International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 6 Issue 10, October - 2022, Pages: 231-243

A Review of Material Requirements, Planning, and Program Evaluation Techniques: through a Just-In-Time Manufacturing Environment

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***Abstract**: This work ascertained the relationship between material requirements planning and program evaluation review technique in the manufacturing environment in Port Harcourt. The objective of the study was to determine the relationship between the dimensions of material requirements planning, such as master production schedule, bill of materials, and inventory status file, and the measures of program evaluation review technique, such as optimistic time, pessimistic time and most probable time in manufacturing environment in Port Harcourt. The targeted population of the study consisted of eighty-eight (88) managers in 22 manufacturing firms in Port Harcourt, Nigeria. The entire population of eighty-eight (88) managers was used for the study without sampling since the population was considered to be large enough to be dealt with. Thus, the study was census research which entails using the entire population. A structured questionnaire was used to obtain primary data after due validation and ascertain the instrument's reliability at 0.74 using Crombach alpha. The researcher was able to retrieve seventy-six (76) copies of the questionnaire distributed. SPSS Version 20.0 was used to run the analysis. Spearman Rank Order was used for the Bivariate analysis. The findings of the study revealed that the master production schedule has a highly positive relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt; the bill of materials has a highly positive relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt, and that; inventory status file has a high positive relationship with program evaluation review technique in manufacturing environment in Port Harcourt. The study concluded that material requirements planning, in terms of the master production schedule, bill of materials, and inventory status file, is a piece of powerful machinery that manufacturing firms can utilize to maximize their profit when matched with program evaluation review techniques in a just-in-time manufacturing environment. Amongst other things, the study recommended that the management of manufacturing firms should train their special personnel to judiciously utilize their material requirements planning, program evaluation review techniques, and other computer-based tools to enhance their customer satisfaction and profitability, among other things.*

***Keyword**: Material Requirements Planning, Program Evaluation Review Techniques, Profit Maximization, and Just-In-Time Manufacturing Environment.*

Background of Study

The world has gone highly digital to the point that even the progress level of projects in manufacturing firms can be viewed using technology. Using technology to visualize the steps toward completing a project in a manufacturing firm is a strong progress sign-in technology in the field of manufacturing/production. In manufacturing/production, this process is referred to as the program evaluation review technique. Sampson (2019) defines the programme evaluation review approach as a project management planning tool used to determine how long it will take to complete a project. Its charts display all known tasks as a network diagram, reflecting their relationship with each other, such as dependencies. Tasks within a project are planned using programme evaluation review technique (PERT) charts, making scheduling and organizing team members simpler. Donald (2016) sees the program evaluation review technique as a technique adopted by organizations to analyze and represent the activity in a project and to illustrate the flow of events in a project. According to Donald (2016), the main goal of the program evaluation review technique is to reduce the cost and time needed to complete a project. In the concept of this work, the program evaluation review technique can be measured in terms of optimistic time, pessimistic time, and most probable time.

The optimistic time estimate is the shortest amount of time that an activity might be finished, providing that everything goes according to plan and that there is only minimal difficulty. In project management activities, pessimistic time is used to express the longest anticipated time frame in which a work is likely to be accomplished. This is the maximum amount of time needed to finish an activity. In this instance, it is a given that several issues with the activity occur. Moreover, the most possible time is the most probable estimate of the time in which an activity is completed under normal conditions. However, the program evaluation review technique in a manufacturing firm would require a technology that would plan and control the material flow in manufacturing companies, so it can join forces with it to maximize profit for the firm. Such technology is referred to as material requirements planning.

Over time, various techniques for organising and managing the material flow in manufacturing businesses have been created, and a few are still in use today. Although the underlying ideas of these planning techniques vary, they all offer the same kind of help. However, although they are all intended to provide the same support, their applicability varies, with the context determining how successfully and efficiently they may be utilised. This has received attention from several researchers (Jawad, 2020). For instance, re-order point approaches are component-oriented and mostly intended for goods with independent demand.

They usually are more appropriate than the more standardized product components, the longer life cycles they have, and the more stable they demand (Haddock & Hubicki, 2016). Material requirements planning (MRP) is a generally applicable method; Segerstedt (2017) defines it as a collection of methods for calculating the amount of material needed based on information from the bill of materials, inventory, and master production schedule. Not because of its prowess in designing goods with reliant demand, but because it functions relatively effectively in all industrial situations. However, it excels when there are several complicated standardised goods or product alternatives, lengthy lead periods for production, and things with erratic demand (Jenkins, 2020). Material requirements planning makes recommendations to release replenishment orders for material. Companies use material requirements planning systems to estimate quantities of raw materials and schedule their deliveries (Vandaele & De Boeck, 2013). Additionally, material requirements planning manifests in the master production schedule, bill of materials, and inventory status file.

The master production schedule, according to Dan (2018), is a production planning technique that establishes how much of a product has to be produced throughout time. The master production schedule (MPS), a component of production planning, specifies which goods must be produced when and in what quantities. A master production schedule often does not include information on the personnel allocated to jobs and the materials used in production. Instead, it displays the models, quantities, and delivery dates of the products the firm intends to create. It considers the demand projection, the overall production schedule, the backlog, the availability of materials, and the capacity. A list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each are included in a bill of materials or product structure (also known as a BOM or related list). A bill of materials is a detailed, organised list of all the materials, parts, and components needed to make or repair a product, together with their names, prices, and required quantities. An inventory status file is necessary to have a real-time picture of the organization's inventory to know what you have in stock, what is on the way or has purchase orders issued, where the inventory is, and what its state is (Raphael, 2019). It provides information about available quantities, needs, planned deliveries, and reorders.

