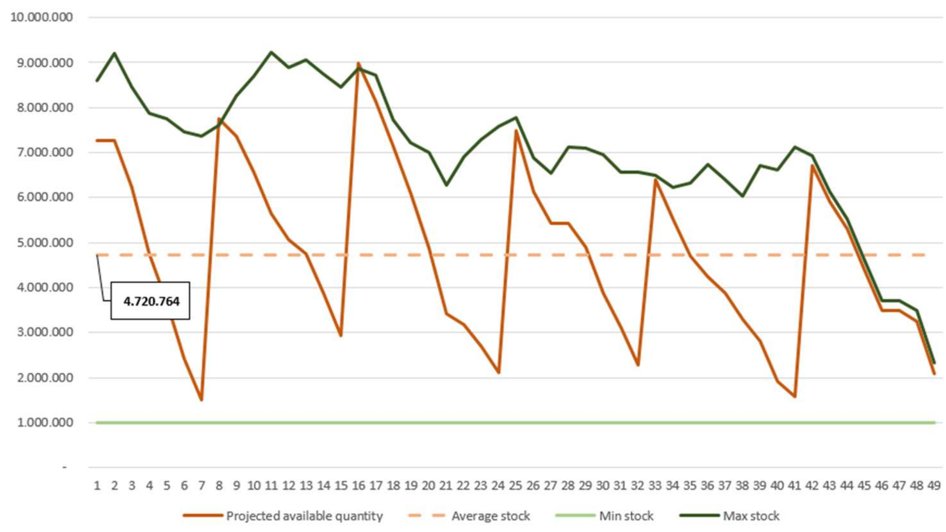

Figure 32: *Stock and Average Stock –VMI Model (A and B)*

In a multi-supplier context, the adoption of the VMI model allows each supplier to maintain lower stock levels. The average stock per supplier is in fact 4.720.764 pieces (*Figure 33*), a value lower than the average stock observed for both Supplier A and Supplier B under the traditional scheduling model. However, this benefit comes with a higher replenishment frequency: with a 50% split of the total demand, each supplier is required to produce twice as many times compared to the traditional scenario.

By aggregating the demand, the situation is as follows (*Table 11 and Figure 33*):

Wk	**W43**	**W44**	**W45**	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W01**
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total Demand			2.104.920	2.951.100	2.097.800	2.518.500	1.859.400	1.506.000	753.890	1.627.000	1.806.200
Stock (open sched)	14.536.000										
Future Schedule											
Schedule Proposal								14.000.000			
Projected Available Quantity	14.536.000	14.536.000	12.431.080	9.479.980	7.382.180	4.863.680	3.004.280	15.498.280	14.744.390	13.117.390	11.311.190
Average Stock	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528	9.441.528
Days of Coverage	56G	49G	42G	35G	28G	21G	14G	70G	63G	56G	49G
Min Stock Level	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000	1.000.000
Max Stock Level	17.225.000	18.415.000	16.935.000	15.740.000	15.495.000	14.910.000	14.745.000	15.195.000	16.545.000	17.370.000	18.465.000

Table 11: Aggregate VMI scenario (A+B)

