

# A COMPARATIVE STUDY OF MATERIAL PLANNING PROCESSES

## Abstract

Material management is simply the process by which an organization is supplied with the goods and services that it needs to achieve its objectives of buying, storage, and movement of material, Efficient material management is very essential. In a world of limited resources, manufacturing businesses follow a chain of processes to convert the naturally available resources from a state of lower value to one of higher value or utility. However, the process of conversion of raw material to a finished (usable) product stage is full of variabilities, uncertainties, complexities, and ambiguities, due to the involvement of a chain of entities in the manufacturing process, right from a supplier to producer to customer.

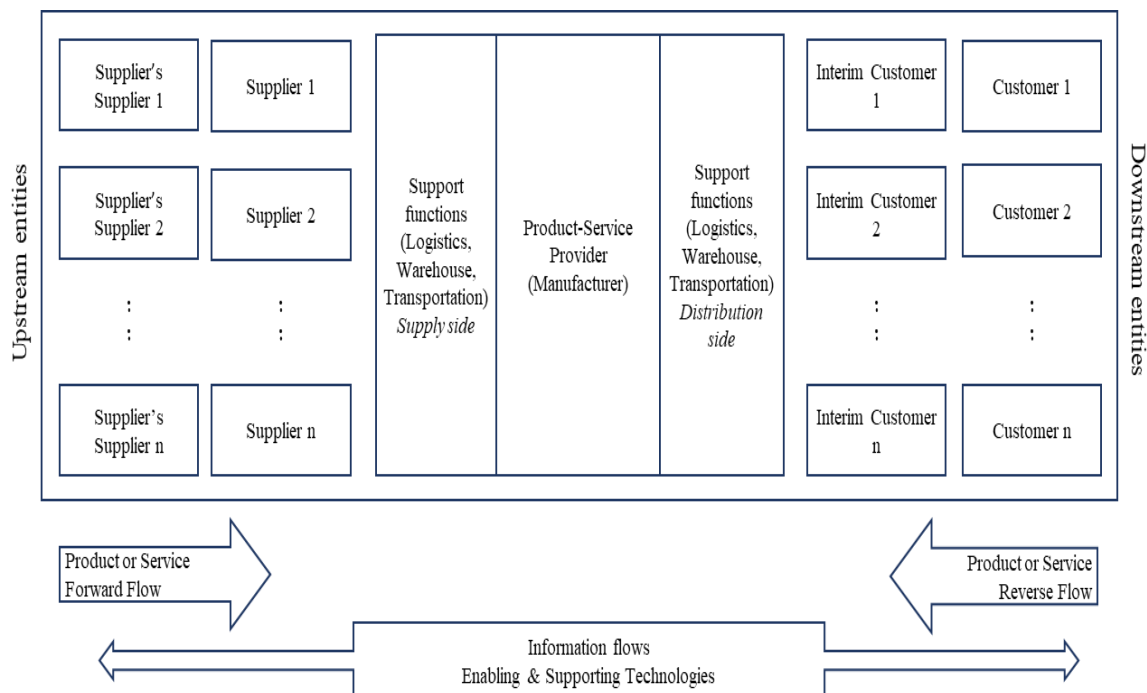
**Keywords:** Material management, Inventory, Business environment and challenges.

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## I. INTRODUCTION

- The Scenario:** In a world of limited resources, manufacturing businesses follow a chain of processes to convert the naturally available resources from a state of lower value to one of higher value or utility. However, the process of conversion of raw material to a finished (usable) product stage is full of variabilities, uncertainties, complexities, and ambiguities, due to the involvement of a chain of entities in the manufacturing process, right from a supplier to producer to customer. These entities form a part of what is known as the Supply Chain and include the suppliers (of natural or man-converted resources), the producer (manufacturer, converter, or value-adder), and the customer (original equipment manufacturer or end consumer of the converted resource).