Statement of Problem

One worrisome issue that has birthed this research effort is that manufacturing firms in Port Harcourt and the entire Rivers State are yet to understand the impact of computer-based tools such as material requirements planning and program evaluation review techniques on profitability in a manufacturing environment. Many of them still focus on other variables that will boost their profitability and pay little or no attention to acquiring and using state-of-the-art computer-based systems that can boost their profitability. In addition, they do not comprehensively develop a master production schedule, bill of materials, and inventory status file in their production process. As a result, they run into a waste of materials, customer dissatisfaction, and loss. Supportively, Dan (2018) averred that manufacturing companies in Rivers State are still reluctant to provide computer-based tools for their manufacturing teams to work with, impacting them negatively. This raises an issue that manufacturing firms in Port Harcourt and the entire Rivers State need to consider and handle with alacrity.

Another issue that has provoked this research effort is the lack of sufficient literature that focuses on the relationship between materials requirement planning and program evaluation review in the manufacturing environment in Port Harcourt. This is bothersome and requires urgent attention. For instance, Jawad (2020) reviewed material requirement planning applications in the industry in Babylon. Kim (2014) carried out a study on material resource planning in the United States of America. Going further, Segerstedt (2017) studied master production scheduling and comparing material requirements planning and cover-time planning in the United Arab Emirates (UAE). It is evident at this point that research on the relationship between material requirements planning and program evaluation review technique in the manufacturing environment in Port Harcourt is yet to gain enough research effort. Consequent to these backdrops, the researcher deems it necessary to carry out this research.

International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
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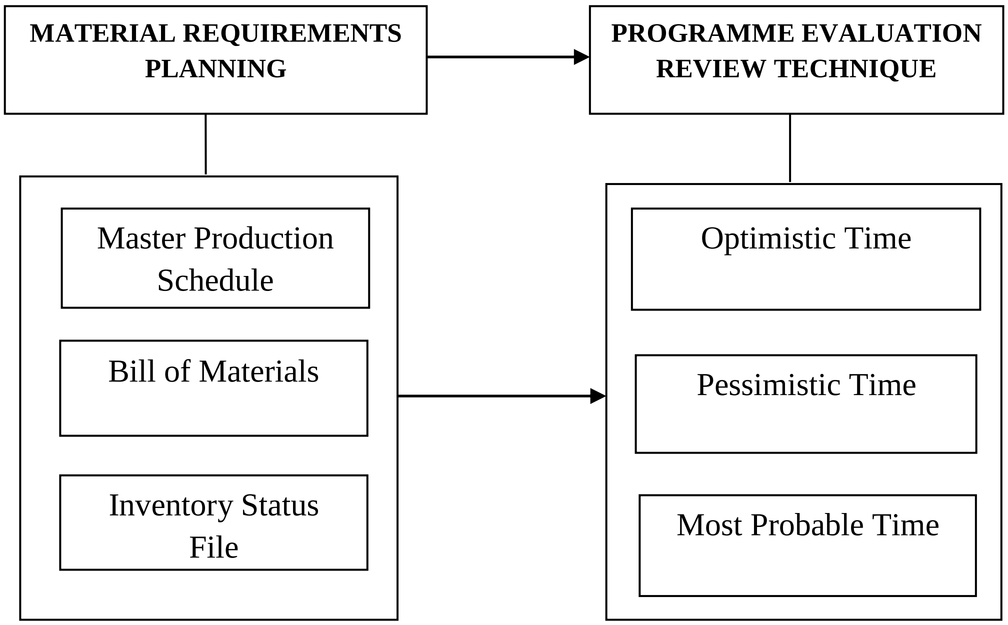
Fig 1: Conceptual Framework of Material Requirements Planning and Programme Evaluation Review Technique.



Source: Researcher's Conceptualization, 2022.

Aim and Objectives

This study sought to determine the connection between programme evaluation review and planning for material requirements in the Port Harcourt manufacturing environment.. The specific objectives of the study include the following:

1. To determine the relationship between the master production schedule and program evaluation review technique in the manufacturing environment in Port Harcourt.
2. To determine the relationship between the bill of materials and program evaluation review technique in the manufacturing environment in Port Harcourt.
3. To determine the relationship between inventory status files and program evaluation review technique in the manufacturing environment in Port Harcourt.

Research Questions

1. What is the relationship between the master production schedule and program evaluation review technique in the manufacturing environment in Port Harcourt?
2. What is the relationship between the bill of materials and the program evaluation review technique in the manufacturing environment in Port Harcourt?
3. What is the relationship between the inventory status file and program evaluation review technique in the manufacturing environment in Port Harcourt?

Theoretical Framework

Rogers' (1962) Diffusion of Innovation Theory is the theoretical framework on which this work is anchored. This theory postulates that individuals and social systems will adopt new technologies and innovative ideas at different points and that the point innovation is accepted into a system determines subsequent outcomes. The assumptions of the theory are as follows:

i) The rate and timing at which people within a particular social system adapt new concepts, methods, and technologies will always vary.

ii) Individuals and arms of institutions that adopt innovations early will naturally outperform late adopters and the laggards (Odu, 2017).

