Investigation of Potential Added Value of DDMRP in Planning Under Uncertainty at Finite Capacity

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Summary: In this project, we investigated how Demand Driven MRP (DDMRP) operates in a capacity constrained environment. Using qualitative and quantitative analysis, we proved that DDMRP increases service levels and reduce both inventory levels and customer order lead times. The financial impact of these results combined with the competitive advantage derived from the improved service gives DDMRP the potential to be a game-changer in supply chain planning.

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Prior to MIT, Ehtesham has worked in supply chain operations for six years, of which the last four years have been spent working for a cement manufacturing company. He has received his MBA from IBA, Karachi.

KEY INSIGHTS

1. DDMRP can have a strong impact on the financial performance of the company and can provide a competitive advantage.
2. Implementing DDMRP results in streamlined operation throughout the internal supply chain.
3. DDMRP provides similar results as a solver-based planning without the 'black-box' effect

Introduction

The Demand Driven Material Requirement Planning (DDMRP) was introduced in 2011 as an effective tool for improving supply chain planning in conditions of demand or operations uncertainty. The Demand Driven Institute (DDI) reports that DDMRP improves service levels by 13% (median) while reducing inventory levels by 31% (median) and customer order lead times by 22% (median). Such results can have a significant impact on the financial performance of a company and provide a competitive advantage. However, further analysis is required to understand what conditions are required to achieve a high level of improvement. If similar results are realized in various industries, DDMRP can be a game-changer in supply chain planning.

This project aims at better understanding of what outcomes can be expected from a DDMRP implementation.
This research focuses on manufacturing planning and investigates the question "What are the potential added values of DDMRP in planning under uncertainty at finite capacity?"

Methodology

We separated the investigations of the potential benefits from the analysis of the impact of capacity on DDMRP. Understanding the added value and the drawbacks of the demand driven method required us

to consult with companies using DDMRP. The approach used had to be both open to capture unexpected results and structured to collect data to perform the analysis. For that reason, our methodology incorporated a combination of semi-structured interviews and a survey. We also conducted a simulation analysis to explore the response of DDMRP in a finite capacity manufacturing environment. The simulation analysis compares DDMRP to different planning approaches available in an Advanced Planning System.

The survey was sent electronically to companies that were using DDMRP in at least one part of their supply chain planning activities. We segmented respondents based on their company profile and their level of maturity in supply chain planning. We analyzed the impact of DDMRP for the different segments to better understand what outputs can be expected from DDMRP.

A simulation analysis was run to evaluate DDMRP performances under finite capacity constraint, in a manufacturing setup. We compared the DDMRP algorithm with two planning algorithms available in a commercial APS system, *OMP Plus*, offered by OM Partners. The simulation mimicked a rolling horizon where time was moving forward. Variability was introduced in the operations and in the demand. The simulated plans were evaluated based on service levels, inventory levels and inventory turns. The simulation used 4 scenarios. Scenario 1 and 2 have stable operations but a low forecast accuracy. Scenario 1 has more capacity available than Scenario 2. Scenario 3 and 4 have higher forecast accuracies but more variability in the operations. The same demand-capacity ratios are used to differentiate Scenario 3 and 4.

A plan was generated for these scenarios using:

- A replenishment heuristic: Every time the projected inventory falls below a minimum stock, a plan is generated to bring it back to a target inventory level.
- The regular DDMRP planning approach: The *NetFlow Position* is brought back to the top of the green part of the buffer whenever it falls into the yellow zone of the buffer.
- A linear programming (LP) solver: The solver balances inventory levels and the capacity

Qualitative and quantitative results

Our qualitative and quantitative results confirm the order of magnitude of the improvements claimed by the DDI (Table 1).

