Using MRP and JIT Techniques for Smart Procurement and Operations of a Restaurant

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Organisations in the hospitality sector face problems in meeting customers' demands of food items within an expected time and cost. However, some materials planning and procurement techniques may help process food items within acceptable lead times. The organisation needs to know what and how much it has on hand and what and how much to purchase from external sources. This paper applied the MRP and JIT concepts in a medium-sized restaurant named that creates various types of food items using raw materials from local and overseas sources. The paper has used actual data over ten weeks of sales of the most popular food items to forecast future demand using a moving average forecasting model. By using the forecast of end products and other information (viz. product structure, bill of materials, inventory on hand, lead-time), an MRP spreadsheet for various raw materials was generated, which would be supplied using the JIT scheduling to meet current and future customer demands within the expected time and at the lowest cost.

Keywords: MRP & JIT, service sector, hospitality, restaurant, lead time, product structure

INTRODUCTION

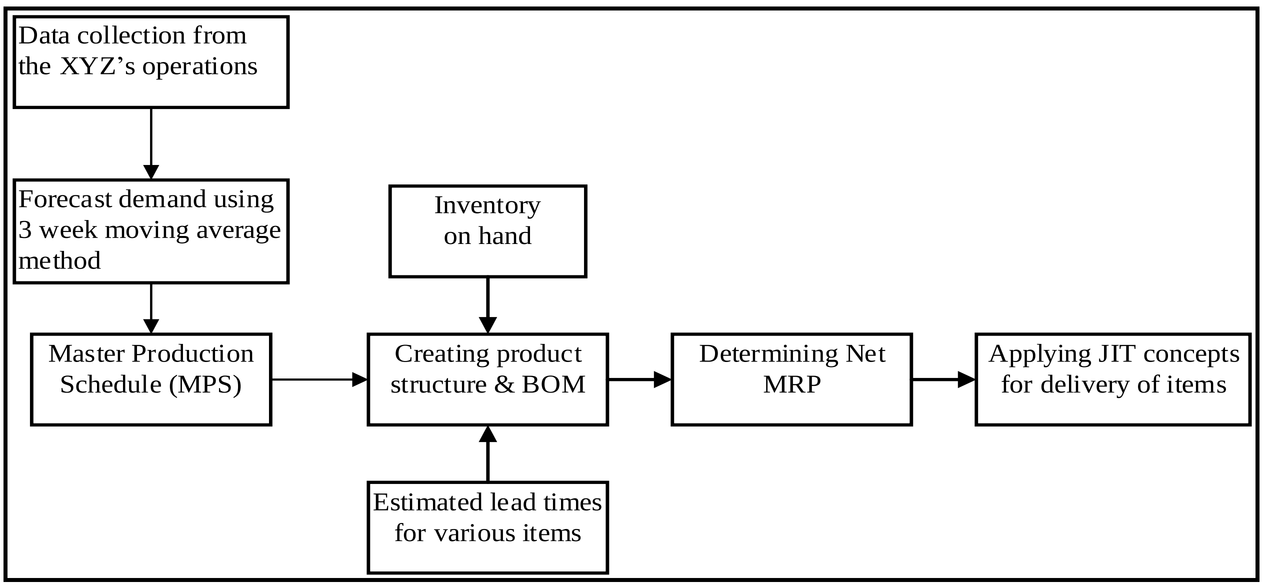
The popularity of JIT (just-in-time) production has increased globally, but before JIT production, MRP (materials requirement planning) was a widely used technique in major firms. While MRP systems have grown in popularity in the USA since the early 1960s, JIT systems have developed in Japan and are getting considerable attention throughout the world. However, according to García-Alcaraz et. (2019), a successful JIT implementation is based on human resources integration (managers, operators and suppliers) and other lean manufacturing techniques applied in the production process. JIT is a subset of lean manufacturing systems that offers benefits to production systems when it is well implemented. JIT is a tool that can easily be applied in hospitality and food services, where customer satisfaction is strongly related to timely delivery of food items.