This theory implies that as manufacturing firms work towards maximizing their profitability by utilizing material requirements planning and program evaluation review techniques, there will be inconsistency on how and when these firms will accept to adopt these tools. Some (especially those who claim to be financially conscious and forget the impact of these tools on profitability) will think that setting up these computer-based tools could bankrupt them. The diffusion theory also implies that manufacturing firms who accept these tools early enough to adopt and utilize them will outperform those who will accept them later.

The justification of the Diffusion of Innovation Theory as the theoretical base of this study is based on the fact that the theory explains and predicts how early adoption of material requirements planning and program evaluation review techniques will have a more significant positive effect on profit maximization than late adoption.

Concept of Material Requirements Planning

Material requirements planning is a computer-based production planning and inventory control system (Kim, 2014). This system determines how much and when to produce component items. It is concerned with both production scheduling and inventory control. It is a material control system that attempts to keep adequate inventory levels to ensure that required materials are available when needed. Material requirements planning is applicable in multiple items with complex bills of materials.

According to Segerstedt (2017), material requirement planning is a collection of procedures for calculating the amount of materials needed based on information from the bill of materials, inventories, and the master production schedule. It offers suggestions about the publication of material replenishment orders. Since this system is time-phased, it recommends reschedule open orders when due dates and need dates are not in phase. Material requirements planning is a computer-based inventory management system designed to improve business productivity. Companies use material requirements planning systems to estimate quantities of raw materials and schedule their deliveries (Vandaele & De Boeck, 2013). According to Vandaele and De Boeck (2013), material requirements planning is designed to answer three questions: What is needed? How much is needed? When is it needed? A list of needs for the subassemblies, components, and raw materials required to make the finished product within the stated timetable is created by working backward from a production plan for finished items. The primary objectives of a material requirements planning system are:

1. To simultaneously ensure the availability of materials, components, and products for planned production and customer delivery,

2. To simultaneously maintain the lowest possible level of inventory,

3. To simultaneously plan manufacturing activities, delivery schedules, and purchasing activities.

Materials requirement planning is especially suited to manufacturing settings where the demand for many components and subassemblies depends on the demands of items that face external demands (Conner, 2015). Demand for end items is independent. In contrast, the demand for components used to manufacture end items depends on the demand for the end items. The distinctions between independent and dependent demands are essential in classifying inventory items and developing systems to manage items within each demand classification. Materials requirement planning systems were developed to cope better with dependent demand items. The three principal inputs of a materials requirement planning system are the master production schedule, the product structure records, and the inventory status records (Jawad, 2020). Without these essential inputs, the material requirements planning system cannot function.

MRP, or material requirements planning, is a widely used technique for organising and managing the flow of materials in manufacturing businesses (Jawad, 2020). This is not because of its prowess in demand-dependent item planning; rather, it functions relatively effectively in all production situations. However, it excels when there are several complicated standardised goods or product alternatives, lengthy lead periods for production, and things with erratic demand (Hair et al., 2010; Gianque et al., 2014; Haddock & Hubicki, 2016; Ford et al., 2018). A common supply planning approach called material requirements planning (MRP) aids companies, particularly producers of goods, in understanding their inventory needs and balancing supply and demand (Jenkins, 2020). MRP systems, which are divisions of supply chain management systems, are used by businesses to effectively manage inventory, plan production, and deliver the appropriate product on time and at the best price.

Systems for planning material requirements enable manufacturing companies efficiently plan and schedule production, ensuring that supplies go through the work order swiftly and assisting companies in meeting client orders on time. Integrating an MRP system throughout a business removes manual tasks like retrieving previous sales data and inventory levels. A layer of complexity is removed and time is freed by spending less time creating Gantt charts and production flows to determine when and where you require product availability. Timing errors are simple when builds are complicated and call for several sub-assemblies in the work sequence. Through an MRP, a user may better understand the parts that go into each subassembly and how long it takes to complete each step, reducing production cycle delays and boosting output. MRP helps your company improve inventory levels and production schedules by giving firms visibility into the inventory requirements needed to fulfil demand. Without this knowledge, businesses are less visible and responsive, which might result in the following:

i. It places excessive stock orders, raising carrying costs and squandering money that may be put to better use elsewhere.
ii. lack of raw supplies makes it unable to satisfy demand and causes lost revenues, cancelled contracts, and out-of-stocks.
iii. Disruptions in the production cycle delay sub-assembly build, resulting in increased production costs and decreased output.

Material needs planning is essential in many industries, from retail to restaurants, to maintain a balance between supply and demand. In addition, manufacturing businesses rely on it as the supply planning system to plan and regulate inventories, scheduling, and production (Jenkins, 2020). planning material requirements process is divided into four distinct stages:

Identifying Requirements to Meet Demand: By entering client orders and sales predictions, the MRP process begins by determining consumer demand and the needs necessary to satisfy it. MRP then breaks down demand into the individual components and raw materials needed to finish the construction while accounting for any necessary sub-assemblies using the bill of materials needed for manufacturing.