**Figure 1**(Source: self-created)

A resilient supply chain needs to be responsive to the varying customer requirements, as well as efficient while executing operations to meet those requirements in terms of volume, variety, and time. This is because a customer's wait time starts from the time of generation of interest and ends upon fulfilment of the requirement, upon payment for the deliverable as per the agreed terms and conditions. For a producer, the customer order execution hence becomes an important function focused to ensure the availability of resources at the right time, quality, and quantity to support the manufacturing function. If the business does not honour this, the customer is volatile enough to move to a competitor, necessitating the planners of today to efficiently plan ahead for all resources that are required to efficiently execute the customer order.

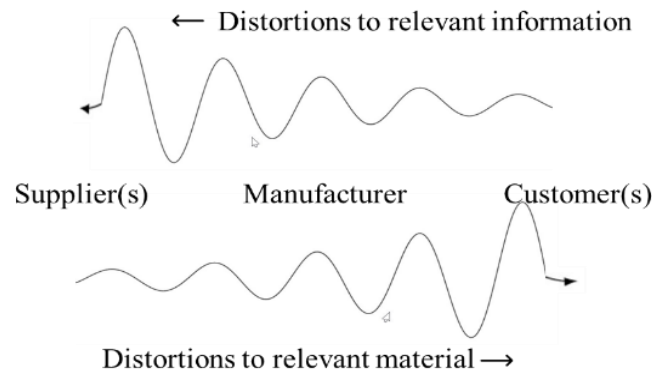
- The Need for Inventory:** Other than the required funds, business resources include manufacturing and distribution capacities, human resource, and the required inventory to ensure that the customer demand is met with the right product in the right quantity of the right quality at the right time and at the right price. Out of these, the inventory comprises

all those items that are used to either support the direct production of the end product or to facilitate the production activity to ensure customer service, and acts like a lubricant to ensure a smooth flow of operations to execute manufacturing functions. Businesses spend money to purchase the raw materials and consumable inventory to produce the finished goods, which only once sold can bring the money back to the business. Until such time, the money is said to be blocked in the form of inventory that critically impacts the bottom line, which makes an efficient Inventory Planning and Control functional critical part of the overall Supply Chain Management. A tightrope walk of inventory planning and control function involves aligning internal operations with external expectations to strike the right balance between extremely volatile demand and supply environment while remaining profitable. This alignment and balancing act is filled with some challenges faced by businesses.

- 3. Industry Challenges:** Recent times have witnessed extremely volatile, uncertain, complex, and ambiguous (VUCA) operating environments, which have made the inventory planning and control function, remain a huge challenge for any business. Such a volatile and less deterministic business environment necessitates businesses to accept demand and supply side variabilities as a way of life. The nature of demand variability is multi-dimensional, in terms of product variety, volumes, and delivery due dates. Such variabilities also apply to the supply side, additionally getting amplified due to the agreed fixed supply order quantities with the suppliers. Planners and executors consistently experience swinging from a risk situation of running out of stocks to sudden receipt of large fixed material order quantities, both posing unique threats to running and managing smooth operations. Businesses today need to manage today's dual-side variabilities to plan and execute their internal operations because external factors like demand and supply are not completely in an organization's control, whereas it seems best to first control the controllable internal factors.

The new normal of today has witnessed increased volatility and variability in the system from both, the demand and supply sides, contributed greatly by the shifting of geopolitical power systems, pandemics, or even very specific instances like the blocking of the Suez Canal due to just one carrier. Whatever the underlying reasons, such VUCA conditions result in creating a nervous system with an additional task for planners and executors to manage the (in)famous bullwhip effect, which is yet another area of concern in any business operation. As the information about demand and supply levels passes through the supply chain, it gets amplified due to the improper flow of relevant information, necessitating recalculating the material requirement to stop such variability to pass between the different supply chain echelons in both directions.

A deeper dive also brings our attention to the root cause is not merely what's being done, but more of how's being performed, which leads to the increased cost of operations. This necessitates a re-look at the way businesses perform processes.