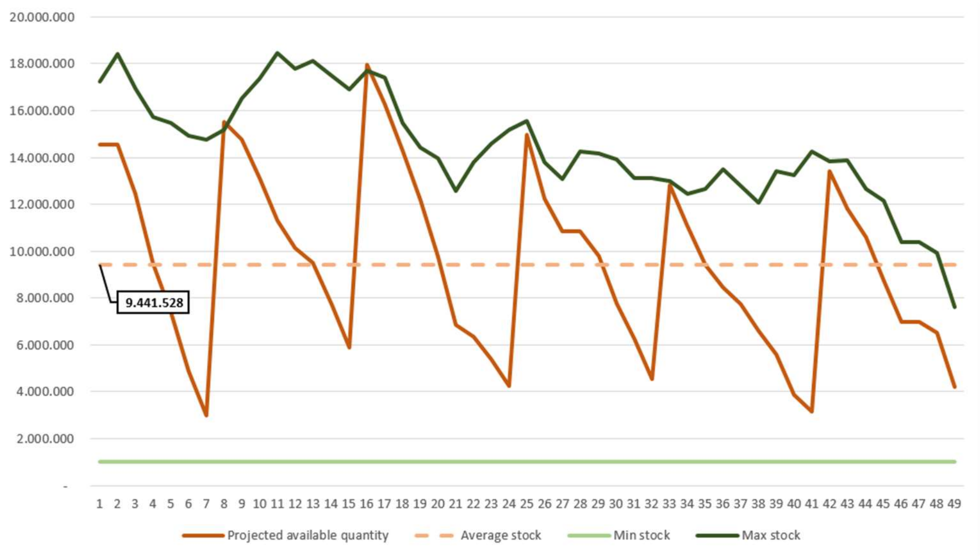

Figure 33: Stock and Average Stock –VMI Model (A+B)

5.1.2.3 Comparison between traditional scheduling and VMI

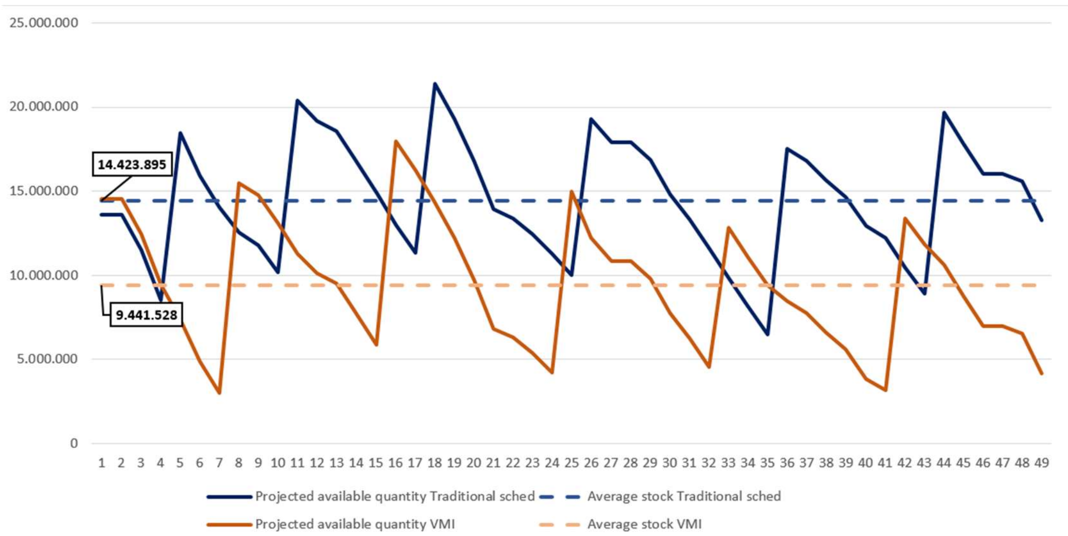

Figure 34: Stock in traditional scheduling VS stock with VMI

The comparison in *Figure 34* once again shows that the VMI enables a significant reduction in average inventory, with average savings of approximately 5.000.000 pieces compared to traditional scheduling.

5.1.2.4 Economic evaluation of multiple-supplier scenario

As shown in the single-supplier case, also in this scenario suppliers can benefit economically from the lower inventory levels achieved through VMI.

To quantify the actual advantage obtained by each supplier, the difference between the stock level generated by the traditional model and the stock level resulting from the adoption of the VMI model was calculated, for each of the 49 weeks. The average deviation was then determined as the arithmetic mean of the weekly differences.

The following assumptions were applied:

- Unit material cost = 0,042€ per piece
- Cost of capital or opportunity cost (annual) = 7%. This represents the implicit return obtained by avoiding the capital investment associated with production.

Based on these parameters, the production savings and the financial savings were computed for both Supplier A (*Table 12*) and Supplier B (*Table 13*).

