AN APPLICATION OF POSTPONEMENT STRATEGY

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ABSTRACT

This article examines the problem of how a business can manage low-volume high-mix products in conditions of demand uncertainty and seasonal pattern. The solution is to use postponement strategy in the manufacturing and purchasing areas. Postponement, as applied to manufacturing, retains the product in a neutral and non-committed status as long as possible in the manufacturing process. Because the inventory is generic, its flexibility is greater: the same components, modules or platforms can be embodied in a variety of end products. This makes postponement one of the most beneficial strategic mechanisms to manage the risks associated with product variety and uncertain sales.

Products and processes are examined to find their commonalities and to explore the level of material by summarizing the demand of the semi-assembly commonality, and pre-building when production has idle capacity. A project model is designed for As-Is and To-Be situations. The result is that the average order fulfillment lead times are reduced by 12.7%, and labor utilization results in lower labor costs.

INTRODUCTION

Customers become increasingly diversified and selective, technology becomes more sophisticated, and product life cycles get shorter. These factors cause many companies to increase product varieties. However, this introduces the multi-faceted problem of getting accurate demand forecasts, dealing with complexity in supply chains and manufacturing processes, managing inventory proliferation, and providing high-quality service to customers (Shen, 2005). Effective supply chain management controls the flow of material and the consumption of resources, so that market demand can be satisfied in the most efficient and effective manner. Discriminating customers demand more choices, requiring greater customization and inciting a worldwide trend toward high-mix manufacturing. Those who fail to respond effectively to this competitive reality will cease to exist (Mahoney, 2007).

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*This is a highly condensed version of a research project report by Ms. Sriviroj; part of her MSc course in supply chain management at Assumption University.

Many companies share the same end goals of on-demand order fulfillment and lower costs of goods sold. However, the ability to realize gains from supply chain optimization is not the same among companies with different product mix and volume ratios. A high volume - low mix manufacturer producing consumer electronics for a broad global market has different leverage points within the supply chain than does a low volume - high mix manufacturer who builds specialized technology products for a narrower market (Gill et al., 2007).

Although customers increase sales revenue by requesting more product varieties, the quantity ordered for each model is low. With limits on operations capacity and constraints on material lead times, this raises the issue of what should be a suitable supply chain strategy for dealing with this kind of manufacturing environment. The aim is to achieve lower cost, better order fulfillment for customers, and help reduce forecast error from demand uncertainty, in the face of these problems.

Yang and Burns (2003) see postponement as one of the tools to deal with demand uncertainty. They believe that two main ideas are behind the postponement concept. First, it is easier to forecast aggregate demand compared to forecasting demand of every finished product. And second, more accurate information (place, time and quantity) can be obtained during the delay period. By redesigning the business processes according to the postponement strategy, they believe that companies can get the missing information which is the reason for demand uncertainty.

This article is based on a case study of a leading electronic manufacturer who provides complex precision optical components. It sells these worldwide, to a few customers, each having unique requirements. There are problems of low shipment delivery performance, due to long order fulfillment lead time, and orders that are subject to a seasonal demand pattern, which results in periods where the demand exceeds the nominal production capacity of the assembly operation. This leads to higher operating costs, especially cost of overtime. During some periods the orders are usually insufficient and there is idle capacity, but the number of operators is fixed each month and for good reasons cannot be allocated to other business unit. The research questions, therefore, are:

1. How is it possible to improve order fulfillment lead times through a manufacturing postponement strategy?
2. How is it possible to improve operation costs with the low volume high mix and seasonal demand pattern through a postponement strategy?

These questions are answered by the following action:

A. Review and study current parameters of operations processes such as assembly process and standard time, labor utilization, and bill of materials.

B. Improve order fulfillment performance and operating costs by using the postponement approach.

One business unit within the company is studied, and one customer. The study focus is on the internal operations processes, from raw material inventory to final products that are ready to ship to the customer.

LITERATURE REVIEW

Postponement or delayed *product differentiation* has been adopted by several companies as a strategic mechanism to manage the risks associated with product variety and uncertain sales, and as a powerful way to enable cost-effective mass customization (Shen, 2005). The concept of postponement is to re-design the product or production process so that the point of differentiation can be delayed as long as possible. In other words, postponement is to delay the commitment to a product's final characteristics until more information is available and more accurate decisions made about the product (Shen, 2005).

There is a growing stream of publications on postponement in various disciplines: Feitzinger and Lee (1997) in strategy; Garg and Tang (1997) in operations research; and Pagh & Cooper (1998) in logistics. Feitzinger and Lee (1997) provide examples of postponement such as Hewlett-Packard, which adopted delayed product differentiation by re-designing inkjet printers to maximize the value of common parts and postponing the localization of the products. Swaminathan and Tayur (1998) illustrate the computer-server assembly postponement practice by IBM through its "vanilla boxes" operation. Whitney (1995) describes how product modularity enabled delayed customization of parts, such as radiators in the automotive industry.