Checking Inventory and Allocating Resources: You can monitor what you have in stock and where it is by using the MRP to compare demand to inventory and allocating resources accordingly. This is crucial if you have inventory spread out over various sites. Additionally, it allows you to see the status of items, giving you access to the ones that have been purchased but haven’t yet shown up at the warehouse and those that have been assigned to a different project. The MRP then directs inventory to the appropriate places and generates suggestions for reorders.

Scheduling Production: The system calculates how much time and workforce are needed to finish each build stage and when they must occur so that production may go without interruption, using the master production schedule. The work orders, purchase orders, and transfer orders necessary for each stage are also identified in the production schedule, determining what equipment and workstations are required for each step. The system accounts for how much time each subassembly consumes when scheduling subassemblies if the build calls for them.

Identifying Issues and Making Recommendations: This is the last action. The material needs planning, connects raw materials to work orders and client orders, so it can immediately notify your team when goods are delayed and offer suggestions for current orders, such as automatically shifting production into or out of the needed buildings, running what-if analysis, and developing exception plans.

Master Production Schedule

An projected construction timetable for producing finished goods or product choices is known as a master production schedule (MPS) (Karl, 2021). It is a crucial element of systems for production planning, such as systems for planning material requirements (MRP). It is a declaration of output rather than a declaration of market demand. The MPS is not a forecast. However, a crucial component of the method used to calculate the MPS is the sales forecast. It displays the models, quantities, and delivery dates of the products the firm intends to create. In addition, it considers the demand projection, the overall production schedule, the backlog, the material availability, and the capacity.

The master production schedule accounts for all build needs and schedules the use of machinery, manpower, and workstations to finish any outstanding work orders. A line on the master schedule grid reflects the anticipated build schedule for those items assigned to the master scheduler. This schedule is kept up to date by the master scheduler, and as a result, it becomes a collection of planning metrics that guide the planning of material needs. It depicts the planned output of the firm in terms of precise configurations, numbers, and deadlines.

The master production schedule, according to Dan’s (2018) definition, is a production planning tool that specifies how much of a product has to be produced over time. This straightforward timetable can serve as a foundation for additional planning and scheduling throughout the company. The Master Production Schedule (MPS), a component of production planning, specifies which goods must be produced when and in what quantities. A master production schedule often does not include information about the personnel allocated to jobs, the materials to be utilised in production, or the items themselves. Instead, it functions more like a contract between the manufacturing and sales departments that balances supply and demand by specifying the minimum amounts to create and the production schedules. In make-to-stock manufacturing settings where a demand prediction drives production planning, a master production schedule is an essential tool. Since an MPS is frequently employed as the primary driver of production activity, it must be accurate and practical to benefit a company's profitability. The master production schedule can also be used in specific make-to-order environments and mixed-mode manufacturing where a business manufactures standard products (Frederick, 2017). Planning the inventory required for manufacturing in this instance is done using the master production schedule and sales estimate. A long-term strategy created for each product independently is a conventional master production schedule. It is carried out with a minimal time bucket (smallest period given) of one week and a planned horizon of three months to two years.

Bill of Materials

A list of the sub-assemblies, raw materials, sub-components, parts, intermediate assemblies, and the quantities of each are part of a bill of materials or product structure (also known as a bill of material, BOM, or related list). A bill of materials might be restricted to a single manufacturing facility or utilised for collaboration between manufacturing partners. A bill of materials is frequently connected to a production order, the issue of which may result in reservations for the bill of materials' stock-based components and requisitions for those that are not. To accurately estimate and arrange supplies, a singular upgraded version of the bill of materials must be maintained. A system integrated into the enterprise-wide inventory management system avoids version control issues and builds against outdated bills, resulting in reworks and increased waste.

A bill of materials (BOM) can define products as they are designed (engineering bill of materials), as they are ordered (sales bill of materials), how they are built (manufacturing bill of materials), or as they are maintained (service bill of materials) (Reid & Sanders, 2012). The many varieties vary depending on the designed purpose and business necessity. The BOM is often referred to as the recipe, formula, or ingredients list in process industries. Engineers commonly refer to the present production configuration of a product as the "bill of material" (or "BOM") rather than the exact bill in order to distinguish it from altered or improved versions that are being researched or tested.

When it comes to electronics, the BOM is a list of the parts used to make the printed wire board or circuit board. The PCB (Printed Circuit Board) layout engineer and the component engineer get the BOM list when the circuit design is finished, and they use it to order the components needed for the design. The top level of a hierarchical BOM represents the finished product, which might be an item or a subassembly. Modular BOMs are those BOMs that outline the sub-assemblies. The NAAMS (North American Automobile Metric Standard) BOM, used in the automotive industry to specify every component in an assembly line, illustrates this. The NAAMS BOM is organised into System, Line, Tool, Unit, and Detail.

Early in the 1960s, the first hierarchical databases were created for manufacturing enterprises to automate bills of materials. This BOM is utilised by vehicle manufacturing businesses as a database to identify the numerous parts and their codes. Creating a BOM, is a crucial stage in the manufacturing process. A BOM, which is also known as an assembly component list, a product structure, or a product recipe, is essential to the efficiency of several manufacturing and supply chain procedures, such as inventory planning, scheduling, product pricing, production, and materials requirement planning (Jenkins, 2021).

