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ỨNG DỤNG KẾ HOẠCH SẢN XUẤT NGUYÊN VẬT LIỆU THEO NHU CẦU VÀO NGÀNH SẢN XUẤT VÀ BÀI HỌC CHO DOANH NGHIỆP VIỆT NAM: TRƯỜNG HỢP CỦA MICHELIN

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Tóm tắt

Hoạch định nhu cầu nguyên vật liệu (MRP) là phương pháp lập kế hoạch sản xuất cơ bản trong ngành sản xuất trong nhiều thập kỷ. Tuy nhiên, kỹ thuật MRP truyền thống dựa trên dự báo và thời gian sản xuất cố định thường không hiệu quả trong sản xuất và quản lý kho. Kế hoạch sản xuất nguyên vật liệu theo nhu cầu (DDMRP) là một cách tiếp cận thay thế điều chỉnh thời gian sản xuất để phản ứng với các hạn chế thời gian thực và liên kết trực tiếp sản xuất với nhu cầu thực tế. Mục đích của nhóm tác giả nhằm khám phá quá trình chuyển đổi của Michelin từ phương pháp MRP truyền thống phụ thuộc vào dự báo sang lập kế hoạch sản xuất nguyên vật liệu dựa trên nhu cầu (DDMRP). Thông qua phân tích định tính các nguồn thứ cấp, các tác giả thực hiện nghiên cứu cách triển khai kế hoạch sản xuất nguyên vật liệu theo nhu cầu (DDMRP) tại Michelin và rút ra những khuyến nghị cho các doanh nghiệp sản xuất Việt Nam đang tìm kiếm phương pháp cải thiện khả năng cung ứng và tính hiệu quả. Kết quả cho thấy Michelin được hưởng lợi từ việc áp dụng DDMRP, giúp cải thiện đáng kể mức dịch vụ và giảm hàng tồn kho tại các nhà máy. Do đó, trường hợp của Michelin là một ví dụ mang tính hướng dẫn cho các doanh nghiệp Việt Nam đang tìm cách vượt qua việc hoạch định nhu cầu nguyên vật liệu dựa

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trên dự báo (MRP) và đạt được những lợi ích về khả năng cung ứng và tính hiệu quả nhờ lập kế hoạch dựa trên nhu cầu.

Từ khóa: Kế hoạch sản xuất nguyên vật liệu theo nhu cầu, Michelin, Ngành sản xuất

APPLICATION OF DEMAND DRIVEN MRP IN MANUFACTURING INDUSTRY AND LESSONS FOR VIETNAMESE FIRMS: A CASE STUDY OF MICHELIN

Abstract

Material Requirements Planning (MRP) has been the foundational production planning methodology in the manufacturing industry for decades. However, the conventional MRP technique based on forecasts and fixed lead times often leads to production and inventory inefficiencies. Demand Driven MRP (DDMRP) is an alternative approach that modifies lead times in response to restrictions in real time and directly links production to actual demand. The author of this study aims to explore Michelin's transition from traditional forecast-dependent MRP approaches to demand-driven planning with DDMRP. Through qualitative analysis of secondary sources, this study investigates how the implementation of Demand Driven MRP (DDMRP) at Michelin's factory draws instructive lessons and recommendations for Vietnamese manufacturing enterprises seeking improved responsiveness and efficiency. The results show Michelin benefited from implementing DDMRP, which improved service levels and reduced inventories significantly at the Michelin plants. Therefore, the Michelin case provides an instructive example for Vietnamese enterprises looking to move beyond forecast-driven MRP and achieve the responsiveness and efficiency benefits of demand driven planning.

Keywords: Demand Driven MRP, Michelin, manufacturing industry

1. Introduction

Efficient production planning and inventory control are critical for manufacturers to stay competitive in today's increasingly dynamic environment. For decades, Material Requirements Planning (MRP) has been the standard system used by manufacturing firms to schedule production and manage inventories. However, reliance on demand forecasts and fixed lead times makes traditional MRP inflexible and misaligned with real-time market requirements. As customer demands and supply chains become more volatile, manufacturers need production planning approaches that are more responsive and adaptive. This research delves into how Demand Driven MRP (DDMRP), as an alternative to forecast-dependent MRP, enabled improved agility and efficiency in production and inventory management at Michelin’s factory in Vietnam. Through an in-depth case study of Michelin’s transition from traditional MRP to DDMRP, this paper draws valuable insights and implications for manufacturing enterprises in Vietnam seeking to move towards demand-driven planning.

Despite a booming manufacturing sector, Vietnamese firms predominantly use rigid MRP systems and grapple with bullwhip effects and poor supply chain visibility. As factories struggle with fluctuating demand, increasing customization, and global supply uncertainties, lessons from Michelin's shift to DDMRP are highly relevant. Adopting demand-driven solutions like DDMRP can help Vietnamese manufacturers gain flexibility, enhance responsiveness, and boost competitiveness.

This research "Application of Demand Driven MRP in Manufacturing Industry and Lessons for Vietnamese firms: A Case Study of Michelin" aims to answer three key questions: (1) How has Demand Driven MRP been implemented at Michelin's factory? (2) What are the current practices and challenges of Vietnamese manufacturers with production planning? (3) What recommendations can be derived from Michelin's DDMRP case study for Vietnam manufacturing firms looking to apply demand-driven MRP?

2. Theoretical framework

2.1. Demand Driven Material Requirements Planning

2.1.1. Definition of Demand Driven MRP

Demand Driven Material Requirements Planning (DDMRP) is a new and dynamic Manufacturing Planning and Control (MPC) system for manufacturing companies facing the current challenges in the industry to obtain a competitive edge (Adarsh & Yamamoto). DDMRP was presented by Ptak and Smith (2011) as a technique for managing material flow that combines novel features with elements from pre-existing methods MRP, JIT, TOC, Six Sigma, and DRP. DDMRP aims to considerably reduce lead time, adapt to market requirements, and respond actively to demand variation by integration and synchronization of planning, scheduling, and execution with actual demand (Ptak & Smith, 2016). By adjusting inventory levels to their sufficient level and addressing variability, this approach seeks to maintain and improve customer service levels. As a result, it makes material requirement planning more efficient and improves information flow and visibility, DDMRP is a more adaptive method that eliminates the bimodal distribution effect of inventory and the bullwhip effect resulting from demand fluctuation (Ptak & Smith, 2011).

As stated by DDI (Demand Driven Institute) founded in 2011 by Ptak & Smith, DDMRP is a formal multi-echelon planning and execution process intended to safeguard and assist in the flow of pertinent information. Furthermore, according to Miclo (2018), DDMRP improves the conventional MRP logic to more successfully satisfy customer expectations in turbulent, dynamic, and ever-demanding situations by incorporating parts of Lean Systems and the Theory of Constraints and adding cutting-edge features like dynamic buffers. It gathers features of the decided demand, product explosion, and time phasing from the conventional MRP system. It also emphasizes waste identification, variance, and pull flow strategy from lean. From Six Sigma, adaptive adjustment to variance is taken and it resembles the focus on bottlenecks, acceptance of buffer inventory, and strategic placement of inventory in TOC (Miclo et al., 2018).

In short, Demand Driven Material Requirements is a supply chain concept that bases production and inventory management on actual customer demand. It maximizes material flow and responsiveness by integrating the Theory of Constraints with Lean Manufacturing. To increase productivity and customer satisfaction, DDMRP focuses on buffer management, dynamic changes, and demand-driven execution.

2.1.2. Components of Demand Driven MRP

Demand-driven Material Requirements Planning (MRP) encompasses 5 components from initiation to implementation essential for efficient inventory management and supply chain optimization. The first 3 key components including Strategic Inventory Positioning, Buffer Profiles and Levels, Dynamic Adjustments deal with the configuration of the DDMRP model, and the last 2 phases, Demand Driven Planning and Viable and Collaborative Execution, indicate the operational and implementation aspects.

Phase 1: Strategic Inventory Positioning

The initial phase of DDMRP involves analyzing potential inventory locations to optimize production flow (Ptak & Smith, 2011; Miclo, 2016). Excessive inventory poses risks during demand fluctuations (Kortabarria et al., 2018), emphasizing the strategic selection of decoupling points to enhance flexibility and reduce lead times (Smith & Smith, 2013).

Six key factors are meticulously evaluated across the BOM, production layout, manufacturing facilities, and broader supply chain infrastructure to determine optimal inventory positions, according to Ptak & Smith (2011). The Strategic Inventory Positioning factors include Customer Tolerance Time, Market Potential Lead Time, Demand Variability, Supply Variability, Inventory Leverage and Flexibility, and Critical Operation Protection.

Traditional methods for determining inventory positions rely on metrics like manufacturing lead time (MLT) and cumulative lead time (CLT). However, these metrics often oversimplify real-world supply chain dynamics. Actively Synchronized Replenishment Lead Time (ASRLT) bridges this gap. ASRLT, the longest unprotected sequence in the Bill of Materials (BOM) for a parent, is crucial for realistic inventory positioning. It enables planners to optimize inventory sizes and establish data-driven alerts. Integrating ASRLT principles enhances supply chain agility, reduces lead times, and boosts operational efficiency, promoting resilience in dynamic business environments.