According to *Lee* (1993), JIT and MRP are independently-developed approaches for managing production and inventory, and the two systems are generally seen as mutually exclusive, but the truth is that they need to be used together for the most effective outcomes. Although the two systems are concerned with different functional areas of production, the objectives are similar: *to get the right part to the right place at the right time.*

The researchers believe that the future success of a manufacturing firm depends on the hybrid concept of both MRP and JIT because the philosophy of MRP is the same as JIT, but one needs to combine the drive and execution of JIT with MRP to make it work. Ptak (1991) supports this argument by saying that MRP has given us the planning tools to make JIT possible (Ptak, 1991….*cited* in Lee, 1993). Some other techniques used before 1960 for inventory control were stock replenishment, reorder points, the EOQ model, selective control techniques (viz. ABC analysis), and aggregate inventory management (Clayton, 1997). MRP started getting developed in 1957, and Joseph Orlicky wrote the first textbook on the subject, 'Materials Requirement Planning: The New Way of Life in Production and Inventory Management'.

MRP deals with *dependent* demand items while forecasting techniques determine the independent demand items. MRP calculates gross and net requirements based on the information available about product structure and the inventory on hand. Thus, for MRP to work effectively, the following information needs to be in place: the master production schedule (MPS), a product structure (to indicate the relationship between end product, subassemblies, and components), bill of materials (BOM), inventory records or inventory on-hand, and the lead-times for individual items (Figure 1). For example, a product consists of a few subassemblies, and a subassembly comprises some components that, in turn, include raw materials.

FIGURE 1
A HYBRID MODEL OF MRP AND JIT FOR THE XYZ OPERATIONS



MRP helps in forecasting by computing the demand-dependent components from the production schedules of their parents. MRP also provides managers with more information than was available in traditional methods. This helps managers in capacity planning, scheduling, and financial budgeting. MRP updates dependent demand and replenishment schedules of components when the schedules for parent items change.

LITERATURE REVIEW

MRP system is based on the dependent demand concept, which means the demand for one item depends on the demand for another (*Seyed-Mahmoud*, 2003). For example, the demand for tyres per week depends on the number of cars produced per week by an automobile company. Every car needs five tyres (4 on the wheels and one reserved in the boot). If the demand for cars falls in the market, then the demand for tyres will also fall. Thus, the demands for all the subassemblies, components and raw materials can be determined if their dependency is established through a product structure (see Figure 2).

MRP and JIT as Useful Techniques

Various researchers have highlighted different aspects of MRP as a planning technique. Petroni (2002), for example, states that the MRP system is a technique to help manufacturers determine precisely when and how much material to purchase and process based on a time-phased analysis of sales orders, production orders, current inventory and forecasts. He adds that MRP will also schedule purchase orders and/or production orders for JIT receipt. Similarly, *Sagbansua et al*. (2010) consider MRP as a computer-based system to organise the timing and order of the dependent demand products. The demand for the end product is used to calculate the demand for the components in lower levels, and the process is divided into planning periods. Finally, the production and assembly functions are organised to ensure the timely delivery of the final product. *Seyed-Mahmoud (2003*) adds that MRP helps in forecasting components with '*lumpy demands*' that occur sporadically and relatively in large quantities (e.g., a bag of flour in the operation of a restaurant or a bag of cement in building construction).

JIT system is an idealised concept of inventory management in which a supply is delivered just in time, whatever material is required, wherever it is required, whenever a maximum supply is needed, and without keeping any stock on hand (Vrat…cited in Munyaka & Yadavalli, 2022). In terms of material resource planning, the JIT concept allows companies to manage their warehouses with greater efficiency, avoiding inventories, shortages, or replenishment orders.

MRP/JIT Implementation

Researchers have also highlighted the issues related to the implementation of MRP or JIT in various contexts. Puspita et al. (2019) investigated how an MRP system could be implemented in an Indonesian restaurant based on the ARIMA-based demand forecasting method of some of the popular food products. *García-Alcaraz et.* (2019) used a structural equation model with variables associated with JIT implementation including management commitment, human resources integration, suppliers, production tools and techniques. Their findings indicate that managerial commitment is the most important variable in the JIT implementation process. They further indicated that JIT should not be considered in isolation but rather be integrated with all other techniques in production systems that support materials flow.

MRP and JIT Complement Each Other

According to *Lee* (1993), MRP is a priority planning technique, not an execution tool. Therefore, significant waste could be avoided through the use of JIT as an execution tool, where only those materials needed on the operation floor are pulled as and when they are required. Lee also proposed a *hybrid model* that incorporates the MRP and the JIT systems in a single framework and remarked that the rationale is not whether MRP is better or JIT but how they complement each other in a hybrid system.