A bill of materials is an organised, detailed list that includes all the materials, parts, and components needed for the production or repair of a product, together with the quantities necessary, the items' names, descriptions, and prices. Instructions for obtaining and putting these items to use are also included in a BOM. A BOM may serve as a central repository for the materials, components, and construction methods needed to create a product because of the scope and depth of the data it gathers.

A bill of materials resembles a plan for producing a product in many ways. It includes all the supplies, parts, and procedures used to make the product. The majority of materials bills are hierarchically organised. Subassemblies, the completed product, and ultimately the components and materials needed to create it are listed from top to bottom. This comprises parts names, numbers, descriptions, and required quantity. Although the idea behind a bill of materials is simple, it may be challenging to create and manage, especially for items with hundreds or even thousands of pieces. For instance, if a supplier cannot fulfill the delivery dates, it may be required to alter one component. This update must be applied everywhere that component is used in the BOM. Adhesives are one type of component that is utilised in several different applications.

Bills of materials also make production more precise and efficient, which is a benefit. An organisation may assess if it has all it needs to continue forward with a low risk of delays by recognizing and valuing all the components and materials required to produce a product before production begins. This lessens the possibility of both resource shortages and component overproduction.

BOMs aid manufacturers in staying under budget and on track by ensuring the proper materials and components are accessible at the right time and in the right amounts. Businesses that use supply chain and provide them a BOM are more certain that the finished product will fulfil their requirements. However, moving forward without a BOM raises the risk of expensive and time-consuming errors. These include insufficient or excessive supplies, manufacturing halts while the components are put together, and additional expediting fees to make up for prior delays.

A bill of materials also guarantees that these products are on hand when needed and in the amounts necessary during manufacturing by providing a centralised record of the materials, components, and assemblies that go into the product. This reduces manufacturing delays and inaccurate inventory counts, which cost time and money. Bills of materials provide homogeneity as well. The goods stay constant when every production run adheres to the same bill of materials. When items must fulfil safety or other requirements, this is crucial in ensuring they live up to client expectations.

When it is important to monitor product failures, the data in BOMs is also crucial. Using this document makes it feasible to pinpoint probable failure sources and identify the parts, materials, and components utilised. BOM management and preparation done manually can easily become cumbersome and prone to mistakes. For example, a supply chain and inventory management solution can assist in automating the development process.

Inventory Status File

An inventory status file is necessary to have a real-time picture of the organization's inventory to know what you have in stock, what is on the way or has purchase orders issued, where the inventory is, and what its state is (Raphael, 2019). There is a file for each item in the inventory that contains comprehensive and recent information. It includes information on amounts that are currently in stock, needs, upcoming deliveries, and reorder information. Lead times, scrap allowances, and safety stock levels are the other details it contains.

This file contains crucial information, such as what should be ordered and when releases should occur (Richard, 2020). In addition, the file contains fully and recently updated information on the item's on-hand quantities, gross requirements, scheduled receipts, and planned order releases. Additionally mentioned are safety stock levels, lead times, and lot sizes. The net needs remain after considering scheduled revenues and readily accessible inventory. The total needs for all resources are known as the gross requirements. Schedule receipts are goods for which a previous order has been placed with the vendor and internal store.

Planned receipts are the quantities ordered from a vendor or internal shop. So that inventory will arrive on time after the lead time offset, the amount and date for the intended order release are given. The inventory status file, which also includes data on anticipated consumption and receipts for each item, is used to determine the amount of inventory that will be accessible for each period. If the estimated current inventory is not expected to be adequate to meet the need in a particular time, the material needs planning tool will recommend buying the item.

Concept of Programme Evaluation Review Technique

The programme assessment review approach helps project managers see the actions needed to complete a project (Gabriel, 2018). Charts for programme assessment and review depicting all tasks as a network diagram are available. This depicts their interrelationship, including any dependencies. They also provide projected completion dates for each activity. The programme assessment review approach establishes the cost as well as the length of time required to finish a certain project development activity.

According to Sampson (2019), the program evaluation review technique (PERT) is a project management planning tool used to calculate the time required to finish a project realistically. PERT charts are used to plan tasks within a project - making it easier to schedule and coordinate team members. PERT charts were created in the 1950s to manage the creation of weapons and defense projects for the US Navy (Sampson, 2019). While PERT was introduced in the Navy, the private sector simultaneously gave rise to a similar method called the critical path. PERT is similar to the critical path in that they are both used to visualize the timeline and the work that must be done for a project. However, with PERT, you create three different time estimates for the project. They include:

1. The quickest length of time each assignment may be completed
2. The most likely length of time
3. Depending on how things turn out, jobs might take the longest time.

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Program evaluation review is a technique adopted by organizations to analyze and represent the activity in a project and to illustrate the flow of events in a project (Donald, 2016). PERT is a method to evaluate and estimate the time required to complete a task within deadlines. PERT serves as a management tool to analyze, define and integrate events. PERT also illustrates the activities and interdependencies in a project. The main goal of PERT is to reduce the cost and time needed to complete a project. According to Donald (2016), PERT planning usually involves the following steps:

1. Finding Tasks and Milestones: Each project has a set of necessary tasks that must be completed. These jobs are organised in a table so that further details on timing and sequencing can be added.
2. Putting the Tasks in the Right Order: The tasks are examined and put in order to provide the desired outcomes.
3. Network Diagramming: A network diagram is drawn using the activity sequence data showing the sequence of serial and parallel activities.
4. Time Estimating: This is the time required to carry out each activity in three parts:
   i. Optimistic timing: The shortest time to complete an activity
   ii. Most likely timing: The completion time having the highest probability
   iii. Pessimistic timing: The longest time to complete an activity
5. Critical path Estimating: This determines the total time required to complete a project.