Phase 2: Buffer Profiles and Levels

In DDMRP's second phase, the focus shifts to determining the appropriate inventory level after fixing positions. Excess inventory ties up cash flow and resources, while too little can lead to shortages and missed opportunities (Kortabarria et al., 2018). Before setting buffer levels, firms must assess whether inventory is an asset or a liability based on market demand. Manufacturing firms often oscillate between excess and insufficient levels (Ptak & Smith, 2011).

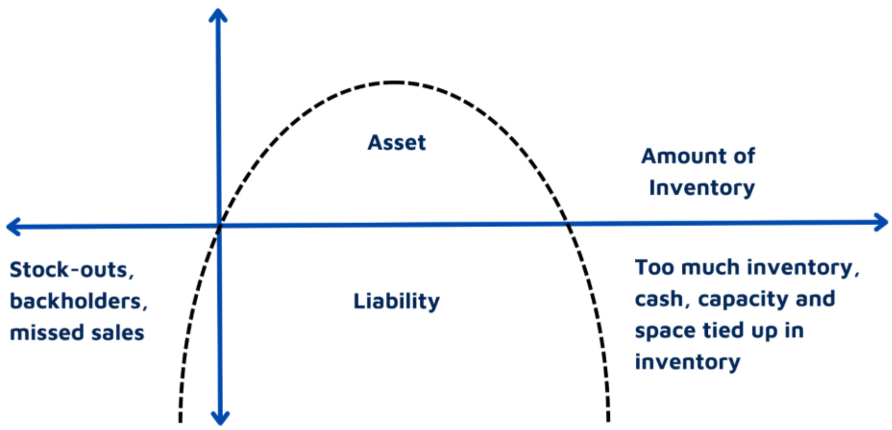


Figure 1: Inventory asset – liability Curve

Source: Ptak & Smith, 2011

According to Ptak & Smith (2011), setting buffer levels in a complex supply chain with numerous parts can be daunting. To simplify this process, buffer profiles categorize parts into families based on specific rules and guidelines, rather than traditional ABC classification. Each profile is divided into color-coded and sized zones, with the sum representing the buffer level for that part family. Factors for categorization include item type (manufactured, purchased, distributed), variability in demand and supply, lead time (short, medium, long), and minimum order quantity policies. These factors result in 54 basic buffer profiles, with the potential for further customization based on organizational needs.

Table 1: Classification based on variability

Variability in parts	Demand	Supply
High	Frequent spikes	Frequent disruptions
Medium	Occasional spikes	Occasional disruptions
Low	Little to no spike	Reliable supply

Source: Ptak & Smith, 2011

Buffer zones are typically color-coded as green, yellow, and red, as depicted in Figure 2. Green indicates no immediate attention is needed, yellow signals the need for refurbishment or replenishment, while red signifies special attention is required for the inventory position (Pekarcikova et al., 2019). The buffer level is calculated by summing the quantities in these zones. For a detailed view, the red zone is further divided into red zone base and red zone safety, as illustrated in Figure 3, which depicts inventory asset liability cover with color-coded zones (Ptak

& Smith, 2011). The sizing of each zone depends on factors such as Delivery Lead Time (DLT), Average Daily Usage (ADU), and Minimum Order Quantity (MOQ) (Kortabarria et al., 2018).

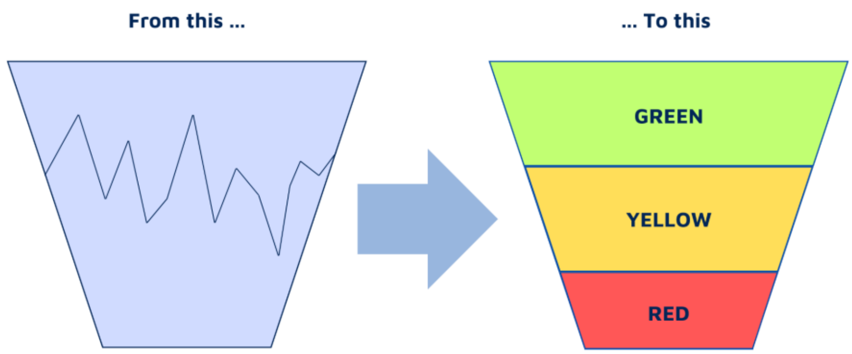


Figure 2: Moving to zone classification in a buffer profile

Source: Ptak & Smith, 2011

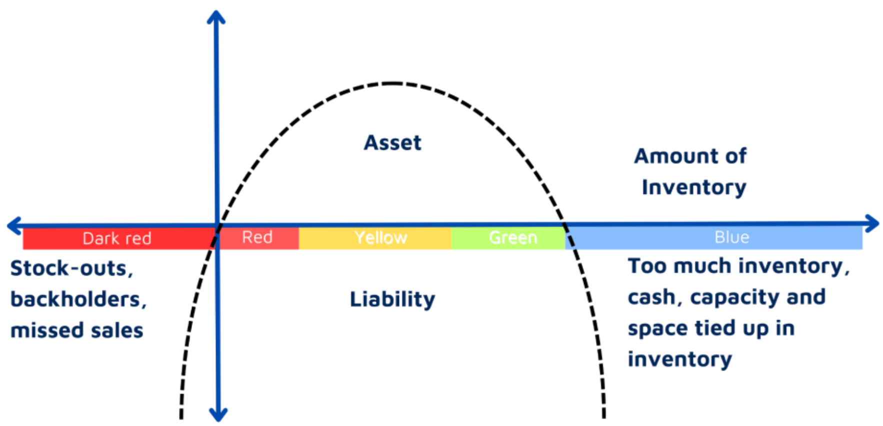


Figure 3: Asset liability curve with buffer zones

Source: Ptak & Smith, 2011

Phase 3: Dynamics buffers

Dynamic buffers entail continuous adjustments in buffer profiles, encompassing location and zone size, which are pivotal for accommodating evolving customer requirements (Kortabarria et al., 2018; Pekarcikova et al., 2019). The factors prompting these adjustments include shifts in suppliers, market opportunities, manufacturing methods, and capacity enhancements, all of which underscore the need for optimizing inventory levels and capitalizing on returns (Ptak & Smith, 2011).

The types of Adjustments in this phase might consist of the following:

- Recalculated Adjustments: Automated adjustments based on the firm's planning system capabilities, including Average Daily Usage (ADU) and zone occurrence-based adjustments, reacting to rolling horizon parameters.

- Planned Adjustments: Strategic and historical considerations for planned situations like seasonality and product transitions, altering buffer levels and zone sizes at preplanned points in time (Ptak & Smith, 2011).

- Manual Adjustments: Provide visibility over unplanned changes, such as discrepancies in ADU due to communication gaps, with alerts like the ADU alert signaling significant changes within a shorter rolling horizon (Ptak & Smith, 2011).

Phase 4: Demand Driven Planning

The Demand Driven Planning system helps generate, coordinate, and prioritize actionable material alert signals, which assess inventory situations and potential impacts (Ptak & Smith, 2011). It works on a Net Flow Equation basis, suggesting when and how much buffer replenishment is needed, and analyzes the Net Flow Position daily at decoupling points (Ptak & Smith, 2016; Pekarcikova et al., 2019). This system assists planners in understanding alert sources and responding promptly to prevent ongoing issues. Furthermore, it facilitates essential supply chain operations like purchase orders, manufacturing orders, and stock transfer orders through Net Flow Position analysis (Kortabarria et al., 2018).

According to Ptak & Smith (2011), the DDMRP Part Planning Designations include:

- Replenished Parts: Managed by color-coded buffers, strategically chosen and recalculated regularly.

- Replenished Override Parts: Similar to replenished parts, but with fixed buffer levels, suitable for specific inventory environments.

- Min-Max Parts: For less critical items, buffer levels adjust based on Average Daily Usage (ADU), with zone coding.

- Non-Buffered Parts: Not stocked; ordered, purchased, or made based on demand.

- Lead-Time-Managed Parts: Crucial, color-coded for easier management, challenging with long lead times and remote suppliers, requiring effective control to mitigate risks and costs.

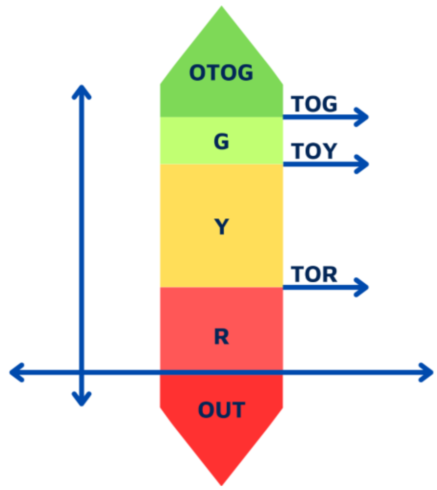


Figure 4: Replenished and replenished override part buffer schema

Source: Ptak & Smith, 2011

Phase 5: Visible and Collaborative Execution

In the fifth phase of DDMRP, the application of various alerts is crucial across existing decoupling points in the Bill of Materials (BOM) (Pekarcikova, et al., 2019). This phase involves both planning and execution processes.

The Planning process encompasses various elements, including the generation of supply orders based on the net flow position and the provision of recommendations for placing these orders. During the Execution phase, supply orders are managed through the integration of color-coded alerts. These alerts serve to improve visibility and prioritize orders, thereby aiding in the identification of critical components and enabling timely actions.