Abuhilal et al. (2006) report that using either JIT-pull or MRP-push inventory control systems depends on variables like inventory cost, demand pattern, average demand level, company policy, risk attitude, and relationship with suppliers. They also indicated that the value of information sharing is maximised during cyclical and variable demand patterns while its effect remains statistically significant at a stable demand pattern.

With the integration of MRP and JIT, the manufacturing environment must be different from that of a conventional MRP-based system. Therefore, some prerequisites must be satisfied to fully operationalize a hybrid system in an uncertain environment (*Lee*, 1993). JIT seems to be attractive to users as it appears paperless and computer-less, while MRP-based systems depend heavily on computers. However, researchers {*Rao et al*. (1988); *Bose et al*. (1988); *Edwards et al.* (1984) - *cited in* Lee (1993)} feel that both JIT and MRP alone as well as in the hybrid framework can benefit from the use of computers.

Many employees including production planners, production managers, customer service representatives, purchasing managers, and inventory managers use the information provided by MRP in manufacturing companies. *Sagbansua et al*. (2010) emphasize that the benefits of an MRP system depend on the use of computers to update data on the component needs. Accuracy is vital in the successful implementation of the MRP system because mistakes in inventory records or bill of materials would result in missing parts, over-ordering of some products and under-ordering of others, and deviations from the production schedule, all of which could result in a lower level of customer service, inefficient use of resources, and delayed deliveries to the customers (*Sagbansua et al*. 2010).

MRP in the Hospitality Industry

Just like the manufacturing firms, the hospitality organisation also faces similar problems of meeting the demand for food items ordered by customers within an expected time and at a reasonable cost. Therefore, some planning is required to process the orders on time. A restaurant, for example, needs to plan and control the types and quantities of materials it needs to purchase, and it needs to plan which products to produce (cook), in what quantities, and to ensure it would be able to meet the current and future customer demands at the lowest possible cost. Making a poor decision in any of these areas will make the company lose customers and money. Let us take an MRP example in an ethnic restaurant called XYZ in Waipukurau, New Zealand.

Purpose and Research Approach

The main purpose of the paper is to develop an MRP framework for XYZ restaurant and implement it through the JIT technique. To implement the framework successfully, the objectives are to (a) record ten weeks of sales information on the most consumed products of the XYZ restaurant; (b) forecast future demand using the 3-week moving average method and establish a master production schedule (MPS); (c) create a product structure and bill of materials, and develop an MRP spreadsheet for the various items required for the operations of XYZ restaurant. The research was conducted at XYZ with its permission, and the operational data were obtained through observation and by talking to the manager/staff of XYZ. The production process and the steps involved were also helpful in understanding the context holistically. The end products from the menu, the ingredients involved, and the sales data of end products (food items) were used for generating the MRP.

THE CASE STUDY

The company for this study is XYZ restaurant, located in the small town of Waipukurau about 60 km from Napier. Only a few restaurants in this town serve ethnic foods with healthy options. Due to a significant trend in customers' inclination towards healthy eating and healthier lifestyles, it seems there is a niche for ethnic foods in the restaurant industry. The town has many fast-food restaurants such as Fish n' Chips, KFC, Pizza Hut, Chinese takeaways, and an Indian restaurant XYZ. The town centre is small with just one main street and many houses around this. The retail stores in the town attract a significant number of consumers with disposable cash to buy goods, and due to the clustering effect, some of them also spend their cash on ethnic meals. The surrounding area is mainly residential, so the residents are regular visitors or customers. XYZ often experiences uncertainty in demand and inventory requirement problems, including too much inventory or even shortages sometimes. Therefore, inventory management is critically needed to analyze the optimum level of inventory in stores. XYZ does not have a scientific management system for making purchases or ordering raw materials so it experiences a state of excess or even shortage of raw materials during operations. Therefore, XYZ needs to plan and procure raw materials scientifically to periodically cater to its customers' needs.

RESEARCH QUESTIONS

In the context described above the following *questions need to be answered: (a)* where will the restaurant get its stock from to meet the consumers' demand? (b) How much food will be required to meet the demand, and what will be the list of items required to cook the various food items on the menu? (c) Will the raw materials (vegetables, fruits) still be fresh after a long journey from the suppliers? The location of suppliers is just as crucial to the cost of stock, especially in the food business where freshness is the key to quality to attract customers. Some of these questions may be answered by MRP systems, as discussed in the subsequent section.