Product life cycles shorten, product variety increases, and customer demands escalate. Consequently windows of opportunity become narrower and more transitory. Companies have to seriously consider manufacturing for and marketing to individual customers, as opposed to mass markets.

Postponement itself is an operational concept. However the motivations for adopting this practice are often at the strategic level, where there are often opportunities for implementing a postponement strategy (Shen, 2005). Below is a summary of the reasons given as primary strategic motivations for postponement.

Primary drivers and benefits of postponement

Company	Primary Driver(s) of Postponement	Primary Benefits
GM	Inventory costs Product variety	Service levels Inventory reduction Maintenance costs
Honda	Product variety	Manufacturing cost reduction
Embraer	Reconfiguration costs	Service levels
Dade Behring	Inaccurate forecasts Inventory costs	Inventory reduction Service level Lead time reduction
Reebox	Inventory cost	Lead time reduction
Polaroid	Reconfiguration costs	Service levels Lead time reduction Reconfiguration costs
Bic	Inventory costs Long lead time	Service level Sales volume increase
McGraw-Hill	Product variety	More accurate forecast
Imation	Long lead time Price erosion Short product life cycles	Lead time reduction More accurate forecasts
Solutia	Reconfiguration costs	Reconfiguration costs Service levels
Xilinx	Product variety Short product life cycles	Service levels

Source: Rietze (2006)

Reduction in inventory, but within a set level of service, is another benefit of postponement. When companies increase variety they increase the number of SKUs and hence must maintain higher inventory, each SKU being subject to different forecasts and requiring different levels of safety stock which acts as a buffer against sudden increases in demand. Safety stock ensures better customer service but also has its cost. Benjaafar and Kim (2004) found that inventory levels increased linearly with variety. They also found that cost was most sensitive to demand variability, capacity constraints, and set-up costs. This highlights the risk associated with having too much variety for products, especially those with high demand variability. Companies can mitigate this risk by standardizing parts, holding more work in process (WIP) inventory, and postponing customization.

Postponement is an enabling mechanism for make-to-order products. Every make-to-order model differentiates products after the perfect or actual demand information is available. In the supply chain, some stages are make-to-forecast, while the remaining stages are driven by actual demand information. There could be multiple postponement points in the make-to-order supply chain process, but actual customer demand is integrated into the supply chain at the last point of postponement (Can, 2008).

Applying Postponement Strategy

In applying postponement, firms can customize and localize products according to customer demand and local market circumstances from a vantage point close to the market (which is especially relevant when a company operates in varied international markets) (Hoek, 2001). This enhances the efficiency of various operations, as they avoid uncertainty about the specification of orders and order mixes. In other words, the company can cope with complexity without having to lower product variety; in fact, they may decide to expand it (Hoek, 2001). Hewlett Packard reported double-digit savings in supply chain costs by applying postponement in manufacturing and distribution (Hoek, 2001). The following Table compares traditional approaches with the postponement approach.

Postponement Opportunities in Operations

	Traditional operations	Postponement opportunities
Uncertainties	Limit operations; uncertainty about order mix and volume	Reduce risk of volume and variety mix by delaying finalization of products
Volume	Produce volumes (flow shop) with large economies of scale	Make batches of one (job shop for customization, flow shop elsewhere)
Variety	Create obsolescence risks	Presume, customize, requiring flexibility
Lead times	Involve long response times	Offer accurate response, yet perform activities within order cycle time
Supply chain approach	Limit variety to gain efficiency advantages	Reduce complexity in operations, yet possibly add flexibility and transport costs

Manufacturing postponement occurs when parts are despatched to the finishing center from more than one supplier. It has the greatest potential for cost savings in inventory because the value of the product increases through the addition of each successive component. Manufacturing postponement usually results in higher production costs, due to the capital cost of switching machinery between different types of variety and sending them to different finishing facilities.

Time postponement occurs when finished products are sent to centralized warehouses closer to the customer than the manufacturing location. The motivation is to increase customer service levels by decreasing customer lead time and to respond quickly to orders by placing inventories closer to the customer without committing to an individual order (Rietze, 2006). The Table below shows a list of the postponement types and which firms would benefit from implementing each type.