Businesses implementing DDMRP have the opportunity to intricately strategize their supply orders, leveraging existing inventory as a primary determinant rather than relying solely on due dates, as advocated by Ptak & Smith (2016) and Kortabarria et al. (2018). Within the framework of DDMRP, execution alerts are methodically classified into two principal categories: Buffer Status Alerts and Synchronization Alerts (Ptak & Smith, 2011).

Buffer Status Alerts are meticulously designed to direct attention towards the status of in-hand inventory or stocked parts, ensuring a comprehensive overview of these crucial components within the supply chain. Conversely, Synchronization Alerts are tailored to concentrate on non-stocked parts, offering targeted insights and management strategies for elements that may not be readily available in inventory but are essential for operational continuity.

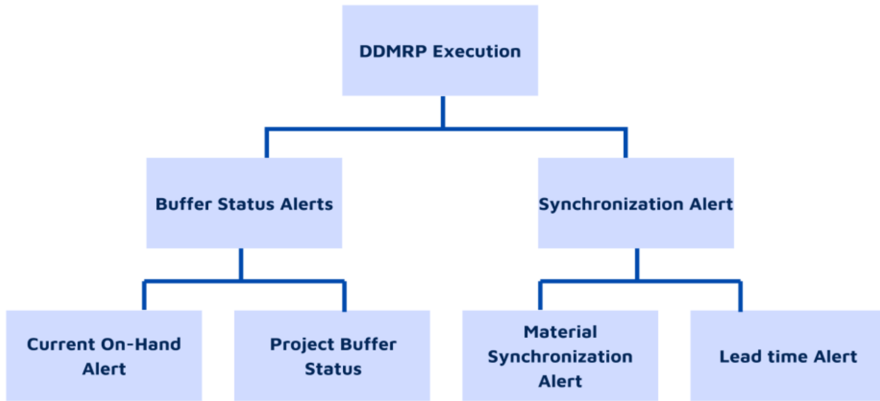


Figure 5: DDMRP Execution Alerts

Source: Ptak & Smith, 2011

2.2. Demand Driven MRP in the Manufacturing Industry

While the foundational ideas of DDMRP were first presented in 2011 in the book "Orlicky's Material Requirement Planning", the widespread adoption of DDMRP in the manufacturing industry gained momentum in the years following the publication of the book. The DDMRP methodology has been continuously refined and expanded upon since its introduction, and organizations began implementing it to improve their supply chain and manufacturing processes as a modern and adaptive approach to managing inventory and production.

2.2.1. Advantages of Demand Driven MRP in Manufacturing Planning

In the previous century, several MPC systems were created to meet industrial requirements. These systems encompassed the Reorder Point (ROP) system, the Material Requirements Planning System (MRP), Just in Time (JIT), and the Theory of Constraints (TOC) philosophy, all widely utilized by many companies (Rondeau and Litteral, 2001). However, between the 1960s and the 1980s, there was a significant shift in market trends and behavior (Rondeau and Litteral, 2001) in which customers started demanding customized products with shorter lead times, and companies transitioned from local to global competition. Adapting to this new business landscape posed daily challenges.

In addressing this evolving scenario, MPC systems played a crucial role by efficiently managing material flow, enabling companies to maintain high service levels for their customers (Ptak & Smith, 2011). Despite these advancements, the MPC systems developed in the 1980s have limitations in managing material flow. Taking into account this dilemma and the needs of an MPC that addresses a demand-driven manufacturing strategy, the DDMRP methodology was developed to effectively oversee the flow of materials and provide a more contemporary solution to the challenges posed by evolving industrial demands.

Given the current intricacies of the manufacturing landscape, characterized by heightened volatility and variability in planning scenarios, adopting a demand-driven manufacturing strategy becomes imperative. In light of this necessity, there are several advantages associated with implementing DDMRP in manufacturing planning.

Firstly, applying DDMRP in manufacturing helps enhance responsiveness to changes and therefore improves customer service levels. DDMRP promotes the consolidation of demand rather than inventory within companies. Consequently, they can efficiently detect and adjust to shifts in the market, enhancing their overall agility (Ptak & Smith, 2011). With the ability to quickly respond to changes in demand and maintain optimal inventory levels, DDMRP helps ensure high service levels for customers. This is particularly crucial in industries where customer demands are diverse and unpredictable.

Secondly, the implementation of DDMRP not only leads to a significant reduction in lead time variability, ensuring more predictable and reliable production schedules but also fosters synchronization across the supply chain, facilitating streamlined coordination of activities to meet market demands efficiently. By strategically placing buffers at critical points in the supply chain, DDMRP helps minimize the impact of lead time variability. The objective of this approach is to shorten the duration of lead times and coordinate activities in accordance with market requirements. This involves meticulous synchronization of planning, scheduling, and execution with the utilization of materials.

Thirdly, the implementation of DDMRP in manufacturing planning offers a dual advantage by enhancing visibility and control, consequently optimizing inventory levels. DDMRP systems play a crucial role in providing real-time visibility into the internal state of the supply chain. This heightened visibility empowers decision-makers with valuable insights, fostering better decision-making and promoting improved collaboration across various facets of the organization. With this enhanced visibility, companies can exert effective control over inventory and production processes, ensuring a more agile and responsive approach to dynamic business conditions. Moreover, strategically positioning inventory involves the adept adjustment of inventory levels, transforming it into a valuable asset for the company. By fine-tuning these levels, businesses can navigate market changes with precision, thus optimizing responsiveness and ultimately contributing to the overall success of the manufacturing operation.

Fourthly, an inherent advantage of DDMRP in the manufacturing process lies in the facilitation of flexible production planning. DDMRP's support for variable batch sizes and lot sizes empowers manufacturers to dynamically adjust production quantities in response to actual demand fluctuations. This flexibility proves instrumental in optimizing production planning by aligning it with real-time market requirements. As a result, companies can operate with increased efficiency, responding promptly to changing demand patterns without overcommitting resources or accumulating excess inventory. The ability to adapt to actual demand not only enhances overall responsiveness but also contributes to waste reduction, as production aligns more closely with market needs, minimizing unnecessary stockpiles and improving resource utilization throughout the manufacturing process. In essence, DDMRP's emphasis on flexible production planning fosters a more adaptive and resource-efficient manufacturing environment.

Lastly, another impactful advantage of implementing DDMRP in manufacturing planning is the reduction of the bullwhip effect. The bullwhip effect signifies the amplification of demand variability as it propagates up the supply chain. DDMRP addresses this challenge by dynamically adjusting inventory levels, effectively minimizing the bullwhip effect and promoting stability throughout the supply chain. This strategic approach ensures that fluctuations in demand are met with agile and measured responses, preventing unnecessary disruptions and creating a more resilient and predictable manufacturing environment. Ultimately, by mitigating the bullwhip effect, DDMRP contributes to the overall stability and efficiency of the supply chain.

With these attributes, DDMRP is positioned to effectively oversee the material flow within the supply chains of companies. Many organizations have adopted this methodology, yielding highly competitive outcomes (Demand Driven Institute, 2017).

2.2.2. Challenges of applying Demand Driven MRP in Manufacturing Planning

Implementing DDMRP in manufacturing planning comes with its set of challenges that organizations must navigate to reap the full benefits of this approach. As DDMRP is a relatively new subject, there is limited research on related topics. Despite the numerous advantages associated with DDMRP, the precise steps for its implementation remain unclear. While previous studies have shown positive outcomes, such as heightened visibility and improved management of raw materials, there exists considerable variability in how organizations execute the DDMRP methodology. This lack of standardized procedures poses a challenge for companies looking to adopt DDMRP in their manufacturing planning. Recognizing the pressing need for consistency, there is a call for the development of a standardized implementation process for DDMRP. Establishing such a framework would not only provide clarity for organizations but also maximize the potential benefits of DDMRP, offering a more reliable and uniform approach for those seeking to leverage this promising methodology in their manufacturing processes.

Another significant challenge in applying DDMRP to manufacturing planning revolves around the strategic positioning of inventory buffers. Determining the optimal buffer positions requires a nuanced understanding of demand variability, lead times, and the inherent dynamics of the supply chain. Setting buffer levels too conservatively may lead to stockouts, jeopardizing customer satisfaction and disrupting production. On the other hand, overly aggressive buffer sizing may tie up excess capital in inventory, affecting overall cost efficiency. Moreover, the dynamic nature of manufacturing environments demands constant adaptation of buffer positions to accommodate changes in demand patterns. Collaborating with suppliers to optimize buffer levels poses an additional challenge, as it necessitates effective communication and coordination to align supply chain elements seamlessly.

Lastly, integrating DDMRP into existing technology infrastructure often requires significant modifications or upgrades to legacy systems. This process can be complex and time-consuming, potentially leading to disruptions in ongoing operations. Achieving seamless data integration poses another challenge, as organizations grapple with the need for accurate and real-time data across various systems and processes. Furthermore, developing the necessary skill set within the workforce to effectively utilize DDMRP represents a critical challenge. Employees accustomed to traditional planning methods may require comprehensive training to adapt to the new approach, emphasizing the importance of investing in human capital. Overall, the challenges associated with initial infrastructure setup underscore the need for careful planning, resource allocation, and strategic execution to ensure a successful integration of DDMRP in manufacturing planning.