**Figure 2**(Source: self-created)

## II. LITERATURE REVIEW

The APICS Dictionary, 16<sup>th</sup> Edition, published by The Association of Supply Chain Management (ASCM), defines a supply chain as a global network of supplying entities (or functions) engaged in delivering the relevant inventory of products or services to the customer entity (or function), in exchange of funds, and as guided by a flow of relevant information. The Dictionary further explains Supply Chain Management as performing functions of planning, execution, and control of many activities involved in the process of conversion of resources, in the most competitive and profitable manner. APICS Dictionary, 16<sup>th</sup> Edition defines Inventory Planning and Inventory Control as the specific activities and methods of respectively determining and maintaining the desired levels of items.

The APICS Dictionary (16<sup>th</sup> Edition) defines a bullwhip effect as an amplified change in the upstream supply position triggered by a small downstream demand situation in the supply chain. This is also supported by the various definitions of supply chain management from various authors compiled in the paper by Jinesh Jain, G. S. Dangayach, G. Agarwal, Soumya Banerjee (2010). It describes Supply Chain Management as an essential practice for the manufacturing industry providing product-service offerings to the end customers.

Today's competition is of two supply chains rather than two organisations, as comes from the main finding of the doctoral dissertation of Seth, Manisha, Kiran, Ravi and Goyal, D. P. Thapar University, Patiala, Evaluation of Supply Chain Management Systems in Automotive Industry of North India (2016). This is closely supported by an analysis first concluded by authors Martin Reeves, Simon Levin and Daichi Ueda in their paper published in the Harvard Business Review based on an investigation of 30,000 organizations in the US over 50 years. The findings revealed that today's businesses face harder times to survive for longer times than earlier because of the variabilities in the environment in which they operate. The adaptability of businesses to today's scenarios hence becomes the key to survival.

The importance of inventory management in business operations was realized during the middle of the last century. Since then, industry practitioners as well as research enthusiasts have continuously been trying to study the planning and execution techniques to continuously improve and become more efficient. This is also emphasized by Shukla R., Garg D. and Agarwal A. (2011) in their paper explaining supply chain management with

respect to the conversion of inventory from the raw material stage to a finished product stage for end customer delivery. Hence it is also necessary to develop a deeper understanding of how the industry practices inventory management activities and some associated challenges.

The work of Souresh Bhattacharya, D. Mukhopadhyay and Dr. Sunil Giri (2014) identifies the demand-side trends as uneven growth, fragmentation, and high demand volatility as some areas of focus. Similarly, on the supply side, some notable trends emerge as high logistics cost from inefficient supply chain operations, absence of supply chain integration, and technology leverage, other than differentiated outsourcing & fragmented supplier base, risk management, and quality concerns.

Joseph Orlicky's book on Material Requirements Planning (1975) outlines the development of the material planning concept right from the time rise of the manufacturing function. The need to manage inventory buffer volumes in a dynamic business environment resulting from limitations of the traditional MRP systems is highlighted in the work of Sridharan, V. and Lawrence LaForge, R. (1990). This today forms the basis of the concept of the Demand Driven Materials Requirement Planning (DDMRP) approach also. In the paper titled "A study on the reengineering processes in selected organisations in India (March, 2001)" by Singh, Madan M, Malhotra (2001), the authors emphasize on need for process change when existing processes are reactive. Two major findings from this work encourage further study in this domain. These are on the fact that increased availability of resources leads to improved customer service levels and that improved supply chain management leads to efficient management at all locations, thereby improving lead times or reducing delays.

An article by Sridharan, V. and Lawrence LaForge, R. (1990), that MRP systems present limitations in a volatile business environment, resulting in a need to manage inventory levels in the form of buffers. This matches with the philosophy of the Demand Driven Materials Requirement Planning (DDMRP) approach also.

In the European Journal of Operational Research, Kannan Govindan, Mohammad Fattahi, Esmail Keyvanshokoo published a journal paper that is a comprehensive collection of findings from various publications of the past two decades. It reviews various studies in the field of supply chain networks and provides an understanding of key supply chain challenges in a volatile environment.