Potential Utilization of Postponement

Postponement Type	Potentially Interested Firms
Labeling	Several brand names High unit value products High product sales fluctuations
Packaging	Variability in package size High unit value products High product sales fluctuations
Assembly	Selling products with several versions High volume incurred by packaging High unit value products High product sales fluctuations
Manufacturing	High proportion of ubiquitous material High unit value products High product sales fluctuations
Time	High unit value products Large number of distribution warehouses

Source: Zinn and Bowersox, 1988

Developing an Action Plan for Postponement

Shen (2005) suggests that there are three steps for formulating and implementing a postponement strategy:

Step1: Identifying the Source of Demand Variability

This identifies the sources of demand variability - product features and associated demand patterns that drive demand variation or variety explosion. In demand variability, there are typically two sources: variance of individual demands and the number of individual demands resulting from the variety a company offers. These two sources are inter-related as offering more variety could increase the uncertainty of each end product.

Step2: Re-design Products and Processes for Postponement

To reduce demand variability, postponement strategy needs to work on both products and processes. Parts commonality can often reduce unimportant varieties and thus variability of demand. Instead of having a separate braking system for each vehicle line, communizing these systems across all vehicle lines usually will not reduce consumers' value from the vehicle (Shen, 2005). Product modularity is an effective way to control combinatorial explosion of varieties by providing common product architecture. Process standardization often accompanies parts commonality to reduce the intermediate or end varieties produced. Process re-sequencing provides the structure, and the most variable features can be added on later. From a forecasting perspective, parts commonality and process standardization create a pooling of demand risk.

Many well-developed industries, such as apparel, paint, and computer, products already have modular structures and a high degree of parts commonality, and processes are standardized (Shen, 2005). Sherman Williams moved its paint-mixing process into retail stores and thus re-sequenced the distribution and mixing process.

Xilinx and General Motors have successfully postponed software customization until the end of the supply chain process (Shen, 2005). In Xilinx's case, customers also have the option of customizing by themselves after sales. Combination of a few feature options could generate greater varieties; therefore an assembly process is also a natural candidate for postponement. For National Bicycle, color is also the one that drives the most variety, so it leaves painting as a process until customers configure their orders (Shen, 2005). In a make-to-order (MTO) setting, option combination is the one which generates the most and is therefore left until after orders come in, as in Dell's case (Shen, 2005). Postponement can be enabled by a combination of product and process changes. Depending on the operations that are postponed, there are different forms of postponement, such as labeling, packaging, assembly, and manufacturing.

Step3: Determining the Postponement Points

The third step is to determine the postponement points, i.e., which processes will be carried out after more demand information is available or demand is realized. There could be multiple points for postponement.

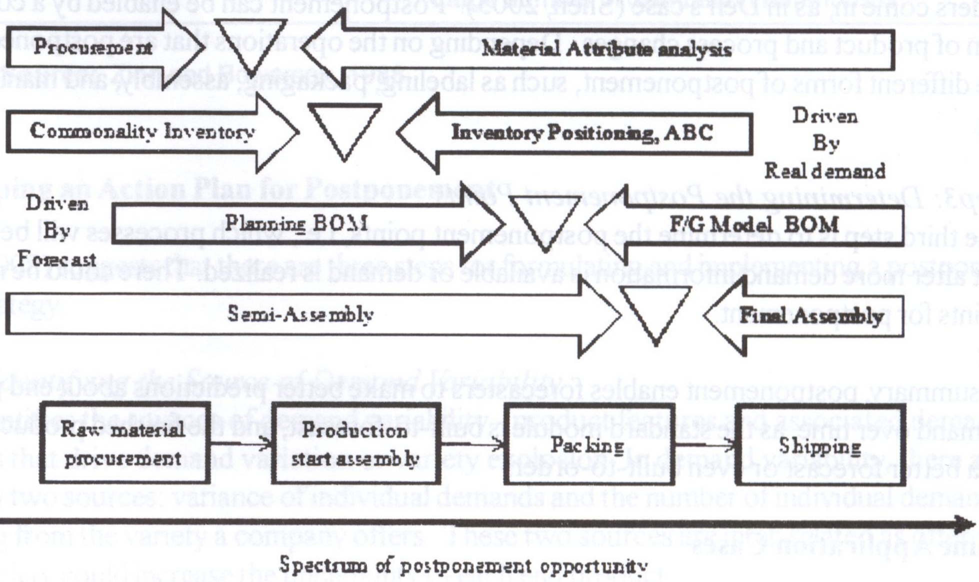
In summary, postponement enables forecasters to make better predictions about end product demand over time, as the standard module is built-to-forecast, and the finished product is built to a better forecast or even built-to-order.