Addressing these challenges requires a holistic approach that encompasses organizational readiness, technological integration, data accuracy, and a willingness to embrace a demand-driven mindset. Organizations that successfully navigate these challenges stand to gain improved responsiveness, reduced lead time variability, and enhanced efficiency in their manufacturing planning processes with DDMRP.

3. Analysis of Demand Driven MRP application in Michelin factory

3.1 Overview of Michelin and its supply chain

3.1.1. General information about Michelin

Michelin, one of the global leaders in tire manufacturing, was founded in 1889 in Clermont-Ferrand, France. After over 130 years, the Michelin Group is now present on every continent, serving customers across 170 countries. The Michelin group is renowned for manufacturing high-performance, innovative tires for diverse vehicles including aircraft, automobiles, heavy equipment, motorcycles, and bicycles.

Since its inception in 1889, Michelin has experienced exponential growth to stand as the second-largest tire producer globally. It can be attributed to its pioneering influence on tire technologies and continuous innovation across connected mobility, sustainable materials, and 3D printing. Moreover, Michelin has also been ranked as the top tire manufacturer among the "World's Most Admired Companies" (Fortune, 2023).

3.1.2. Vision – Mission

With vision, Michelin has committed to meeting a huge challenge to make mobility safer, cleaner, more efficient, and universally accessible with four key characteristics: *Airless, Rechargeable, Connected, and 100% Sustainable*. Besides, Michelin's mission statement: "offering our customers the best tire at the best price in each segment of the market" and "setting the standard in quality of service" is a commitment to providing high-quality, innovative tires at competitive prices while emphasizing exceptional customer service.

3.1.3. Michelin's supply chain

Michelin operates an expansive, complex supply chain supporting its substantial tire manufacturing and distribution operations worldwide. Key elements include raw material sourcing, manufacturing, and quality control at 123 plants globally, inventory management at distribution centers, coordinating logistics, selling through OEM/retail/e-commerce channels, and providing aftermarket services. As the world leader in tires and a major purchaser of natural rubber - a core raw material for tires, Michelin recognizes its obligation to ensure a sustainable supply chain. The company evaluates suppliers on CSR criteria and fosters close relationships focused on quality and environmentally sound processes. Besides, Michelin had three major supply chain objectives: improving customer service, reducing costs, and optimizing inventories. However, fluctuating demand and pressure to minimize inventories posed difficulties.

To accomplish these goals, a highly efficient and effective supply chain is required to maintain and grow their global business. Michelin implemented Demand-Driven MRP to directly connect production to real-time orders, enabling enhanced inventory and production planning. By linking live demand data across the supply chain, Michelin achieved better visibility and control to maintain its competitive edge as the premier global tire manufacturer.

3.2. Drivers to Michelin adoption of Demand Driven MRP

Due to scarce capacity, a growing portfolio of tire types, and a significant increase in parts resulting from the company's innovation efforts, Michelin's supply chain complexity has increased substantially and has become more difficult to manage. The market in which the company operates also became increasingly volatile and competitive, as well as impacted by seasonal demand. In this context, the traditional MRP system applied by Michelin lacked efficiency and caused variations in manufacturing operations. The two issues included the system nervousness of MRP resulting in serious time and quantity change at low levels, and variance of production signal in the Bimodal effect. The other issue was the Bullwhip effect facilitating the accumulation and amplification of uncertainty both upstream and downstream.

The complex and volatile "new normal" in the supply chain

Table 2: Comparison between current Supply Chain Characteristics and before 2000

Supply Chain Characteristics	Before 2000	Current supply chain
Supply Chain Complexity	Low	High
Product Life Cycles	Long	Short
Customer Tolerance Times	Long	Short
Product Complexity	Low	High

Supply Chain Characteristics	Before 2000	Current supply chain
Product Customization	Low	High
Product Variety	Low	High
Long Lead Time Parts	Few	Many
Forecast Accuracy	High	Low
Pressure for Leaner Inventories	Low	High
Transactional Friction	High	Low

Source: LLC, D.D.I. (2017)

One attribution to the inefficiency of the MRP model is the change in the characteristics of the contemporary supply chain which is a huge gap compared to the 1960s supply chain when conventional planning rules like MRP were formulated. The planning rules have not appreciably changed since its advent. The changes in circumstance have huge implications for supply chain planning as the supply chain has elongated and fragmented while customer tolerance times have dropped. This disparity means holding stock at some strategic point is a must to keep and grow sales and planning horizons are more remote from actual demand realization. Also, detailed item-level forecasting is much more difficult.

As supply and production lead times were longer than customer tolerance times, the Sales & Operation planning (S&OP) and forecast recalculation are time and energy-intensive. The MRP system had worked well for several years as low demand fluctuation ensured smooth production. However, since the 2000s, the global environment evolving with uncertainty and variability of demand disrupted Michelin's multi-level organizations, and the MRP system needed to be run more frequently to make a better forecast.

The Bimodal effect resulting from the significant variance of production signal at a single factory level

Michelin's information provided from the MRP systems was based upon the sales forecast extracted from the S&OP process to calculate the inventory level that should be in stock to cover projected sales for each SKU. Then, replenishment orders for material are released including quantity and required date, which sum up a dependent planning system. Amongst Michelin's real-life complicated supply chain, many SKUs and equipment requirements require planners to schedule work in certain sequences. The purposes are to cover demand and operate efficiently by minimizing costs, enlarging production batches, and appropriate lead times. However, the MRP system was not optimal for operational efficiency in this changing environment.

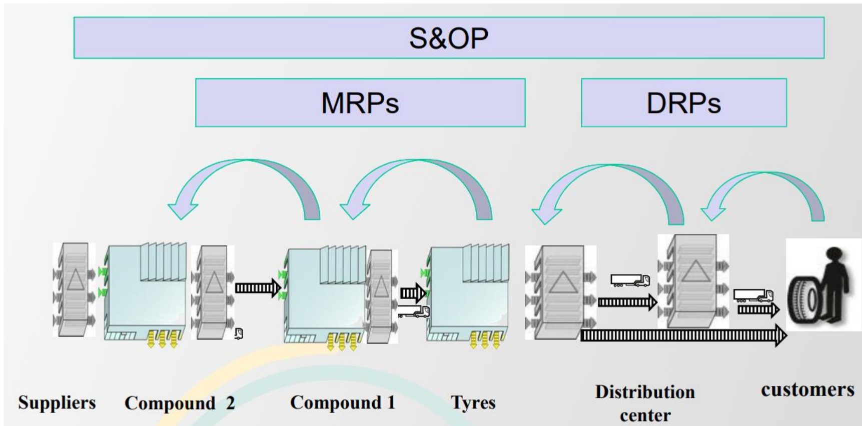


Figure 6: On-going process and systems in Michelin Supply Chain

Source: Prod'Agile (2017)

More frequent runs of the MRP system resulted in conflicting recommendations and significant variance in production signal after each run (Oliinyk, 2022). Misled production signals and inherent "system nervousness" characteristics of MRP systems caused the aggregate inventory to exhibit bimodal distribution in which a large number of SKU/parts had too low inventory while another large number had too high. Only a small number of SKUs maintained inventory level at the optimal level but it was short-lived due to "system nervousness" (Smith, 2014). The bottom line effects to the company were chronic inventory shortages, back orders, excessive and overstocked positions, and high expedited expenses and wastes. As the inventory level had a bimodal distribution alternating from minimum to maximum norms, the broader SKU lists along with more complex demand variability and operational environment led to excessive and poor quality of inventory. The surveyed Michelin factory in Valladolid recorded frequent shortages and excessive amounts of materials at various stages of the production cycle with additional and costly efforts of planning changes, overtime, and shipments and late shipments of its OE tires due to constant changes in production plans generated by MRP (Nagao & Varela, 2016).

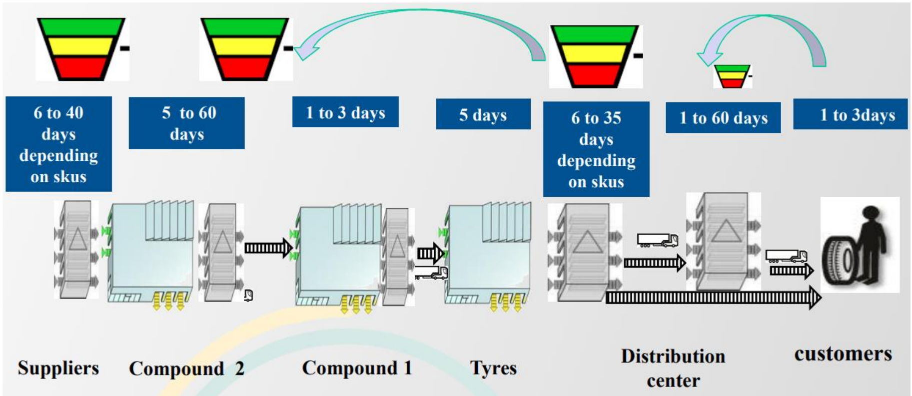


Figure 7: Excessive and poor quality of inventory (Bimodal) in Michelin's Valladolid factory

Source: Prod'Agile (2017)

The Bullwhip effects resulting from activities coupled through DRP/MRP techniques as collective SCM problem

The Valladolid factory of Michelin exhibited unstable communicating orders or transfer demand signals up the chain with the inherent transport delays of moving products down the chain due to a complex operational environment adapting to demand fluctuations, which accounted for inventory quickly moving from being back ordered to being excess (Oliinyk, 2022). Repeated modifications led to chaotic reactions in multi-step, multi-level organizations like Michelin (Aduwa et al. 2023). Also, activities coupled through the MRP system were different in terms of flexibility from short to long lead time. Demand forecast updating and safety stocks to cover the difference between forecasted demand and what was sold were involved to mitigate the effects. However, when the inventory level lowered even one unit below safety stock, it triggered a re-supply, consequently amplifying distortion in the bullwhip effect.