Shofa, M. J., Moeis, A. O., & Restiana, N. (2018, April) in the paper "Effective production control in an automotive industry: MRP vs. demand-driven MRP" evaluate and compare the performance of DDMRP and MRP in terms of average inventory levels, taking an automotive company in Indonesia as the context of a case study. Results of this study show a 94% compression of lead times in case of DDMRP with respect to MRP based planning. Similarly, R. Miclo, F. Fontanili, M. Lauras, J. Lamothe, B. Milian Science Direct, Elsevier (2016) also conducted a case study-based investigation to objectively and quantitatively compare MRPII & DDMRP systems, resulting in DDMRP referred over traditional MRP systems.

To summarize, what has changed over time, is as follows:

**Table 1: Summary of Today’s Changed Business Environment**

<b>Parameter</b>	<b>Earlier</b>	<b>Now</b>
Variability	Stable	Volatile
Customer wait time, reflecting available lead times	Dependent on supplier	Defined by the customer, immediate
Need for adaptability to changing scenarios	Negligible	Dynamic
Complexity in supply chain functioning	Simple, taut, local	Complex, expanded, global
Planning focus	Material resource	Manufacturing resources
Product structure, variety, and need for customized solutions	Limited	Extremely varied
Inventory Management	Auto-driven, reactive mode	Proactive lean management

### III. THE GAPS

Based on the understanding captured from various work in the field, it is evident that the management and optimization of inventory remain key activities to be carried out by the planners of today’s business operations. However, due to the volatility of the environment, inventory planners usually quail two universal points of undesirable experiences, inventory being either ‘too little’ or ‘too much’. Too little inventory is the experience of facing raw material or component shortage, warranting expediting to avoid missing the production and delivery schedules. Too much inventory increases the inventory holding costs along with the risk of part obsolescence or even damage during storage. Somewhere between these two extremes lies the point of an optimal range of inventory that can help in managing cost-effective operational flow. So, the question is, is there a way we could organize the internal way of working in a manner so that the planners can plan, purchasers can purchase, and the delivery team can deliver, all in the given reaction time? That is why matured organizations need to work on demand-driven methods rather than pure forecast-based estimates. The readiness of an organization to change its mindset from a push-based resource requirement planning to one that is driven by the actual visible demand remained under doubt. Unless this is explored and feedback captured directly from the relevant stakeholders, the best way forward can still not be determined.

### IV. APPROACHES TO MANAGE THE CHALLENGES / PRACTICES IN INVENTORY MANAGEMENT

Industry planning practices are classified under two categories (a) Traditional Deterministic Forecast Driven Approach and (b) Innovative Demand Driven Approach. This is followed by a discussion of their respective merits and demerits and a comparison on a few bases of distinction factors.

- 1. Traditional Deterministic Forecast Driven Approach:** Conceived in the middle of the last century, the conventional practices to manage operational challenges were innately based on an assumption that businesses could operate in a deterministic environment characterized by stable demand and supply positions, where the planners could plan for a

derived requirement of resources for pre-determined stable demand and supply capabilities. Using the forecast of the independent demand item (end product), and input parameters like the bill of material, the on-hand quantities, pre-agreed order quantities, and the associated lead time for the material item, it was possible to calculate the quantity and time of availability of the dependent item (raw material, sub-assembly). The benefit of such a forecast-based material requirements planning (MRP) approach is the ability to get the output as a time-phased plan for a material requirement in terms of what will be needed, how much will be needed, and when.

However, since forecast involves estimating for the future, despite the most appropriate forecasting technique, due to the unstable nature of actual demand, there is always a margin of error involved. The variability in forecast numbers over every subsequent planning period often results in experiencing high levels of irrelevant items while carrying low levels of the relevant ones. With the use of such planning practices in an extreme demand and supply variability environment, businesses experience the bimodal behaviour of inventory that is, having an excess inventory of items not immediately in demand, and having scarcity of items that are immediately in demand. This translates into simultaneously blocking the critical funds (and organizational resources) in the form of irrelevant inventory as well as interruptions in production due to a shortage of the relevant inventory. Excess inventory means funds blocked as unsold or unmanufactured products, while material shortages further demand an additional investment of funds to ensure the timely availability of the relevant inventory.