INDEPENDENT VS DEPENDENT DEMAND INVENTORY MODELS

According to Munyaka & Yadavalli (2022), in an independent demand inventory model, the demand for one item is independent of the demand for another item, but in the dependent demand inventory model, the demand for one item is directly dependent on the demand for another item. For example, in an automotive assembly plant, the demand for the console, tyres, engine, etc. depends on the number of cars in demand. To manage the manufacturing process of finished products in the case of dependent demand for raw materials and other components, the MRP technique is mainly used. This tool is applied along with the JIT and Kanban system.

The MRP system is dependent on the accurate demand forecast for finished goods, and the system requires three main inputs to function: (a) the master production schedule (MPS); (b) the bill of material (BOM) or the product structure records; and (c) inventory status records. The MPS indicates the number of finished goods desired and the expected time of receipt of their delivery, including the necessary safety stock. The BOM consists of data on each material required to produce the next higher-level product (called parent). The BOM includes the type of raw materials (parts and components), the item number, and the description and quantity per assembly and subassemblies needed to manufacture an item. Finally, the inventory status file maintains the information including stock on hand and scheduled receipts (Munyaka & Yadavalli, 2022).

Kortabarria et al. (2018) studied demand-driven MRP (DDMRP) to deal with efficiency in material management in a company that previously was using MRP. In 2011, DDMRP was developed to improve existing MPC systems' shortcomings by protecting the supply chain from variability and dealing efficiently with material management issues. The outcomes of the case study show that using DDMRP resulted in higher visibility in the supply chain and a reduction in the inventory level while material consumption increased. However, this was achieved without any reduction in the high service level of the company.

MRP or ERP (Enterprise Resources Planning) is an indispensable tool for large manufacturers. Until recently, however, many small businesses could afford neither the initial cost nor the resources required to maintain a full-fledged manufacturing planning software system. However, it does not take too many products or too many parts before the manual or spreadsheet approach fails, and a small company becomes the victim of its success – with inventories out of control and production planning and execution failing. The solution for small manufacturing companies is MRP software which answers four questions: *what to make*, *what to buy; when to make it*, and *when to buy it*. One such software called "E-Z-MRP" has evolved over several years to solve some of the problems related to production and procurement planning and execution for small manufacturers. No on-site or off-site training is required, and no consultants are needed to implement it, as the help is readily available through the manual (*What is MRP software*?).

MRP APPLICATION: AN EXAMPLE OF A RESTAURANT

Let us take the example of XYZ restaurant which needs to purchase items from different suppliers for its operations. XYZ gets some of these items delivered directly by local suppliers. However, sometimes, XYZ purchases some of its items in bulk to get price discounts, and then the items are stored in the warehouse from where they are brought into the stores as and when required during the operations. If XYZ purchases insufficient quantities of an item(s) used for cooking food products, it will not be able to meet the customers' demand. On the other hand, if it purchases excessive quantities of an item(s), then money will get stuck and wasted due to the opportunity cost. Moreover, some items will need to be maintained as a safety stock. A decision to release a purchase order for an item with an unrealistic lead time can result in a stock-out situation and loss of customers.

Data for MRP

XYZ restaurant serves a set of *curries* (*end products*) based mainly on three types of *sauces* (*subassemblies)*: Korma, Butter chicken or tomato, and Rogan Josh as shown in Figure 2. One of these three sauces has been further expanded into various levels (levels 2, 3, and 4) with their required ingredients indicated.

The actual sales data of these three types of sauces or curries for XYZ have been recorded, and the demands for the next eight weeks have been forecasted (see Table 1) using the 3 week-moving average methods as discussed in the section below.