3.3. Michelin's application of Demand Driven MRP

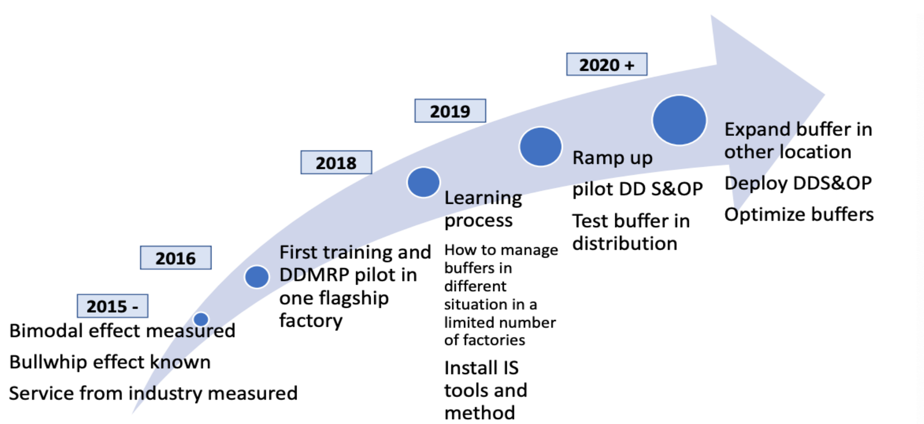


Figure 8: Michelin's Demand Driven Roadmap

Source: Michelin (2019)

According to Michelin (2019), in 2015, the Bimodal and Bullwhip effect due to variable customer demand were measured across Michelin's supply chain. To update the management of work, production, and storage, Michelin implemented the Demand Driven MRP management model in its factory in Valladolid as a pilot project in the third and fourth quarter of 2016. In 2017, 8 pilots were operated to learn in the context of different business cases (Prod'Agile, 2017). The innovative method allowed factory production to be based on actual sales to improve service levels and optimize inventory. The model uses strategic decoupling points to drive supply order generation and management throughout the supply chain.

In its position phase or strategic decoupling, decoupling points of inventory are strategically placed within the production structure to stop the transfer and amplification of variability in demand signal distortion and supply continuity (LLC, 2017). The factory obtained explicit results of shortened planning horizons and compressed lead time. Buffers in the pioneer pilot project in Valladolid, Spain were placed in a factory warehouse. Other pilot projects were carried out in the USA, Italy and France. In the USA, decoupling points included factory warehouses and local distribution centers. Italy's factory buffers were in factory warehouses connecting 2 intercontinental Middle East/ Africa and North America (Prod'Agile, 2017).

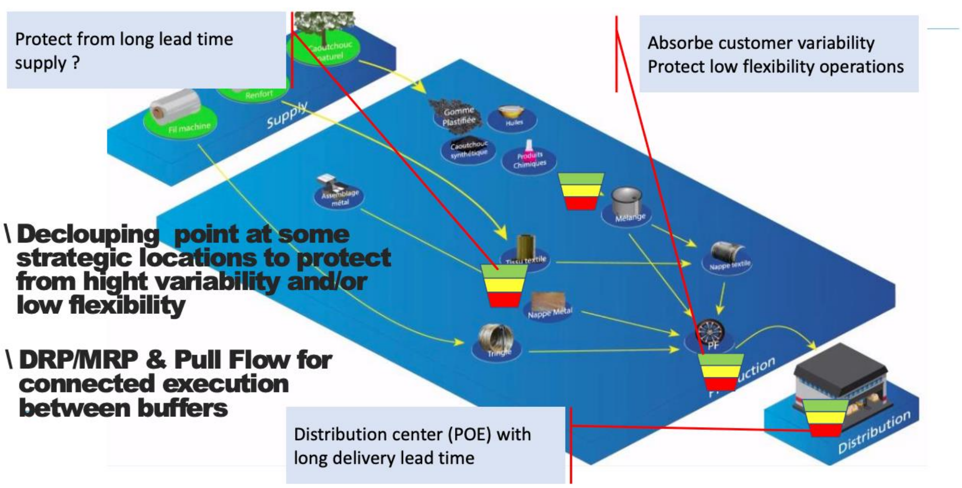
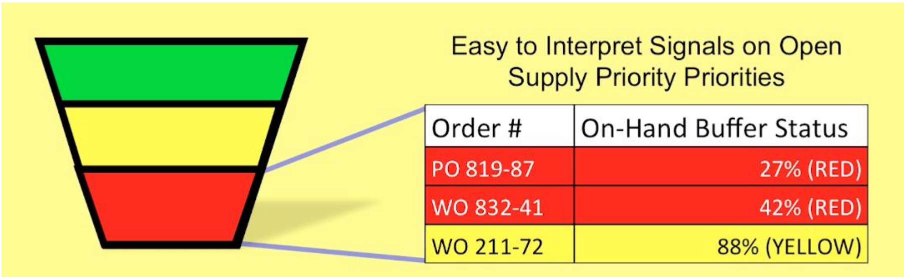


Figure 9: Strategic decoupling placed within the SC

Source: Michelin (2019)

Then, buffer profiles and levels are inserted at chosen decoupling points where part demand information and DDMRP part settings are mingled to create color-coated 3-zone buffers, each zone having distinct purposes (Demand Driven Institute, 2017). DDMRP stock positions are ensured never net-to-zero. With this system, Michelin's factory can adjust the buffer level as Average Daily Usage is updated or in anticipation of planned events or seasons in Dynamic Buffer Adjustment (Prod'Agile, 2017). In the Demand Driven Planning phase, the Valladolid factory will qualify sales orders within a short-range horizon qualify as demand allocations. Lastly, DDMRP execution manages the open supply orders from Michelin's Valladolid factory using easy-to-interpret signals on Open Supply Priority against the On-hand Buffer Status (Demand Driven

Institute, 2017). The lower the on-hand level, the higher the threat to maintain the flow and the higher the execution in priority.



Order #	On-Hand Buffer Status
PO 819-87	27% (RED)
WO 832-41	42% (RED)
WO 211-72	88% (YELLOW)

Figure 10: Demand Driven Execution phase

Source: Demand Driven Institute (2017)

At the end of the project, a finished product buffer has been designed, dynamic, and changing as a function of sales. Following the training and pilot projects, key learnings are extracted. The first pilot in Valladolid started quickly but the initial learning curve required 1 year and consultants' help. Overall, the planning and manufacturing are linked to the firm needs and priorities of customers, and campaigns are launched with the certainty of meeting customer requirements, no more crisis for Original Equipment customers was recorded. The production mode drives the buffer types and sizing, signal is stabilized drastically with the same level of inventory. Key savings observed from pilots also include bimodal improvement and lower inventory for Original Equipment customers. Other key points are changes in management in the factory mainly in the central supply chain for the value of decoupling and management to promote a global flow approach, as a result of new trust data and capacity adjusted up and down based on buffer signal input to S&OP (Prod'Agile, 2017).

Since the beginning of the pilot projects, the Valladolid factory aligned on the method by formulating the first training module General Rules IS Architecture, and setting a new process of deployment and training modules, which facilitated the learning process of 8 other pilots in different situations. In 2019, the factory ramped up the pilot Demand Driven S&OP and tested the buffer in distribution. The system was then deployed in 60 Michelin sites. The deploy method and resources included 6 months estimated to ramp up a plant in 3 phases with a full-time dedicated person (Prod'Agile, 2017). During the pilots, consultants were involved, however, Michelin gradually gained autonomy in carrying out DDMRP.

3.4. Evaluation of the Demand Driven MRP application in Michelin

Originally devised to address industry challenges, the implementation of DDMRP not only provided a solution but also represented an innovative shift that brought about substantial improvements to the entire Michelin global supply chain. Overall, the implementation of the buffer model has, first and foremost, provided a clear understanding of short-term customer demand and eliminated signals of disruption in the supply chain to foster prompt responses to those demands.

In addition, DDMRP has enhanced the level of autonomy and empowerment within the company's supply chain management. It is also acknowledged for effectively managing the low levels of global inventory at Michelin (Michelin, 2019).

Michelin was first engaged in Demand Driven Technologies through a trial in one of their factories in Spain, and the benefits were immediately provable after the implementation of the DDMRP concepts. According to a 2021 report by Intuiflow, the implementation of DDMRP empowered the flagship factory to promptly address possible service disruptions in the production line, ensuring a stable production process. The report highlights an optimized performance of the production system with a significant improvement in service level. Specifically, the factory successfully elevated them from 91 percent to an impressive 99 percent. Furthermore, the report identifies positive developments in other indicators of supply chain efficiency, including a notable 20 percent reduction in inventory levels and a substantial 15 percent decrease in lead time. The immediate improvement has proved the suitability, reliability, and efficiency of DDMRP in the manufacturing planning and controls systems, thus leading to a wide expansion of this model in Michelin's global manufacturers. In 2019, Michelin reported it had adopted the DDMRP model across 27 global manufacturing sites, and expected to launch in 45 sites to enhance the efficiency and smooth operations across the global supply chain (Michelin, 2019).