The production savings correspond to the avoided cost for the supplier, due to the fact that a certain quantity of items is not produced. It is obtained by multiplying the average stock deviation by the unit material cost:

Production savings = *Average* $(\sum_{i=1}^{49}(Proj\ Qty\ VMI_{\ i} - \ Proj\ Qty\ sched_i))$

The financial savings represent the economic benefit deriving from the reduced amount of capital tied up in inventory during the analysis period. It is calculated by applying the cost of capital to the production savings:

Financial savings (49 weeks) = $Production\ savings \times Cost\ of\ capital\ \times (\frac{49}{52})$

SUPPLIER A											
Cost of Capital or Opportunity Cost		7%									
Cost per Piece		0,042	€/piece								
Setup Cost		2.500	€								
Wk	**W43**	**W44**	**W45**	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W01**
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Proj Qty VMI – Proj Qty Sched	68.000	68.000	68.000	68.000	-12.980.900	-11.721.650	-10.791.950	-3.038.950	-3.038.950	-2.225.450	-1.322.350
Average	-3.917.077	Pieces									
Production Savings	164.517	€/week									
Financial Savings	10.852	€									

Table 12: Stock difference VMI vs. MRP (10 out of 49 weeks) and potential savings (Supplier A)

SUPPLIER B											
Cost of Capital or Opportunity Cost		7%									
Cost per Piece		0,042	€/piece								
Setup Cost		2.500	€								
Wk	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W01
Week	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Proj Qty VMI – Proj Qty Sched	868.000	868.000	868.000	868.000	1.916.900	657.650	-272.050	5.974.950	5.974.950	5.161.450	-7.741.650
Average	-1.065.290	Pieces									
Production Savings	44.742	€/week									
Financial Savings	2.951	€									

Table 13: Stock difference VMI vs. MRP (10 out of 49 weeks) and potential savings (Supplier B)

For Supplier A, the traditional planning model showed a higher initial open schedule, therefore the reduction in average inventory levels is more significant: the average weekly stock difference amounts to 3.917.077 pieces, which, when valued at the unit cost, generates a potential production savings of around 164.517 € per week (3.917.077 pcs × 0,042 € per piece). When considering the opportunity cost of capital, the resulting financial saving over the 49-week horizon equals 10.852 € (164.517 € × 7% × 49/52).

For Supplier B, the average stock reduction is approximately 1.065.000 pieces per week, resulting in an estimated average production savings of around 44.742 € per week. When considering the opportunity cost of capital, the resulting financial saving over the 49-week horizon equals 2.951 € (44.742 € x 7% x 49/52). Here as well, an economic benefit is observed, although lower compared to Supplier A, since the initial scheduled inventory in the traditional model was lower.

This sourcing logic may lead to an increase in the number of setups required by suppliers. Assuming a setup cost of 2.500 €, the estimated financial benefit calculated for Supplier A (10.852 €) would be sufficient to cover just over three setups. Considering 3 additional set up as in the example, the savings is equal to: 3.352 € (10.852 € – (2.500 € x 3)). For Supplier B, however, the estimated financial benefit (2.951€) would cover only one setup, meaning there would be no real financial savings. This inconsistency derives from the different initial open scheduled levels; once the starting schedules are aligned between the two models, the estimated economic benefits would appear more consistent.

5.1.3 Operational benefits: summary of findings

The comparative analysis has shown that the application of VMI, both in a single-supplier and multi-supplier setup, enables a significant reduction in average stock levels compared to traditional MRP-based planning. This is made possible by the elimination of fixed reorder lots, the lower safety margin required, and improved synchronization with actual consumption.

In the multi-supplier case, the introduction of VMI leads to a stable and proportional distribution of demand according to the assigned shares, eliminating the strong discontinuity in replenishment cycles typically observed in the traditional scenario. This allows a considerable reduction in average stock levels, generating an economic benefit through lower capital tied up in inventory and enables more stable production planning for each supplier. However, this benefit is counterbalanced by an increased number of production runs, which results in higher setup costs. This situation does not arise in single sourcing, where inventory levels are lower, but the number of production runs remains unchanged. Considering the whole situation, the cost savings, net of the additional setup costs, are higher for the single-source supplier compared to multiple suppliers.

In the case of Lavazza, which does have an internal warehouse, the reduction of stock levels, and therefore of tied-up capital, does not represent a direct benefit. However, this advantage results in several indirect positive effects for the company.

Among these, the most relevant is the increased flexibility and responsiveness of the supply chain. Since replenishment decisions are based on consumption forecasts updated weekly, orders become more accurate and better aligned with the actual demand: errors are reduced and the required materials are made available on time. Furthermore, the supply chain becomes more capable of absorbing sudden demand fluctuations, supply disruptions, product changes, or variations in the product mix. The supplier, benefiting from greater visibility of Lavazza's needs, can detect any graphical or technical modifications to the material in advance and promptly adapt its production process. This leads to a reduction in scrap, disruptions or delays, and faster response times throughout the entire operational flow.