The theory behind forecasting demand for curries and net requirement planning for items required

(a) The **demand forecasting** formula (Russell & Taylor, 2009) is based on the simple moving average using n periods as discussed below.

$$MA_n = \{\sum_{i=1}^{n} Di \,/n \tag{1}$$

where n = number of periods in the moving average

D_i = demand in period i

So, the 3-week moving average demand (Table 1) has been computed using equation (1) as follows:

D_4 = Demand for week 4 = ($D_3 + D_2 + D_1$)/3

D_5 = Demand for week 5 = ($D_4 + D_3 + D_2$)/3

Accuracy of Forecasting

According to Choia et al. (2022), most forecasting studies have focused on model building and improving forecasting accuracy, and only a few have focused on developing predictor variables. Research shows that machine learning techniques can provide more accurate predictions by processing more data. The cost of error can be explored with the processing and analysis of large amounts of internal and external data through machine learning techniques so that restaurant operators can take steps to reduce the extra cost of forecast errors. The accuracy of forecasts depends on various factors, including key economic indicators, holidays, temperature, expert knowledge, etc.

However, small restaurants still prefer to use their experience and common sense for forecasting due to the limited resources and inadequate acumen in data analytics. The mean absolute deviation or MAD is one of the most popular and simplest methods to measure forecast error (Russell & Taylor). MAD is an average of the difference between the forecast and actual demand and is computed as

$$\text{MAD} = \sum \text{absolute value of (actual demand – forecast demand)/n} = \sum|A_t - F_t|/n \tag{2}$$

where t = the period for which demand is calculated

A_t = actual demand in period t

F_t = forecast demand for period t

n = the total number of periods

|| = absolute value free from the + or - signs

The error of this forecasting method could be expressed by computing the ‘Mean absolute deviation’ using equation (2) or MAD = 10.42. Table 1 shows the actual and forecast values of demands of these curries in different weeks of operation. The forecast demand of curries from weeks 4 to 11 is the master production schedule (MPS) for XYZ, for which it has to create the list of dependent demand items. To cook various curries in XYZ, the three different types of sauces cooked are Korma sauce, Tomato sauce, and Rogan Josh sauce.

TABLE 1
DEMAND FORECAST FOR BUTTER CHICKEN/TOMATO CURRIES (BCT) BASED ON DIFF. TYPES OF SAUCES

Week	Actual sales of BCT curry (A)	Forecast demand for BCT curry using a 3-week moving average (F)	Absolute deviation AD = |A-F|
Week 1	70		
Week 2	85		
Week 3	65		
Week 4	58	73	15
Week 5	72	69	03
Week 6	83	65	18
Week 7	52	71	19
Week 8	68	69	01
Week 9	77	68	09
Week 10	74	66	08
Week 11		73	

(b) The **net requirement planning** for XYZ for all the ingredients required for different types of sauces. The company follows the policy of lot-for-lot (LFL) ordering and maintains no safety stock. The net requirement of item k = (Gross requirement of item k + Allocations) – (On hand quantity of item k + Scheduled receipts of item k), where k = 1, 2, 3, …

$$NR_k = (GR_k + A_k) - (OH_k + SR_k) \tag{3}$$

In other words, the **Net requirement** of item k = (Total requirement of item k – Available quantity of item k)

$$NR_k = (TR_k - AV_k) \tag{4}$$

Inventory on hand, gross required quantity, and the lead times for placement of orders for different items are recorded in Table 2, while Table 3 indicates the bill of materials (BOM) for Butter chicken or Tomato sauce based on the product structure in Figure 1.

TABLE 2
INVENTORY ON HAND AND LEAD TIMES

Ingredients	On hand (gm)	Gross Required Quantity (gm)	Lead time (week)
Tomatoes	1400	6400	2
Onion	3000	10000	2
Coconut milk	100	1250	2
Cashew nuts	400	500	1
Ginger	10	40	1
Garlic	15	60	1
Cinnamon	10	40	1
Cloves	10	60	1
Pepper	50	60	1
Cardamom pods	10	30	1

Ingredients	On hand (gm)	Gross Required Quantity (gm)	Lead time (week)
Fenugreek leaves	0	100	1
Olive oil	500	1700	2
Yoghurt	0	100	2
Butter	0	1000	2
Cream	1000	4000	1

TABLE 3
BOM FOR THE BUTTER CHICKEN/TOMATO SAUCE FOR SERVINGS OF 5 KG

Paste type	Lead time (week)	Quantity (gm)	Ingredients
Paste 1	2	500	Butter
		800	Tomato puree
Paste 2	1	10	Cumin seeds
		10	Cloves
		10	Cinnamon sticks
		15	Coriander leaves
		5	Pepper
		50	Fenugreek leaves
Paste 3	1	2000	Fresh cream
Paste 4	1	1	Nut paste
		400	Cashews
		100	Almonds

These data will help XYZ address two important inventory control questions: (i) *how much to order?* and (ii) *when to order*? This restaurant follows a '*lot-for-lot'* rule, which means ordering what is required with no safety stock and no anticipation of further orders (*Heizer & Render*, 2011).