The substantial benefits of DDMRP were further underscored by Mr. Thibaut d'Herouville, who was the current Vice President of Supply Chain Passenger Car at Michelin, during his presentation of Michelin's DDMRP implementation results at the Demand Driven World Conference in 2019. The results indicated that, on average, the 27 factories implementing DDMRP experienced a 10 percent increase in customer service satisfaction. Furthermore, 25 percent of the industrial stock was eliminated compared to 2016, with one-third of that reduction attributed to the implementation of DDMRP. The implementation also successfully prevented urgent production plan changes, a stark contrast to historical records indicating such changes occurred on average once every two weeks. Mr. Thibaut d'Herouville affirmed that DDMRP played a pivotal role in enabling Michelin to smooth the signal across the supply chain and foster a lean organizational structure across the global supply chain. Nevertheless, Mr. Thibaut d'Herouville argued that DDMRP could solely be a short-term solution for material planning and controls, and the company has to revert to the formal models for tactical projection due to the shortcomings of DDMRP in the long run. Hence, achieving a complete elimination of the bullwhip effect appears to be a challenging goal for Michelin's manufacturers. In a progressive move, Michelin has embraced Demand Driven S&OP to effectively manage the tactical projection of materials planning and inventory controls.

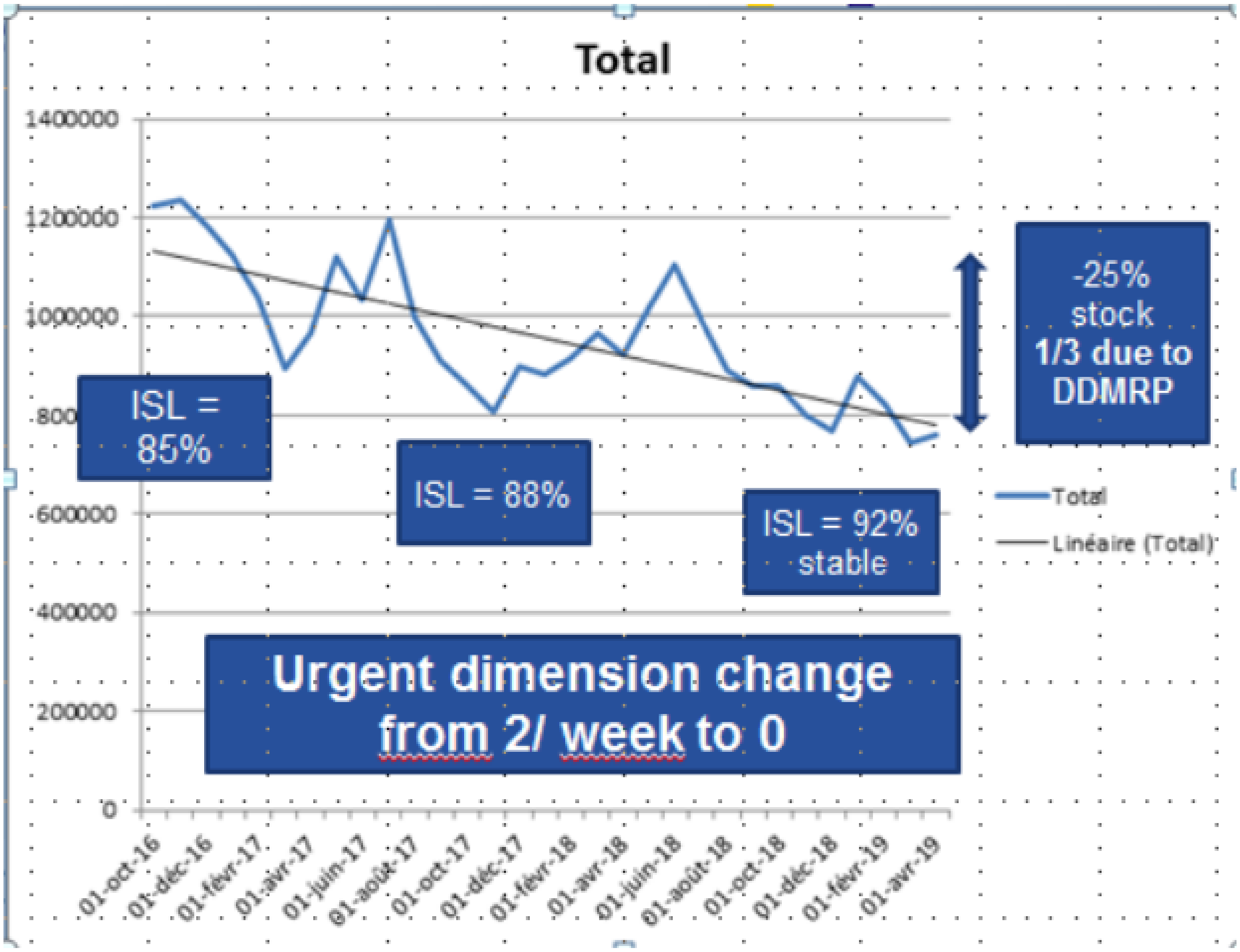


Figure 11: Variation of Industrial Stocks in Michelin's factories (2016-2019)

Source: Demand Driven World Conference, 2019

Michelin's adoption of DDMRP has improved the efficiency of manufacturing planning and control systems, and its journey made it become a representative case study of the DDMRP application in the manufacturing field. Initially, Michelin gained global recognition as a major tire manufacturer, yet the company has proactively made innovations to adapt to the dynamic market changes, exemplified by the successful implementation of DDMRP to efficiently manage material flows. Furthermore, the integration of DDMRP is an ongoing process that demands adequate staff training and the accumulation of valuable experiences. In particular, Michelin invested three years in the learning process before officially implementing and expanding this model across the global supply chain. The learning process demanded Michelin to prepare for a high-quality workforce and customize the buffer models according to different circumstances. Lastly, the case of Michelin has proved that DDMRP is not an optimal tool that could supersede demand forecasting. Still, the model plays an integral role in supporting the manufacturers to better forecast, react promptly to, and satisfy the ever-changing customer demand in the market.

4. Recommendations for the application of Demand Driven MRP in Vietnamese manufacturing firms

4.1. Overview of Vietnamese manufacturing firms' practices in Manufacturing Planning

Vietnamese manufacturing firms employ a combination of both traditional and modern practices in their manufacturing planning processes to meet market demands, improve efficiency, and ensure sustainable growth in an increasingly competitive global environment. However, there are critical points that hinder the flow of materials and information in the supply chain of Vietnamese manufacturing companies.

High on-hand inventory level

Manufacturing firms in Vietnam often source their products from China and other nations, and face logistical challenges due to the weight and pricing constraints of its goods (*Zuerl)*. Therefore, to address these problems, they opt for sea transport in containers, purchasing materials in bulk to optimize transportation costs. Besides that, they adopted a proactive approach by procuring materials before the required date to tackle fluctuations in supply. Despite relying on demand forecasts for planning, which turn out to be ineffective, Vietnamese manufacturing firms frequently encounter discrepancies between forecasted and actual demand (Kim Kha, 2020). This led to the necessity of maintaining a high safety stock level to prevent stockouts and ensure consistent service levels. On the other hand, the company's inability to accommodate rush orders stemmed from limitations in supplier capacity and the prohibitively high costs associated with air transportation. Consequently, maintaining a high safety stock emerges as the most viable strategy for managing demand uncertainty. This approach resulted in a surplus of on-hand inventory, leading to increased inventory-holding costs for these firms.

The discrepancy between the frequency of purchase order planning and lead time

Another problem with Vietnamese manufacturing firms in purchasing strategy is the infrequency and the manual process involved. The average lead time of these companies is often found to be longer than the frequency of their material purchase planning (*Zuerl),* which means that they are planning material requirements for several months, or even years in advance. It is also important to note that the process of identifying material requirements is time-consuming and labor-intensive. It involves manually inputting data into spreadsheets and the ERP system, which takes a lot of effort.

However, this infrequent planning means that these companies lack real-time visibility into their inventory status. They will not review it until the following date of planning, which means they cannot react to unforeseen issues or changes in demand until the next planning cycle. This therefore increases the risk of stockouts, prompting these firms to maintain a high safety stock level.

Lack of visibility to manage the references of the same product groups

Manufacturing firms in Vietnam procure goods from various suppliers, some of whom supply multiple types of goods. These suppliers are found to set a common Minimum Order Quantity (MOQ) that applies to all references within the same product family. However, the majority of manufacturing firms in Vietnam have an ERP system lacking the capability to identify and visualize material status by product families, which thus hinders the determination of optimal joint purchase orders based on the established common MOQ. As a result, these firms have to set the MOQ individually for each reference, leading to the purchase of more units than necessary.

Silo effect in the supply chain

In case manufacturing firms outsource the assembly of certain components to improve production efficiency, they often provide the subcontractor with customer forecasts and deliver the required raw materials to their warehouse (Blancas et al., 2014). However, frequent changes in customer forecasts are found to lead to mismatches between the assembled components and the companies' actual needs. This resulted in unnecessary assemblies and delays in assembling required components due to late orders.