The main advantage of PERT charts is that they offer a clean, minimalist overview of a project. This makes it easier to identify important success factors such as the critical path, key tasks, and potential bottlenecks. Conversely, PERT charts can be very labor-intensive to create. Just creating the initial network diagram can be a significant undertaking. Creating realistic estimates of task duration can require a lot of skill and experience. It may also require some degree of research.

If anything changes, such as adding new tasks, or adjusting time estimates, the PERT chart needs to be correctly updated. The more complex a PERT chart is, the harder it can be to update it without error. Dedicated PERT chart software can make this process a lot easier.

Possibly, the most famous use of PERT charts was on the Polaris Fleet Ballistic Missile project back in the late 1950s (Sampson, 2019). This was where the technique was developed and its capability was amply demonstrated. However, once a project moves into business, as usual, charts can still be a useful way of keeping track of performance. For example, a chart of accounts can help a user keep track of financial movements, and an inventory control chart can help you manage your supplies and avoid wastage.

Optimistic Time

Optimistic time represents an estimate of the minimum possible time by which an activity can be completed assuming that everything is in order according to the plan and there can be only a minimum amount of difficulty. It is expressed as "t_o."; this is the fastest time an activity can be completed. For this, the assumption is made that all the necessary resources are available and all predecessor activities are completed as planned. The estimate of the minimum possible time an activity can complete under an ideal condition is called an optimistic time estimate. Additionally, it is the shortest possible time; the fastest time to complete the activity; in this, we assume that all the resources are available; it does not delay at any stage.

Pessimistic Time

Pessimistic time is a concept used in the program evaluation and review technique (PERT). It represents the longest estimated time within which a task is likely to be completed and is used in project management activities. This is the maximum time required to complete an activity. In this case, it is assumed that many things go wrong related to the activity. A lot of rework and resource unavailability is assumed when this estimation is derived. This is the maximum time taken by activity with delay. If there is any delay as every stage is included, it excludes the natural calamities. It is the longest time taken. Pessimistic time, expressed as 't_p,' represents an estimate of the maximum possible time by which an activity can be completed assuming that things may not be following the plan and there can be an incidence of difficulties in carrying out the activity.

Most Probable Time

Most of the time, project managers are asked only to submit one estimate. In that case, this is the estimate that goes to the upper management. Most probable time, expressed as 't_m, 'represents the estimate of time for completion of an activity, which is neither optimistic nor pessimistic, assuming that things should go in a normal way, and if the activity is repeated several times, in most of the cases, it will be completed in time represented by t. The most probable time is the most probable estimate of the time in which an activity is completed under normal conditions. This time is based on the previous experience of qualified engineers or foremen. It allows few delays, which generally happen in the execution of any project.

Profit Maximization

Using material requirements planning and program evaluation review techniques in a just-in-time manufacturing environment can maximize profit for business growth. Material requirements planning, a computer-based production planning and inventory control system, determines how much and when to produce component items. This system keeps adequate inventory levels to ensure that required materials are available when needed. It ensures that unnecessary inventory or purchases are not made. It also ensures that excessive production or manufacturing is not carried out. Since this system is time-phased, it recommends reschedule open orders when due dates and need dates are not in phase—all of these help maximize profit for the manufacturing firm. Supportively, Jenkins (2020) averred that material requirements planning (MRP) is a standard supply planning system to help businesses, primarily product-based manufacturers, understand inventory requirements while balancing supply and demand. Material requirements planning systems allow a manufacturing firm to plan and schedule production efficiently, ensuring materials move through the work order quickly and helping businesses fulfill customer orders on time. This helps enhance program evaluation review techniques so that the firm can calculate the time it will take to finish a project. With these functionalities infused in MRP alongside program evaluation review techniques, a manufacturing firm can make much profit in a just-in-time manufacturing environment. Manufacturing firms in Port Harcourt and Rivers State can make judicious use of this system and maximize profit for their businesses.

Master production schedule (MPS), one of the manifestations of material requirements planning (MRP) in this work, helps to take all build requirements and plans machinery usage, labor, and workstations to account for all outstanding work orders to be completed. The master production schedule represents the manufacturing firm's production plans, expressed in specific configurations, quantities, and dates. With such information in handy for a manufacturing firm, it becomes easy for the optimistic time, pessimistic time, and most probable time to be determined, thereby boosting the profitability of a technologically wired manufacturing firm. Furthermore, since the master production schedule defines how much of a product needs to be manufactured at different periods, it helps a firm manufacturing plan better on inventory and customer satisfaction (Dan, 2018). This means that such manufacturing firms do not run out of products/raw materials, so they will not miss a business opportunity in their line of business. This means more money for them at the end of the day.