Based on the product structure (Figure 2), and information related to inventory on hand and lead times in Tables 2 and 3, the net requirement planning for different materials is presented in Table 4 for the XYZ operations.

FIGURE 2
PRODUCT STRUCTURE FOR BUTTER CHICKEN/TOMATO SAUCE (REF TABLE 3)

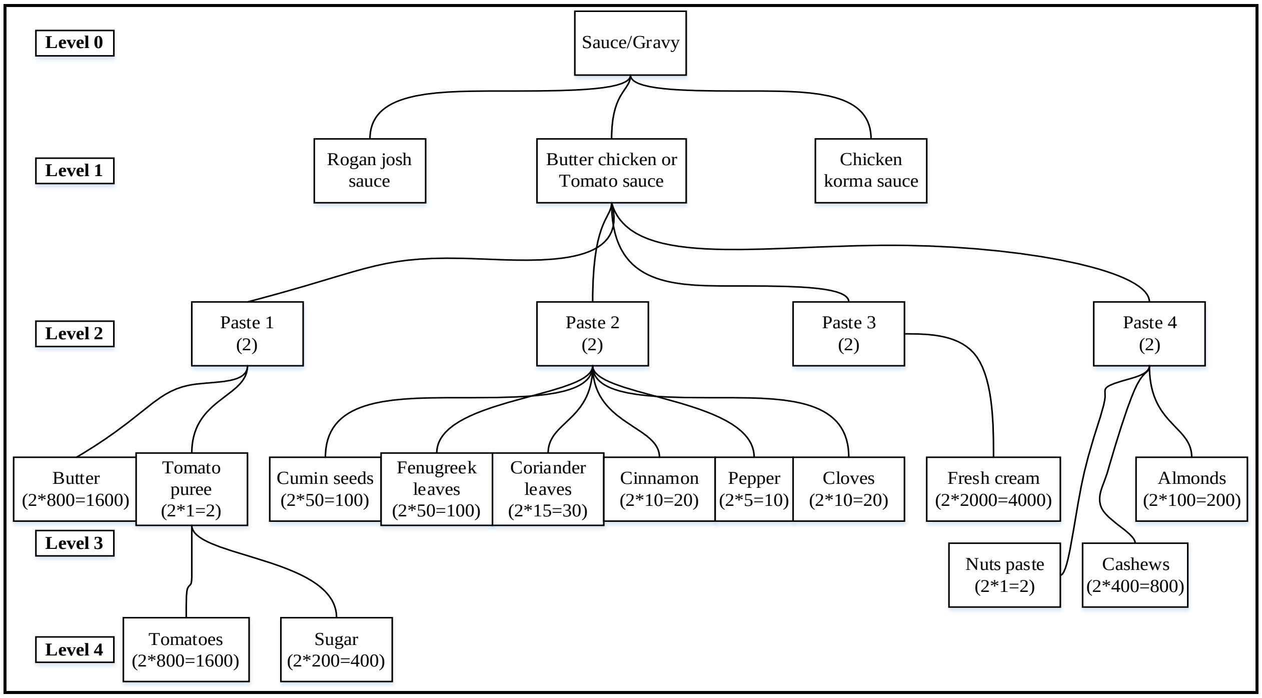


TABLE 4
NET REQUIREMENT PLANNING FOR COMBINED INGREDIENTS

Ingredient	Week	0	1		2	3	4	5	6	7	8
Cumin seeds	GR		0	0	0	0	0	0	0	0	320
LFL, SS = 0 LT=1	OH	80	80	80	80	80	80	80	80	80	80
	NR										240
	OR									**240**	
Tomatoes	GR		0	0	0	0	0	0	0	0	6400
LFL, SS = 0 LT=2	OH	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
	NR										5000
	OR								**5000**		
Onion	GR		0	0	0	0	0	0	0	0	10000
LFL, SS = 0 LT=2	OH	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
	NR										7000
	OR								**7000**		
Coconut milk	GR		0	0	0	0	0	0	0	0	1250
LFL, SS = 0 LT=2	OH	100	100	100	100	100	100	100	100	100	100
	NR										1150
	OR								**1150**		
Cashew nuts	GR		0	0	0	0	0	0	0	0	500
LFL, SS = 0 LT=1	OH	400	400	400	400	400	400	400	400	400	400
	NR										100
	OR									**100**	