One of the consequences of the traditional forecast approach has been the bimodal behaviour of the inventory, which means having excess and shortage of the same inventory item, sometimes leading to more of the unwanted material and less of the needed one. A major contributing factor to rapidly rocketing high inventory levels is the fixed minimum order quantities, necessitating the planners to deal with both excess level situations, as compared to the actual demand levels. As the (cycle) stock depletes with time, the conventional material planning systems again trigger supply order generation as per the pre-agreed minimum order quantity, instead of on a lot-for-lot requirement basis. Once received, the quantity is more than needed in the said planning period, resulting in excess stocks, again depleting gradually over time based on average daily consumption.

Thus, the conventional resource planning methods contribute both toward high inventory carrying costs as well as high stock out costs, translating to an organizational challenge to minimize the investment of funds in maintaining the most optimal levels of inventory. A not-so-accurate forecast number used as the basis of planning automatically creates the need to re-plan (re-adjust) during the next planning period. Such actions also fundamentally violate the basic fundamentals of Lean Management and the Theory of Constraints practices. Further, considering the limitation to increasing the top line, businesses resort to improving the bottom line by controlling costs in a typical forecast-driven planning environment, where cost reduction remains the ultimate objective to ensure returns on investment (ROI). Some major cost contributions come from the rework, replanning, or re-execution due to the unpredictable variabilities in the environment. Hence, the obvious reaction has been to reduce the costs by way of reducing the unpredictability and estimating the future to the maximum extent possible. That is why businesses rely on effective forecasting methods to determine the future in this not-so-deterministic world. This uncertainty and variability from the supply, as well

as demand side, has resulted in organizations either carrying more irrelevant inventory, or less of the relevant inventory, consistently challenging operations to contain the operational costs to remain an efficient supply chain, sometimes compromising being a responsive supply chain.

2. **Demand Driven Approach:** Around the year 2011, Ptak, Carol and Smith, Chad the founders of Demand Driven Institute Inc., USA propounded an innovative Demand Driven Material Requirements Planning (DDMRP) approach that embraces the inevitable variabilities on the demand and supply sides, prescribing focus on managing the flow of relevant material and information in a manufacturing business environment, with the right kind of resources that make operations lean, taut, and scalable (MOLTS). The flow-based DDMRP operating model uses the actual demand information as the primary input rather than solely depending on erroneous forecasts alone. It thus necessitates businesses to build internal supply capabilities to meet customer requirements of varieties and volumes, by developing the ability to monitor the net flow in operations. This enables inventory planners with a summarized view of net inventory inflows and outflows in the planning period, as given below.

Net flow equation = On-hand inventory quantity + On-order inventory quantity – Qualified Demand from the customer

Such visibility helps protect the operational flow, contributing by reducing overall lead times and associated costs through improved cash-to-cash cycle time. The relevant inventory is identified by strategically identifying decoupling points for creating and managing the buffers for inventory, manufacturing capacities and lead times. Under this approach, the supply order relies more on the supplier's agility on a dynamic basis, enabling the order quantities to align with the confirmed future demand, instead of pre-agreed fixed quantities. The relevant information is shared with relevant entities in the supply chain due to increased trust and collaboration and supported by the ability to provide an agile response to order flow variability.

A flow-based system enables facilitates reliability and consistency in providing services, thus maximising the revenues with a minimum amount of inventories synchronizing supply with demand. Simply said, protecting the flow leads to maximizing assured revenue with minimum inventory, and curbing all ancillary costs, thus achieving the desired ROI.