Before a manufacturing or production firm goes into manufacturing a particular product, one of the very important things it requires is a bill of materials – a comprehensive list of the items (with their required quantities) needed alongside their prices for better financial management, among others. More explicitly, a bill of materials or product structure gives a comprehensive list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities needed to manufacture an end product. Another impact of a bill of materials in a just-in-time manufacturing environment is that it averts unnecessary panic generated by the sudden discovery of a lack of material for production/manufacturing. A bill of materials takes into account every material that would be needed for manufacturing. As such, nothing is left out that might generate unnecessary panic of truth, a structured, comprehensive list of the materials, components, and parts required to manufacture or repair a product, as well as the quantities in which the materials are needed, and their names, descriptions, and costs, coupled with the use of program evaluation review techniques is capable of generating more money for the organization. By identifying and pricing all the materials and components needed to make a product before production begins, an organization can determine whether it has everything it needs to move forward with minimal risk of delays. This facilitates efficient and accurate manufacturing and reduces the likelihood of shortages and overage of materials or components. Additionally, by helping ensure the right parts and materials are available at the right time and in the right quantities, BOMs help manufacturers remain within budget and on schedule and minimize inventory inaccuracies and production delays, both of which cost time and money.

Inventory status files, another dimension of material requirements planning, can maximize profit in a just-in-time manufacturing environment. The inventory status file contains important information, such as what items should be ordered and when orders should be released (Richard, 2020). This means that the inventory status file always considers the products, materials, and parts that should be produced or purchased and when that should be done. This helps keep the organization abreast with every development around their inventory, helping the firm service their customers satisfactorily. This goes on to add to the organization's profitability. In addition, the inventory status file gives complete and up-to-date information on the hand quantities, gross requirements, scheduled receipts, and planned order releases for the item.

Methodology

The explanatory cross-sectional survey research design was adopted for this study. The study population comprised eighty-eight (88) managers in 22 manufacturing firms in Port Harcourt, Nigeria. The entire population of eighty-eight (88) managers was used for the study without sampling since the population was considered to be large enough to be dealt with. Thus, the study was census research which entails using the entire population. The researcher was able to retrieve seventy-six (76) copies of the questionnaire distributed. The Statistical Package for Social Sciences (SPSS) version 20.0 was applied in the data analysis using the statistical tool: the hypotheses were tested using Spearman's Rank Order Correlation Coefficient. The Spearman's (rho) correlation was used to analyze the relationship between independent and dependent variables at P < 0.05 (two-tailed test).

Results Finding

Ho₁: The master production schedule has no significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt.

Table 1: Correlation between Master Production Schedule and Programme Evaluation Review Technique

			Master Production Schedule	Program Evaluation Review Technique
Spearman's rho	Master Production Schedule	Correlation Coefficient	1.000	0.688**
		Sig. (2-tailed)	.	.000
		N	76	76
	Program Evaluation Review Technique	Correlation Coefficient	**0.688****	1.000
		Sig. (2-tailed)	.000	.
		N	76	76

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: SPSS Output

Table 1 above shows an r-value of 0.688 at a significance level of 0.00 which is less than the chosen alpha level of 0.05 for the hypothesis relating to the master production schedule and program evaluation review technique. Since the significance value is less than the alpha level of 0.05, the null hypothesis (Ho_1) states that the master production schedule does not have any significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt is rejected. The alternate hypothesis (Ha_1) is accepted. This implies that the master production schedule positively correlates with the program evaluation review technique in manufacturing firms in Port Harcourt.

Ho₂: Bill of Materials has no significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt.

Table 2: Correlation between Bill of Materials and Programme Evaluation Review Technique

			Bill of Materials	Program Evaluation Review Technique
Spearman's rho	Bill of Materials	Correlation Coefficient	1.000	0.659**
		Sig. (2-tailed)	.	.000
		N	76	76
	Program Evaluation Review Technique	Correlation Coefficient	**0.659****	1.000
		Sig. (2-tailed)	.000	.
		N	76	76

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: SPSS Output

Table 2 above shows an r-value of 0.659 at a significance level of 0.00, less than the chosen alpha level of 0.05 for the hypothesis relating to the bill of materials and program evaluation review technique. Since the significance value is less than the alpha level of 0.05, the null hypothesis (Ho_2) states that the bill of materials does not have any significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt is rejected. However, the alternate hypothesis (Ha_2) is accepted. This implies that the bill of materials has a highly positive relationship with the program evaluation review technique in manufacturing firms in Port Harcourt.

Ho_3: The inventory status file has no significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt.

Table 3: Correlation between Inventory Status File and Programme Evaluation Review Technique

			Inventory Status File	Program Evaluation Review Technique
Spearman's rho	Inventory Status File	Correlation Coefficient	1.000	0.690**
		Sig. (2-tailed)	.	.000
		N	76	76
	Program Evaluation Review Technique	Correlation Coefficient	**0.690****	1.000
		Sig. (2-tailed)	.000	.
		N	76	76

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: SPSS Output

Table 3 above shows an r-value of 0.690 at a significance level of 0.00 which is less than the chosen alpha level of 0.05 for the hypothesis relating inventory status file and program evaluation review technique. Since the significance value is less than the alpha level of 0.05, the null hypothesis (Ho_3) states that the inventory status file does not have any significant relationship with the program evaluation review technique in the manufacturing environment in Port Harcourt is rejected. The alternate hypothesis (Ha_3) is accepted. This implies that the inventory status file positively correlates with the program evaluation review technique in manufacturing firms in Port Harcourt.