Ginger	GR		0	0	0	0	0	0	0	0	40
LFL, SS = 0 LT=1	OH	10	10	10	10	10	10	10	10	10	10
	NR										30
	OR									**30**	
Garlic	GR		0	0	0	0	0	0	0	0	60
LFL, SS = 0 LT=1	OH	15	15	15	15	15	15	15	15	15	15
	NR										45
	OR									**45**	
Cinnamon	GR		0	0	0	0	0	0	0	0	40
LFL, SS = 0 LT=1	OH	10	10	10	10	10	10	10	10	10	10
	NR										30
	OR									**30**	
Cloves	GR		0	0	0	0	0	0	0	0	60
LFL, SS = 0 LT=1	OH	10	10	10	10	10	10	10	10	10	10
	NR										50
	OR									**50**	
Pepper	GR		0	0	0	0	0	0	0	0	60
LFL, SS = 0 LT=1	OH	50	50	50	50	50	50	50	50	50	50
	NR										10
	OR									**10**	
Cardamom pod	GR		0	0	0	0	0	0	0	0	30
LFL, SS = 0 LT=1	OH	10	10	10	10	10	10	10	10	10	10
	NR										20
	OR									**20**	
Fenugreek	GR		0	0	0	0	0	0	0	0	100
leaves LT=1	OH	0	0	0	0	0	0	0	0	0	0
	NR										100
	OR									**100**	
Olive oil	GR		0	0	0	0	0	0	0	0	1700
LFL, SS = 0, LT=2	OH	500	500	500	500	500	500	500	500	500	500
	NR										1200
	OR								**1200**		
Yoghurt	GR		0	0	0	0	0	0	0	0	100
LFL, SS = 0, LT=2	OH	0	0	0	0	0	0	0	0	0	0
	NR										100
	OR								**100**		
Butter	GR		0	0	0	0	0	0	0	0	1000
LFL, SS = 0, LT=2	OH	0	0	0	0	0	0	0	0	0	0
	NR										1000
	OR								**1000**		
Cream	GR		0	0	0	0	0	0	0	0	4000
LFL, SS = 0, LT=1	OH	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
	NR										3000
	OR									**3000**	

Index: GR = Gross requirement; OH = On hand inventory; NR = Net requirements; LT = Lead time; OR = Order release; LFL = Lot-for-Lot; SS = Safety Stock

CONCLUSIONS

The MRP model suggested in the paper and the supply of various items on a JIT basis would help XYZ Restaurant significantly in its materials procurement process and delivery. This will also help in reducing excess inventory in the restaurant and will prevent potential financial losses because many items have their expiry dates and may be prone to perishability.

This method of materials planning is also expected to save the company a few thousand dollars in the form of reduced cost of renting a warehouse for storing the extra items, reduced cost of transporting them from the warehouse to the kitchen, and reduction in cost due to multiple materials handling if the items are not supplied on a JIT basis.

All the different ingredients needed by XYZ to produce the *end products (the food items)* have been accurately identified, so the chances of stock-out of these items during operations are almost zero or minimal.

The 3-month moving average method has been used to forecast the demand for end products (finished food items) to make forecasting more simplified and realistic in practice. This method can be used with very little training in Excel spreadsheets.

RECOMMENDATIONS

In addition to the above-proposed hybrid model, XYZ Restaurant may also follow the ‘selective control techniques’ including ABC, VED, and FSN analysis for its inventory control. For example, fast-moving items can be purchased in bulk by getting price discounts from the growers or suppliers and storing them in the warehouse, which can be brought from time to time in the stores as per the JIT concept when needed. The *fast*-moving items can be consumed in a few days, so there will be no need to store them for a long time, which will reduce the inventory carrying cost.

Slow- and *non-moving* items can be purchased in smaller lots and can be brought straight to the operations (kitchen area) because they move very slowly. Therefore, keeping them in a warehouse will be a waste of space and costly for the company.