5.2 Management-level impacts and benefits

From a managerial perspective, the adoption of the VMI model leads to a significant simplification of planning activities and a reduction in operational workload for packaging planners. In the traditional MRP-based approach, planners are required to constantly verify system proposals, manually adjusting quantities, delivery dates, and allocations among multiple suppliers. This process is not only time-consuming, but also highly prone to errors, especially when managing a large number of item codes with variable demand. With VMI, suppliers gain direct visibility on consumption forecasts and take responsibility for scheduling material replenishment within predefined stock limits. As a result, planners no longer need to intervene continuously in the generation of orders, shifting their role from operational execution to supervisory and exception-based control.

As previously mentioned, the introduction of the VMI model at Lavazza began in July and is progressing gradually. At present, approximately one hundred (over more than one thousand) material codes are managed under this new logic. In this initial phase, the managerial benefits are not yet fully perceptible. Packaging planners still have to work with two parallel systems, traditional MRP and VMI, which increases operational complexity. Furthermore, even the codes already migrated to VMI still require constant monitoring and significant support for suppliers, who are learning the new approach and adapting their internal processes. For this reason, the level of manual intervention remains high.

5.3 Collaborative-level impacts and benefits

The transition from MRP-based management to VMI represents a major change in the relationship between the company and its suppliers. The transparent sharing of consumption data and stock projections enables suppliers to operate with greater visibility and alignment to actual demand, fostering a climate of mutual trust. The supplier is no longer just an executor but becomes an active player in the process.

At the same time, suppliers take on a higher level of risk compared to traditional management. For each material code, the company defines a maximum and minimum stock level and commits to recognizing the quantities stored at the supplier within this range, with a tolerance of +10% above the maximum level. If the supplier decides to produce additional quantities to increase their own safety margin, such excess volumes are not covered by Lavazza if they are not actually consumed. Conversely, if sales forecasts rise quickly or the supplier fails to produce in line with the required demand, the responsibility for any stockout risk lies entirely with the supplier.

In this trade-off scenario, the significant reduction in inventory required compared to MRP-based management represents a major economic advantage for the supplier, in terms of lower working capital and reduced storage costs. At the same time, this benefit becomes an effective negotiation lever for Lavazza, which can encourage suppliers to adopt the new management model by balancing the increased accountability with a tangible economic return.

6. Conclusion

The aim of this thesis was to analyse the transition from the Material Requirements Planning (MRP) model to the Vendor Managed Inventory (VMI) model and to evaluate its operational, managerial, collaborative, and economic impacts within Lavazza's supply chain.

The simulations carried out showed an average stock reduction of about 40% in the single-supplier case and around 35% in the multi-supplier case. These results demonstrate that adopting the VMI model allows a significant decrease in tied-up capital and improves stock stability. Moreover, the model enhances the synchronization between consumption and replenishment, contributing to the reduction of the bullwhip effect and increasing the responsiveness and flexibility of the production system.

However, in the multi-supplier context, the economic benefit resulting from the reduction of tied-up capital is partially offset by higher setup costs, due to the production of smaller but more frequent batches that better follow the consumption trend. This shows that, in this scenario, the VMI model requires a careful evaluation of the trade-off between inventory reduction and increased operational complexity.

From a managerial point of view, the implementation of the VMI model simplifies planning activities, reduces the number of corrective interventions required by planners, and shifts their role from operational to a more strategic and supervisory one. However, these benefits can be fully achieved only when a larger number of material codes are managed using this approach.

At a collaborative level, the model strengthens trust and transparency with suppliers, improving the quality of shared information and enhancing the overall responsiveness of the supply chain. Furthermore, the wider the VMI model is extended to a greater number of material codes, the more significant the overall benefits will be, provided that the characteristics of the selected materials and the management capabilities of the involved partners are carefully evaluated.

In conclusion, the Lavazza case confirms that adopting the VMI model, even in a context without an internal warehouse, represents an innovative and replicable strategy capable of improving operational efficiency, reducing tied-up capital, and promoting stronger, more transparent, and more sustainable collaboration across the entire supply chain.

Figures

Tables

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