Discussion of Findings

The test of hypothesis one revealed that the master production schedule positively correlates with the program evaluation review technique in manufacturing firms in Port Harcourt. This implies that what the manufacturing firm plans to produce that is expressed in specific configurations, quantities, and dates helps the manufacturing firm to evaluate the optimistic time, pessimistic time, and the most probable time of production for whatever type and amount of goods to be produced. In a study, Raphael (2019) found that digitally planning material requirements sets a manufacturing firm on a fast wheel of progress that positively impacts their profit-making and other variables. Technologically scheduling a production process in a manufacturing environment helps to improve production activities, thereby maximizing the organization's profitability. With handy information such as what the manufacturing firm plans to produce being expressed in specific configurations, quantities, and dates for a manufacturing firm, it becomes easy for the optimistic time, pessimistic time, and most probable time to be determined, thereby boosting the profitability of a technologically wired manufacturing firm.

Furthermore, according to Dan (2018), a master production schedule helps a firm manufacturing plan better on inventory and customer satisfaction since it defines how much of a product needs to be manufactured at different periods. This means that such manufacturing firms do not run out of products/raw materials, so they will not miss a business opportunity in their line of business. This is an addition to the firm's profit.

The test of hypothesis two showed that the bill of materials positively correlates with the program evaluation review technique in manufacturing firms in Port Harcourt. This further means that a comprehensive list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and quantities needed to manufacture an end product impacts a manufacturing firm's program evaluation review, thereby promoting the organization's earnings. Before a manufacturing or production firm goes into manufacturing a particular product, one of the very important things it requires is a bill of materials – a comprehensive list of the items (with their required quantities) needed alongside their prices for better financial management, among others. More explicitly, a bill of materials or product structure gives a comprehensive list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities needed to manufacture an end product. Another impact of a bill of materials in a just-in-time manufacturing environment is that it averts unnecessary panic generated by the sudden discovery of a lack of material for production/manufacturing. A bill of materials takes into account every material needed for manufacturing, and as such, nothing is left out that might generate unnecessary panic. Truthfully, a structured, comprehensive list of the materials, components, and parts required to manufacture or repair a product, as well as the quantities in which the materials are needed and their names, descriptions, and costs, coupled with the use of program evaluation review techniques are capable of generating more money for the organization. By identifying and pricing all the materials and components needed to make a product before production begins, an organization can determine whether it has everything it needs to move forward with minimal risk of delays. This facilitates efficient and accurate manufacturing and reduces the likelihood of shortages and overage of materials or components. Additionally, by helping ensure the right parts and materials are available at the right time and in the right quantities, BOMs help manufacturers remain within budget and on schedule and minimize inventory inaccuracies and production delays, both of which cost time and money.

The test of hypothesis three proved that inventory status file has a highly positive relationship with program evaluation review technique in manufacturing firms in Port Harcourt. This shows that the complete and up-to-date information on the hand quantities, gross requirements, scheduled receipts, and planned order releases for the item gives the manufacturing firm a plethora of information to go about its production process without making excess/under-budget and production. According to Raphael (2019), an inventory status file is essential to have a real-time view of inventory across the organization to understand what items you have on hand and which are en route or have purchase orders issued, where that inventory is, and what the inventory's status is. An inventory status file can also maximize profit in a just-in-time manufacturing environment. The inventory status file contains important information, such as what items should be ordered and when orders should be released (Richard, 2020). This means that the inventory status file always considers the products, materials, and parts that should be produced or purchased and when that should be done. This helps keep the organization abreast with every development around their inventory, thereby helping the firm service their customers satisfactorily and add to the organization's profitability.

Conclusions

The study has shown that material requirements planning is a veritable tool through which manufacturing firms can jointly utilize program evaluation review techniques in a just-in-time manufacturing environment to boost their financial strength. Furthermore, the master production schedule, bill of materials, and inventory status file can be used by a manufacturing firm to enhance their ability to determine the optimal time, pessimistic time, and most probable time, thereby maximizing their profit. In light of these, this work, therefore, concludes that material requirements planning in terms of the master production schedule, bill of materials, and inventory status file are very competent tools manufacturing firms can utilize to maximize their profit when matched with program evaluation review techniques in a just-in-time manufacturing environment. It, therefore, implies that manufacturing firms that undermine the use of 21st-century technological tools such as material requirements planning and program evaluation review techniques stand the risk of customer dissatisfaction, thereby cutting down on their profit.

Recommendations

Based on the findings, the following recommendations were made:

1. Manufacturing firms should equip their manufacturing environments with all necessary state-of-the-art technological tools, such as material requirements planning and program evaluation review techniques, as these can maximize their profit.
2. Managers of manufacturing firms should train their special personnel to judiciously utilize their material requirements planning, program evaluation review techniques, and other computer-based tools to enhance customer satisfaction and profit, among other things.
3. Before every manufacturing or production takes place, managers in manufacturing firms should ensure that they have a comprehensive bill of materials that carries the list of all required materials, components, and parts, as well as the quantities in which the materials are needed and their names, descriptions, and costs. This will ensure that production takes place swiftly and correctly, promoting the firm's profit.

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