Thus, a demand-driven modern approach is

- Based on visible customer order status for the planning period
- Planned with daily buffer level adjustments based on pre-set factors on variabilities and lead times – for specifically identified (critical) items
- Focused on Net Flow Equation to manage buffer levels of critical items and accordingly decide supply order quantities



## V. COMPARISON ON THE BASIS OF (A) IDENTIFIED DISTINCTIONS AND (B) COMMON POINTS

Although both approaches inherently strive to minimize inventory investment and maximise manufacturing efficiency while meeting the desired customer service levels, there are prominent differences in both approaches.

**Table 2: Points of Dissimilarities between the Two Approaches**

<b>Parameters</b>	<b>Conventional Forecast-driven Planning</b>	<b>Demand-Driven Planning</b>
Primary focus	Corrective approach as errors can be calculated only at the end of a period/operations Cost control based on realizing the forecast errors Planning primarily for FG and RM Tactical to Operational focus	Proactive approach as it plans and adjusts during the operation, rather than at the end of it Flow of operations, to bring in agility in operations, that automatically controls cost Plans for critical items at any stage of operations, not limited to FG and RM alone Strategic to Tactical planning with an operational execution focus
ROI management	Cost reduction is the ultimate objective to ensure ROI	Smooth flow of operations is the objective to result in reduced costs and improved ROI
Planning	Forecasts as the primary input for resource planning at tactical and operational levels Re-planning to accommodate forecast errors while planning for the next period	Actual demand is the primary input for resource planning for both long-term and short-term planning Adjusts alongside on a daily/weekly basis to accommodate changes
Bi-modal behaviour of inventory	Due to forecast based approach, supply order size results in sudden rise and fall in inventory levels for an item	Supply order is not strictly based on fixed quantities, but rely on supplier relationship to be agile in operations
Bullwhip effect	Greater margin of error in planning coming from a higher magnitude of demand variability, due to the inherent push-based approach. This results in corrective actionable leading to post-operational adjustments and crisis management	Operational planning improves due to the ability to adjust quickly, despite the given variability on the demand and supply sides. This is an inherent pull-based approach, honouring the adjustment for local conditions, embracing variabilities and accordingly planning for supply capabilities
Lean management	Due to heavy reliance on forecasted numbers, bimodal inventory behaviour warrants	Lean concepts are built into the demand-driven approach, as supply order quantities can be managed dynamically

	Any buffer quantity is considered an evil	Focus on the flow of uninterrupted operations, with daily buffer level monitoring, based on relevant information on relevant material
Building safety into operations	Carry safety stocks of FG and RM, to protect from variabilities in demand & supply, respectively	Optimize buffers of stock, time, and capacity; hence this approach enables planning for resources not limited to the material alone

**Table 3: Points of similarities between the two approaches**

Parameters	Conventional Forecast-driven Planning and Demand-Driven Planning
Inventory Management	Both approaches enable planning for material resource planning and management
Focuses on	Increasing the ROI. However, both approaches take a different route to achieve the end objective.
Forecasting	Forecasting remains an input parameter in the demand-driven approach also. Although the reliance on it is lesser.
Supply Order Generation	One of the key outcomes from both planning approaches is the generation of supply orders. Both approaches differ in their approach to generating specific order volumes and frequency.
Theory of Constraints	Both approaches honour Theory of Constraints as the focus is to effectively manage constraints on a continuous improvement basis.
Planning factors	To different extents, both approaches require (static or dynamic) planning factors like on-hand quantity, planning horizon, lead time, MOQ (if applicable), yield percentage, etc.

With the understanding and analysis of two approaches to inventory planning and control, it becomes evident that the two approaches intend to achieve a common end goal of meeting the customer service levels in the most effective manner by facilitating efficient operations.

Conventional business practices have evolved with practices that encourage profit maximization, so as to reserve the best margins for the organization, even if that is at the cost of other partners in the supply chain. Since revenue generation is limited to market potential, increasing the profit margins is considered feasible by way of cost reductions. While this is acceptable math, the underlying concept is ensuring that cost remains within its targeted bounds. Energies get exhausted in reducing costs through better supplier negotiations, reduction in freight costs, value-added-value-engineering (VAVE), choking the distribution margins, and other such tactics that have proven to be good in the short term. Accountants will tell that below a particular cost level, it does not make sense to produce and sell. This means that there has to be something more fundamental to be focused upon, rather than cost alone.