The lack of visibility, also known as the silo effect, forced the subcontractor to often handle rush orders by disassembling and reassembling components. However, this was not always feasible because the subcontractor did not always have the necessary raw materials for rush orders. This lack of visibility also results in an increased bullwhip effect across the supply chain, requiring the subcontractor to hold higher inventory levels in its warehouse.

4.2. Challenges of Vietnamese manufacturing firms in applying Demand Driven MRP

Designed to address the limitations of traditional methods within Material Planning and Control (MPC) systems, DDMRP is crafted as a significantly more efficient tool capable of tackling existing challenges, where older methods have proven to be ineffective. Whilst DDMRP has been proven in various research to be able to address the shortcomings of the traditional method in supply chain management, there have not been many examples of successful applications of such method in the process manufacturing of Vietnamese firms. The following aspects shall be stated to justify the inability yet to apply DDMRP to Vietnamese manufacturing firms.

The first reason for such failure in applying DDMRP in Vietnamese manufacturing companies shall be contributed by a sense of cultural resistance. A notable obstacle is the entrenched reliance on traditional forecasting methods within the industry. Vietnamese manufacturing firms have had a history of using Material Requirements Planning (MRP) that is closely tied to the country's economic development and industrialization. In the late 1980s and throughout the 1990s, Vietnamese manufacturing firms began to adopt modern business practices, including the implementation of MRP systems. As the global manufacturing landscape evolved, the demand for efficiency and competitiveness drove firms to embrace advanced planning and control methodologies. Traditionally, these firms have operated within a forecasting-oriented culture, where historical data guides inventory management decisions. Shifting to a demand-driven approach requires a fundamental change in mindset, challenging established practices, and ingrained beliefs among employees. The reluctance to abandon familiar forecasting methods in favor of real-time demand adjustments can result in skepticism and pushback.

As a result, such resistance to change has created a consequential drawback relating to employment skills and knowledge of DDMRP, which then poses a hindrance for manufacturers to adopt this model. The successful application of DDMRP in Vietnamese manufacturing firms requires a workforce equipped with specific skills and knowledge. Proficiency in data analysis and interpretation becomes vital, given the fact that DDMRP relies on real-time and accurate information. Inaccurate or incomplete data can lead to suboptimal decisions in inventory management. Additionally, skilled data analysts are needed to design algorithms and models that can analyze data in real-time, allowing the system to make quick and accurate decisions on inventory levels and replenishment. Despite the fact that data analysts in Vietnam get paid up to 420 million VND/year *(Topdev, 2022),* the field is considered new and always faces a labor shortage in Vietnam. Such a shortage makes implementing this new model more complicated and harder to succeed for Vietnamese manufacturing businesses.

Thirdly, data accuracy and availability, together with limited technological adoption remain obstacles when Vietnamese manufacturers approach DDMRP. DDMRP relies heavily on real-time and accurate data to facilitate dynamic adjustments in response to fluctuating demand. However, many Vietnamese enterprises face hurdles in ensuring data accuracy due to outdated technology infrastructure and insufficient integration across various operational facets. Legacy systems and manual data entry processes contribute to data silos, hindering the seamless flow of information. Moreover, the limited adoption of advanced technologies, including modern ERP systems capable of supporting DDMRP principles, poses a substantial impediment. The gap in technology adoption hampers the manufacturing firms' ability to fully leverage the benefits of DDMRP, hindering the agility and responsiveness that the methodology promises.

Last but not least, the challenges associated with the DDMRP itself have discouraged Vietnamese manufacturing enterprises from stepping up with this modern model. *Firstly*, the problem arising out of the implementation of DDMRP shall be in connection with the choice of inventory position due to the increasing complexity of production processes and products with multiple Bill of Materials (BOM) levels. DDMRP introduces the concept of strategically placing inventory buffers at various points in the supply chain to protect against variability and uncertainties. The inventory positioning process involves determining the appropriate levels for these buffers based on factors such as demand variability, lead times, and the desired service levels. Moreover, due to the lack of data accuracy and availability, the dynamic nature of the Vietnamese market, which constitutes rapidly changing consumer preferences and market trends, has become its own significant challenge. The constant shifting in preferences and trends makes it hard to grasp the in-time database with such outdated technology, resulting in inaccurate lead time. *Secondly*, in the realm of transparent and cooperative execution, discrepancies have been noted between the anticipated buffer stock zones and the actual buffer levels on hand. This presents a challenge, raising questions about the accuracy of the translation from planning to execution as asserted by DDMRP *(Miclo, 2016)*.

4.3. Recommendations for Demand Driven MRP application of Vietnamese manufacturing firms

By minimizing inventory levels and improving responsiveness to dynamic customer demands, the DDMRP application can bring about a transformative change in the manufacturing planning and control systems of Vietnamese manufacturers. Notwithstanding its potential, the DDMRP concepts have not found favor among Vietnamese manufacturers due to the aforesaid barriers to adoption, leading to limited integration of this methodology within the Vietnamese manufacturing context. Building upon the insights gained from Michelin's successful implementation of DDMRP, practical recommendations are compiled for Vietnamese manufacturers and policy-makers to initiate the integration of these concepts and address the deficiencies in their current planning systems.

4.3.1. Recommendations for Vietnamese manufacturing firms

Embrace innovative changes

Successful implementation of DDMRP must come first with leaders' willingness and commitment embracing innovative ideas to overcome shortcomings of their current operating systems. Costs, risks and uncertainties associated with DDMRP implementation cause top managers of Vietnamese manufacturing firms to resist changes, especially the case of small and growing businesses who have not encountered any drawbacks with conventional methods. Nevertheless, considering the dynamic changes in the global market, it is imperative for them to acknowledge the urgency for initiating innovative methodologies to optimize their company's supply chains and compete effectively on a global scale. Such shifts in employer awareness could spark the development of a well-structured strategic plan for the implementation of DDMRP in the material planning and control systems.

Prepare for the organizational readiness

For effective DDMRP integration, Vietnamese manufacturing companies should proactively prepare the conditions that support the smooth operation of this model. DDMRP heavily depends on real-time and accurate data to enable dynamic adjustments in response to fluctuating demand, thus IT infrastructure including hardware, software, and services should be acquired to support the process of data collection, storage and analysis. In the specific context of small and medium manufacturing enterprises facing financial constraints, it is prudent to carefully assess their current financial status to customize investments based on immediate needs and budgetary constraints.

Additionally, comprehensive training becomes essential when implementing a DDMRP integrated supply chain, as the integration of DDMRP into the supply chain may present challenges for workers who have been working with the traditional MRP model. Furthermore, attracting skilled technological workers is crucial for the manufacturing firms to meet the demands of the advanced technology associated with DDMRP implementation.

Execute a comprehensive learning process

Drawing on the insights derived from Michelin's case, comprehensive practical trials are vital before a successful implementation of DDMRP. The Vice President of Supply Chain at Michelin contends that the unique features and working environments across various manufacturing sites can play a pivotal role in determining the optimal size and location of inventory buffers. This, in turn, determines overall results of the implementation. Hence, a gradual integration of this model into the supply flow, accompanied with systematic observation of its results, is recommended. This approach allows for the determination of the most suitable level of inventory buffers that can effectively accommodate expected demand variability, lead times, and desired service levels.

Outsource to third suppliers

Numerous third-party suppliers in the market are offering supply chain management solutions, including material planning solutions specifically tailored for Vietnamese manufacturers. Manufacturing companies could consider outsourcing the implementation process to a reliable third party or acquiring a software solution to optimize the efficiency of their material planning and control systems.

4.3.2. Recommendations for the Vietnamese government

Simultaneously, it is crucial for the manufacturing firms to receive government support to successfully implement DDMRP and propel innovative transformations. Most Vietnamese manufacturing firms are small to medium enterprises with lack of essential resources for innovation adoption, thus they require external support from the government, specifically in terms of financial aid and access to high-quality labor force. Hence, two practical lessons are proposed for the Vietnamese government as follows.

Foster the innovative transformation process

The Vietnamese government should create favorable conditions for Vietnamese manufacturing firms in their innovative transformation paths. Particularly, this indicates a need for government initiatives aimed at enhancing the national workforce by providing them with in-demand skill sets such as data science and computer science, aligning them with the demands of upgraded technology in the contemporary era.

Simultaneously, they should improve the transparency of information and knowledge among the manufacturing industry. This implies the necessity for regularly organizing seminars connecting companies and professionals, with a specific focus on the DDMRP model. Such events would enable tailored consultancy for individual firms and promote the diffusion of innovation among the industry.

Offer soft loans for innovative purposes

The Vietnamese government should also provide financial support to the manufacturing firms for their innovative efforts, including the adoption of DDMRP model. Procurement processes for accessing innovative loans should be streamlined and aligned with the current accounts of Vietnamese manufacturing firms, facilitating easy access and maximizing efficiency in investment.