Implications for Management

The XYZ restaurant will need to organise a workshop to give basic training to its staff on how MRP helps the restaurant operations, how to record sales data, inventory on hand, lead time, and the list of suppliers with their addresses. In this context, Petroni (2002) identified some factors that could help in the successful implementation of MRP systems. He found that in-house expertise and experienced personnel could be predictors of technical success. Companies should train management and staff and ensure they receive help from experienced people. The study also indicated that the accuracy of inventory records, demand forecasts and capacity planning data before MRP implementation are positively correlated to success.

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REFERENCES

Abuhilal, L., Rabadi, G., & Sousa-Poza, A. (2006, June). Supply chain inventory control: A comparison among JIT, MRP, and MRP with information sharing using simulation. *Engineering Management Journal*, *18*(2), 51–57.

Bose, G., & Rao, A. (1988, September). Implementing JIT with MRP II creates a hybrid manufacturing environment. *Industrial Engineering*, pp. 49–53.

Choi, J., Zhang, Y., & Nadzri, N.I.B.M. (2022, April). A review of forecasting studies for the restaurant industry: Focusing on results, contributions and limitations. *Global Business & Finance Review*, *27*(2), 61–77. pISSN 1088-6931/eISSN 2384-1648. https://doi.org/10.17549/gbfr.2022.27.2.61

Clayton, T. (1997, March). In the beginning, there was MRP... *New Zealand Manufacturer*, pp. 12–13.

Cook, M. (1984). The marriage of MRP and JIT - Is it possible? In *Readings in Zero Inventory* (pp. 138–40). APICS 27th Annual International Conference, Las Vegas, NV.

Edwards, J., & Anderson, J. (1984). Integrating JIT with MRP — An update. In *Readings in Zero Inventory* (pp. 129–32). APICS 27th Annual International Conference, Las Vegas, NV.

García-Alcaraz, J.L., Realyvasquez-Vargas, A., García-Alcaraz, P., Pérez de la Parte, M., Fernández, J.B., & Macias, E.J. (2019). Effects of human factors and lean techniques on just-in-time benefits. *Sustainability*, *11*(7), 1864–1884. doi: 10.3390/su11071864

Heizer, J., & Render, B. (2011). *Operations management* (10th Ed.). Upper Saddle River, New Jersey, USA: Pearson Education, Inc.

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*, *11*(4), 632–650. https://doi.org/10.3926/jiem.2654

Lee, C.Y. (1993). The recent development of the integrated manufacturing system: A hybrid of MRP and JIT. *International Journal of Operations & Production Management*, *13*(4), 3.

Munyaka, J.B., & Yadavalli, V.S.S. (2022, July). Inventory management concepts and implementations: A systematic review. *South African Journal of Industrial Engineering*, *33*(2), 15–36.

Petroni, A. (2002). Critical factors of MRP implementation in small and medium-sized firms. *International Journal of Operations & Production Management*, *22*(3), 329–348.

Ptak, C. (1991). MRP, MRP II, OPT, JIT, and CIM — Succession, evolution, or a necessary combination? *Production and Inventory Management Journal*, 2nd Quarter, 7–11.

Puspita, F.M., Primadani, N.A., & Susanti, E. (2019). Application of material requirement planning with ARIMA forecasting and fixed order quantity method in optimizing the inventory policy of raw materials of Sederhana restaurant in Palembang. In *Advances in Economics, Business and Management Research: Proceedings of the 5th Sriwijaya Economics, Accounting, and Business Conference (SEABC 2019)* (Vol. 142, pp. 71–76).

Rao, A., & Scheraga, D. (1988). Moving from manufacturing resource planning to just-in-time manufacturing. *Production and Inventory Management*, 1st Quarter, 44–49.

Russell, R.S., & Taylor III, B.W., (2009). *Operations management: Creating value along the supply chain* (6th Ed.). John Wiley & Sons, Inc.

Sagbanşu, L., & Alabay, M.N. (2010, October). An MRP model for supply chains. *International Business Research*, *3*(4), 124–131.

Seyed-Mahmoud, A. (2003). MRP contributes to a company's profitability. *Assembly Automation*, *23*(3), 257–265.

What is MRP software? (n.d.). *E-Z-MRP*. Retrieved from http://www.e-z-mrp.com/