## VI. CONCLUSIONS

A series of interviews conducted with 10 industry practitioners in Delhi-NCR region, revealed the following findings:

1. Forecasting is essentially an estimation of the future. Even the best planners cannot predict the future with 100% accuracy, especially in a world of multiple variabilities.
2. To keep costs under control, businesses strive to minimize the blockage of funds in the form of inventory or capacity, thus risking stockout and excess stock situations.
3. Inventory bimodal behaviour, bullwhip effect, and hindrances in practices of lean management are a norm in managing operations.
4. Safety stocks are maintained primarily at the entry and exit points in the manufacturing process, with a focus mainly on raw materials and unsold finished goods, only. However, the entire product structure and manufacturing routing also needs to be planned for the requirement of intermediate parts.
5. With interruptions in the flow of operations, lead times increase, thereby increasing the overall costs.
6. Maximizing return on investment brings the focus back to the cost control mechanisms, in turn sacrificing the smooth flow of operations.

## REFERENCES

- [1] Bhattacharya, S., Mukhopadhyay, D., & Giri, S. (2014). Supply chain management in Indian automotive industry: Complexities, challenges and way ahead. *International Journal of Managing Value and Supply Chains*, 5(2), 49.
- [2] Ducrot, L., & Ahmed, E. (2019). Investigation of potential added value of DDMRP in planning under uncertainty at finite capacity.
- [3] Favaretto, D., & Marin, A. (2018). An empirical comparison study between DDMRP and MRP in Material Management. Department of Management, UniversitàCa'Foscari Venezia Working Paper, (15).
- [4] Ihme, M., & Stratton, R. (2015). Evaluating demand driven MRP: a case based simulated study. *International Conference of the European Operations Management Association*. Neuchatel, Switzerland. <http://irep.ntu.ac.uk/id/eprint/26668>
- [5] *J. of the Acad. Mark. Sci.* (2010) 38:32–41. DOI 10.1007/s11747-009-0136-2
- [6] Jain et al. / Supply Chain Management: Literature Review and Some Issues / pp. 11-25 *Journal of Studies on Manufacturing (Vol.1-2010/Iss.1)*
- [7] *JIEM*, 2018 – 11(4): 632-650 – Online ISSN: 2013-0953 – Print ISSN: 2013-8423
- [8] Joseph, A. A. (2019). Implementing DDMRP in a Lebanese multiproduct industrial company. *Proche-Orient Études en management*, 31(1), 25-47.
- [9] K. Govindan et al. / *European Journal of Operational Research* 263 (2017) 108–141
- [10] Kortabarria, A., Apaolaza, U., Lizarralde, A., & Amorrtu, I. (2018). Material management without forecasting: From MRP to demand driven MRP. *Journal of Industrial Engineering and Management*, 11(4), 632-650.
- [11] Lambert, D. M., & Cooper, M. C. (2000). Issues in supply chain management. *Industrial marketing management*, 29(1), 65-83.
- [12] Lee, Hau & Padmanabhan, V. & Whang, Seungjin. (2015). The Bullwhip Effect In Supply Chains. *Engineering Management Review, IEEE*. 43. 108-117. 10.1109/EMR.2015.7123235
- [13] Martin Reeves, the evidence of a problem, *Harvard Business Review* Feb-2017
- [14] Miclo, R., Fontanili, F., Luras, M., Lamothe, J., & Milian, B. (2016). An empirical comparison of MRPII and Demand-Driven MRP. *IFAC-PapersOnLine*, 49(12), 1725-1730.
- [15] Miclo, R., Fontanili, F., Luras, M., Lamothe, J., & Milian, B. (2016, June). An empirical study of Demand-Driven MRP. In *6th International Conference on Information Systems, Logistics and Supply Chain-ILS Conference* (pp. 1-7).
- [16] Miriam Pekarč'iková, Peter Trebuňa, Marek Kliment, Jozef Trojan, *Management and Production Engineering Review* Volume 10 • Number 2 • June 2019 • pp. 50–59 DOI: 10.24425/mper.2019.129568