5. Conclusion

Along with reviewing multiple benefits of Demand Driven MRP for organizations, the research team analyzes Michelin's application of this method in its MPC system to bridge the gap between theory and the implementation of DDMRP in actual production conditions. Positive results have been detected regarding the increase in visibility and the materials flow. The study also identifies challenges facing Vietnamese manufacturing firms to apply DDMRP in the alteration of conventional methods. Based on the existing challenges and analysis of Michelin's work, we propose several recommendations to incorporate DDMRP into the manufacturing firms' MPC system, which emphasizes firms' willingness to embrace innovative changes and enhance organizational readiness. This research provides valuable insight into both theoretical and practical implications for Vietnamese manufacturing firms in further coping with unpredictable demand and operations environment. However, a standardized implementation process of DDMRP has not yet been clear due to the company's application adaptive to its operations characteristics and the lack of studies found in the literature. Therefore, to showcase the effectiveness and practicality of the DDMRP methodology, potential directions for future research may involve defining a standardized implementation process through comparative case studies.

References

Adarsh, A. & Yamamoto, Y. (n.d.), "School of Innovation, Design and Engineering Demand Driven Material Requirements Planning Master thesis work 30 credits, Advanced level Product and process development Production and Logistics Arakatla Adarsh.", Available at: https://www.diva-portal.org/smash/get/diva2:1509015/FULLTEXT01.pdf.

Aduwa, F., Lundquist, J. & Persson, F. (2023), "Implementing DDMRP Supply Chain Transformation Through Inventory Management.", Available at: https://liu.diva-portal.org/smash/get/diva2:1821748/FULLTEXT01.pdf [Accessed 27 Jan. 2024].

Blancas, L., Isbell, J., Isbell, M., Tan, J. & Tao , W. (2014), "Efficient Logistics A Key to Vietnam's Competitiveness Countries and Regions.", Available at:

https://documents1.worldbank.org/curated/en/646871468132885170/pdf/Efficient-logistics-a-key-to-Vietnams-competitiveness.pdf.

Demand Driven Institute (2017), "Demand Driven Material Requirements Planning (DDMRP).", *DDI*, Available at: http://www.demanddriveninstitute.com/ddmrp [Accessed 28 Jan. 2024].

Demand Driven World Conference (2019), "Demand Driven World Cases.", Available at: https://www.demanddriveninstitute.com/case-studies [Accessed 30 Jan. 2024].

Fortune (2023), "World's Most Admired Companies.", Available at: https://fortune.com/ranking/worlds-most-admired-companies/ [Accessed Jan. 28AD].

Ihme, M. & Stratton, R. (n.d.), "Evaluating Demand Driven MRP: a case based simulated study.", Available at: https://core.ac.uk/download/pdf/30650567.pdf [Accessed 28 Jan. 2024].

Institute, D.D. (2011), "Demand Driven Material Requirements Planning (DDMRP).", Available at: https://www.demanddriveninstitute.com/ddmrp.

Intuiflow (2021), "Case Study: Michelin and DDMRP.", Available at: https://demanddriventech.com/case-study/michelin/ [Accessed 28 Jan. 2024].

Kortabarria, A., Apaolaza, U., Lizarralde, A. & Amorrortu, I. (2018), "Material management without forecasting: From MRP to demand driven MRP.", *Journal of Industrial Engineering and Management*, Vol. 11 No. 4, p. 632.

LLC, D.D.I. (2017), "An Introduction to DDMRP (HD).", Available at: https://vimeo.com/208396607 [Accessed 28 Jan. 2024].

Michelin (2019), "Case Study Consumer Products.", Available at: https://www.demanddriveninstitute.com/_files/ugd/390972_f327cb47f8844734a5a3d63756496374.pdf [Accessed 28 Jan. 2024].

Michelin - DGA. (n.d.), "Homepage.", Available at: https://purchasing.michelin.com/en/ [Accessed 28 Jan. 2024].

Michelin - DGA. (n.d.), "Sustainable purchasing.", Available at: https://purchasing.michelin.com/en/sustainable-purchasing/ [Accessed 28 Jan. 2024].

Michelin Natural Rubber Operations: 2021 Report | 1 Michelin Natural Rubber Operations: 2021 Report | 2. (n.d.), Available at: https://purchasing.michelin.com/wp-content/uploads/sites/50/2022/11/Michelin-Natural-Rubber-Operations-and-Supply-Chain-2021-Report-V1.2.pdf.

Michelin-case-study-video. (n.d.), "Michelin Drives Supply Chain Cost Reductions and Service Improvements with Luminate Planning and Logistics.", Available at: https://blueyonder.com/knowledge-center/collateral/michelin-case-study-video [Accessed 28 Jan. 2024].

Michelin. (n.d.), “Michelin - The VISION Concept.”, Available at: https://www.michelin.com/en/innovation/vision-concept/ [Accessed 28 Jan. 2024].

Miclo, R., (2016), “Challenging the ”Demand Driven MRP” Promises : a Discrete Event Simulation Approach.”, Available at: https://www.researchgate.net/publication/322220127_Challenging_the_Demand_Driven_MRP_Promises_a_Discrete_Event_Simulation_Approach

Miclo, R., Lauras, M., Fontanili, F., Lamothe, J. & Melnyk, S.A. (2018), “Demand Driven MRP: assessment of a new approach to materials management.”, *International Journal of Production Research*, Vol. 57 No. 1, pp. 166–181.

Nagao, R. & Varela, H. (2016), “TURING PATTERNS IN CHEMICAL SYSTEMS.”, *Química Nova*, Available at: doi:https://doi.org/10.5935/0100-4042.20160026.

Oliinyk, S. (2022), “DDMRP vs MRP Inventory Management.”, Available at: https://demanddriventech.com/blog/mrp-inventory-management/ [Accessed 27 Jan. 2024].

Orue, A., Lizarralde, A. & Kortabarria, A. (2020), “Demand Driven MRP – the Need to Standardise an Implementation Process.”, Available at: http://dx.doi.org/10.4995/ijpme.2020.12737 [Accessed 28 Jan. 2024].

Pekarčíková, M., Trebuňa, P., Kliment, M. & Trojan, J. (2019), “DEMAND DRIVEN MATERIAL REQUIREMENTS PLANNING. SOME METHODICAL AND PRACTICAL COMMENTS.”, *Management and Production Engineering Review*, Vol. 10 No. 2, pp. 50–59.

Prod'Agile (2017), “Fapics -DD World Michelin Lyon-5.”, Available at: https://139b7ba6-57f5-40f4-a9cb-3c134e42ba5c.filesusr.com/ugd/af37d3_e9b25c56b5ed450ba32729e0c7b3b130.pdf [Accessed 1 Feb. 2024].

PTAK, C. & SMITH, C. (2011), Orlicky's Material Requirements Planning McGraw Hill Professional

Ptak, C. & Smith, C. (2011), “Orlicky’s Material Requirements Planning.”, Available at: https://www.accessengineeringlibrary.com/content/book/9780071755634 [Accessed 27 Jan. 2024].

Ptak, C.A. & Smith, C. (2016), “Demand Driven Material Requirements Planning (DDMRP).”, Available at: https://www.econstor.eu/bitstream/10419/261762/1/1766006280.pdf

Purchasing Documents. (n.d.), “Sustainable Natural Rubber Progress Report 2015 - 2020.”, Available at: https://purchasing.michelin.com/en/sustainable-natural-rubber-progress-report-2015-2020/ [Accessed 28 Jan. 2024].

RONDEAU, P. & LITTERAL, L. A. (2001), “The evolution of manufacturing planning and control systems: From reorder point to enterprise resource planning.”, *Production and Inventory Management Journal*, Vol. 42, pp. 1-7.

SmartOSC (2023), “Data Analyst Salary in Vietnam: A Comprehensive Overview”, Available at: https://careers.smartosc.com/en/data-analyst-salary-in-vietnam-a-comprehensive-overview/ [Accessed 2 Feb. 2024].

Smith, C. (2014), “Does your Company have the Bimodal Inventory Distribution?” , Available at: https://www.linkedin.com/pulse/20140721142137-12416095-does-your-company-have-the-bimodal-inventory-distribution/ [Accessed 27 Jan. 2024].

Smith, D. & Smith, C., (2013), “What's Wrong with supply chain metrics.”, *Strategic Finance*, Vol. 95 No. 4, pp. 27 - 33.

Tien, N.H. & Vinh, N.D.T. (2019), “Analyzing the Prospects and Limitations of the ERP Market in Vietnam.”, *International Journal of Commerce and Management Research*, Vol. 5 No. 5, pp.46–50.

tư, T. chí K. tế và D. báo-Bộ K. hoạch và Đ. (n.d.), “Sai lầm thường gặp khi lập kế hoạch sản xuất.”, Available at: https://kinhtevadubao.vn/sai-lam-thuong-gap-khi-lap-ke-hoach-san-xuat-683.html [Accessed 2 Feb. 2024].

www.michelinman.com. (n.d.), “How Are Tires Made?”, Available at: https://www.michelinman.com/auto/auto-tips-and-advice/tires-101/how-are-tires-made [Accessed 28 Jan. 2024].

www.techsciresearch.com. (n.d.), “Vietnam Enterprise Resource Planning (ERP) Market Size, Share, Growth & Forecast 2027”, Available at: https://www.techsciresearch.com/report/vietnam-enterprise-resource-planning-market/9513.html.

Zuerl, K. (n.d.), “Vietnam Supply Chain: Insights into Current Challenges”, Available at: www.diplomatic-council.org. Available at: https://www.diplomatic-council.org/node/1134.