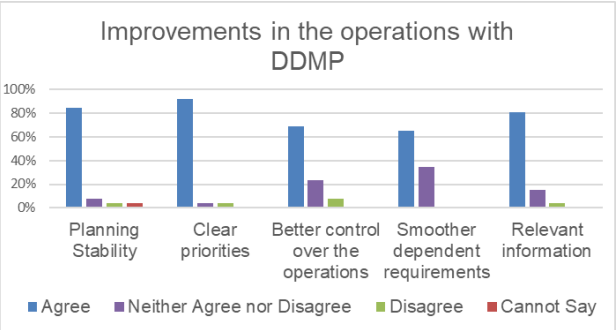
Table 1: Result of DDMRP implementation across all industries

Operational Consideration	Average change post DDMRP	Frequency of occurrence
Inventory level	-20%	-
Inventory turns	-13%	-
Service level	13%	-
Customer order lead time	-48%	-
Repositioning of decoupling points	-	54%
More stable planning	-	85%
Clearer priorities		92%

The respondents' companies are diverse in terms of annual revenues. About 46% of the respondents report an annual revenue between $100 and $500 million. About 29% of the companies have a revenue exceeding $10 billion.

All respondents describe a reduction in inventory level ranging from 3% to 53%, with an average of 20%. They also report an improvement of 13% in service level and a reduction of their customer order lead time by 48%. If payment terms are not changed, decreasing the inventory level reduces the working capital and can increase the Return On Investment (ROI) of the company. The improved service level and the reduced customer order lead time offer a competitive advantage. This competitive edge can result in higher revenue, further improving the ROI.

Figure 1: Improvements in the operations with DDMRP



Change management has been a central topic in our interviews, and the surveyed companies frequently mentioned it as one of the main challenges. We learned during the interviews that DDMRP calls for a comprehensive supply chain education program within the companies. Every company had to train people from different functions, from finance to manufacturing to procurement. We then realized that the DDMRP projects made these companies do what all companies should do: align the different actors of the supply chain with the same objective. We concluded that these companies trained the different actors of their internal supply chain to the basic concepts of flows, the nature of the interactions between the different departments, and the importance of aligning the decisions and the policies of the different functions.

The companies state that implementing DDMRP improved their operations. Fig.1 shows the impact of DDMRP on the companies' operations.

Simulation analysis

DDMRP results show a strong resilience variability or capacity constraint. DDMRP performs better than heuristics-based planning. The solver provides the highest service level, but it requires higher inventory levels than DDMRP. (Table 2)

In order to facilitate the comparison between the scenarios, the planning parameters were not changed. This explained why the service levels went down as the constraints increased.

Our simulation shows that DDMRP provides similar results as the LP solver without the black box effect. Maintaining and updating a solver can also be challenging for companies. However, solvers can find interesting and non-trivial solutions to use the manufacturing resources. We observed such an unexpected result in our solver analysis.

Our simulation analysis proves that DDMRP is capable of operating in capacity-constrained environments. However, smoothing out the capacity throughout the week can be challenging.

Conclusions

In this project, we confirmed that companies using DDMRP achieve inventory reduction and increase their service level simultaneously. This can improve financial performance and provides a competitive advantage. This research proves that DDMRP can perform well in planning at finite capacity under uncertainty. DDMRP offers an elegant planning approach that is both easy to understand and very efficient. The demand driven approach can reduce the working capital and offer a competitive advantage, which gives DDMRP the potential to be a game-changer in supply chain planning.

Table 2: Overview of the simulation results

	APS Heuristics			APS Solver			DDMRP		
	Average Inventory Turns	Average Inventory on hand	Average Service Level	Average Inventory Turns	Average Inventory on hand	Average Service Level	Average Inventory Turns	Average Inventory on hand	Average Service Level
Scenario 1	35	69000	97.2%	58	52747	98.3%	95	32001	95.5%
Scenario 2	50	50613	85.7%	70	44646	96.7%	94	28283	88.6%
Scenario 3	46	51548	91.9%	63	43710	96.7%	94	29897	92.5%
Scenario 4	51	47516	80.7%	73	37470	94.6%	86	26042	84.0%