- [17] Romain Miclo. Challenging the "Demand Driven MRP" Promises : a Discrete Event Simulation Approach. Modeling and Simulation. Ecole des Mines d'Albi-Carmaux, 2016. English. NNT : 2016EMAC0016 . tel-01673811
- [18] Sathwani, S. A study on the impact of inventory and distribution coordination on supply chain performance. A study on the impact of inventory and distribution coordination on supply chain performance (2017)
- [19] Sahai, G., Seth, A. (2020). "Changing Business Operations in Disruptive Times – a review paper". Int. Journal of Advanced Science & Technology, Vol. 29(10s), 7818-7825.
- [20] Seth, M., Kiran, R., & Goyal, D. P. (2016). Evaluation of supply chain management systems in automotive industry of north India (Doctoral dissertation).
- [21] Shofa, M. J., Moeis, A. O., & Restiana, N. (2018, April). Effective production planning for purchased part under long lead time and uncertain demand: MRP Vs demand-driven MRP. In IOP Conference Series: Materials Science and Engineering (Vol. 337, No. 1, p. 012055). IOP Publishing.
- [22] Shukla, R. K., Garg, D., & Agarwal, A. (2011). Understanding of supply chain: A literature review. International Journal of Engineering Science and Technology, 3(3), 2059-2072.
- [23] Singh, S. C., & Pandey, S. K. (2015). Lean supply-chain: a state-of-the-art literature review. Journal of Supply Chain Management Systems, 4(3), 33.
- [24] Sinha, A., & Ubale, S. S. (2019). Demand Driven Approach to Combat Nervousness of Auto Supply Chain in India.
- [25] Somu, A. A study on supply chain management in small and medium auto ancillary units in Coimbatore district of Tamil Nadu.
- [26] Sridharan, V. and Lawrence LaForge, R. (1990), "On Using Buffer Stock to Combat Schedule Instability", International Journal of Operations & Production Management, Vol. 10 No. 7, pp. 37-46.
- [27] ZACHARIAH GEORGE, A. B. I. T. H. (2018). Demand driven materials requirement planning (DDMRP). A new method for production and planning management.

## ONLINE REFERENCES

- [1] <http://hdl.handle.net/10603/181005>
- [2] <https://hbr.org/1985/09/mrp-jit-opt-fms>
- [3] <http://www.apics.org/apics-for-individuals/publications-and-research/apics-dictionary> APICS Dictionary (2019), International Standard Book Number: 978-O-56490-6, 16th ed. pg 29
- [4] <https://www.ascm.org/>
- [5] <https://www.demanddriveninstitute.com/>

## BOOKS

- [1] Ptak, C.A. and Smith, C. (2008), "Beyond MRP", APICS Magazine, (July/August 2008).
- [2] Ptak, C.A. and Smith, C. (2011), Orlicky's Material Requirements Planning, 3rd ed., McGraw-Hill, New York.
- [3] Demand Driven Adaptive Enterprise, Industrial Press, Inc. (2019)
- [4] Demand Driven Materials Requirement Planning, Industrial Press, Inc. (2019)
- [5] Precisely Wrong, Industrial Press, Inc. (2019)
- [6] Senge, P. M. (2006). The fifth discipline: The art and practice of the learning organization. Currency.
- [7] Orlicky, J. (1975). Material requirements planning: the new way of life in production and inventory management. McGraw-Hill.
- [8] Plossl, G.W. (1995), Material Requirements Planning, 2nd ed., McGraw-Hill, New York.
- [9] George Plossl, Orlicky's Material Requirements Planning, 2nd edition, McGraw-Hill, New York, N.Y., 1994, p. 4.)