Some Application Cases

Pagendarm (1991) studied the use of a strategic buffer of in-process inventory and delay in final packaging of end-items, at Kodak Company. The result was that Kodak reduced manufacturing costs, and maximized the ability to respond to consumer demand patterns, both daily and seasonal. Hoek (1997) distinguishes four categories of down-stream postponements. These are based on technology, processes, products, and market operating characteristics that do or do not favor specific postponement applications. Van Hoek et al. (1998) provided a cross-case comparison of postponement practices to allow for generalization. Ritetze (2004) highlights some of the leading companies who are pioneers of postponement and includes case studies of other companies who have followed their lead. Can (2008) studied the relationship of four strategies (postponement, mass customization, modularization and customer order decoupling point), and used pair-wise relationships of these strategies, in a case study of Autoliv Electronics. Xu (2004) studied two approaches to buffer inventory against demand uncertainty: make-to-anticipated-order as a pull, and postponement; and a commonality strategy to lower the demand uncertainty which can optimize multi-stage inventory placement with the minimum holding cost of total safety stock.

RESEARCH METHODOLOGY

Postponement is based on the principle that the final assembly or customization does not take place until the final market destination and/or customer requirement is known. In this research, the challenge is to use a postponement approach to match demand with supply at the appropriate time, so that it could be possible to improve order fulfillment performance and operating costs. The following Figure shows the theoretical framework for this study.



Methodological Framework

One business unit within the company was selected for analysis. As it does not represent a large population while still remaining rich in information to be analyzed, it was therefore decided that both quantitative and a qualitative methodology would be appropriate. Data was collected in 2008/2009, for actual and forecast costs and times. The researcher then analyzed existing business processes. The Oracle ERP system and MRP (Material Requirement Planning) schedule were run weekly, and the system generated the MDS (Master Demand Scheduling System) plan for each item. Throughout this period, buyers were involved. Data analysis was performed on operations costs and materials. ABC analysis was used to separate group of materials. Analyses were performed of the BOM structure map with the HPU of each unit, and of each material by BOM matrix map with the commonality group in each semi-assembly

At this step an analysis of the relative capacity of the various process steps within the assembly operation was performed to determine the applicability of a postponement strategy in order to address seasonal concerns. Data of the process was analyzed and BOM identified where the operation that use the same materials in assembly will be defined as the sub-assembly level.

The As-Is data and processes were thus assembled, as were those of To-Be. Planning BOM would help to reduce excess or obsolete materials, because the company would order only the materials that are common in each product group, and delay ordering the unique materials until receiving the product order. Building common sub-assembly products would help to balance production capacity where the demand pattern is seasonal. This would enable the company to aggregate demand of each low volume and high mix of product configuration, by using previously idle capacity to make sub-assembling, while enabling reserve capacity to build the final product in the peak demand period. A second procurement approach would be to postpone ordering unique materials that have short lead times, such as packaging, labeling, or materials that are used close to the final process.

It is essential to identify where it is appropriate to apply postponement strategy. Postponement may correspond to details of certain attribute(s), not of the whole order. Generally, the logic behind the concept of postponement is:

(1) The overall demands (the number of aggregate items) are relatively easy to accurately forecast.

(2) Accurate information on demand for every product variation in every sales location is available in the delay period. In theory, the DP (Decoupling point) does not have to be the same point at which postponement is applied in theory. In addition, to correspond to several attributes of the demand, there might be several postponement points in the same supply chain.

FINDINGS AND ANALYSES

After analyzing the As-Is data, the relationship between the raw material usage per BOM and the process is calculated. The planning BOM is created in this process at the points that have the most commonality of materials and processes, so that the material preparation and manufacturing can start to produce semi assembly during the period with idle capacity. For manufacturing postponement: products in semi assembly forms which can be customized quickly in production facilities; for purchasing postponement: delay purchasing of unique item, and expensive parts that have short lead time.

Manufacturing postponement

After reviewing work instructions of the product and monitoring the actual process in the production line, the point is identified where the process makes a difference to the final product. That is the point of postponement in the manufacturing process.

The whole process starts with producing the semi assemblies that can be made in parallel. Next is the testing and programming process which depends on the final product configurations. There follows the process to produce another semi-assembly. The semi assembly process follows, while the next process is that which has different material usage and this final process will be determined as the point of postponement. Therefore, the real demand from actual orders received will drive the process and material at this point to upstream level.

Purchasing postponement

After defining and setting up a group of common processes and semi assembly, the semi assembly set is to discover if there is common use or uniqueness to the final product. Common materials are classified into four groups: Pull, Continuous replenishment, Push, and Inventory. Positioning is related to the lead time of each material by using the push-pull strategy and by matching the lead time of the materials with the degree of demand uncertainty. This means the common materials will have lower demand uncertainty than the unique materials. ABC analysis is also used to determine the purchasing strategy at this point.

Develop the new process

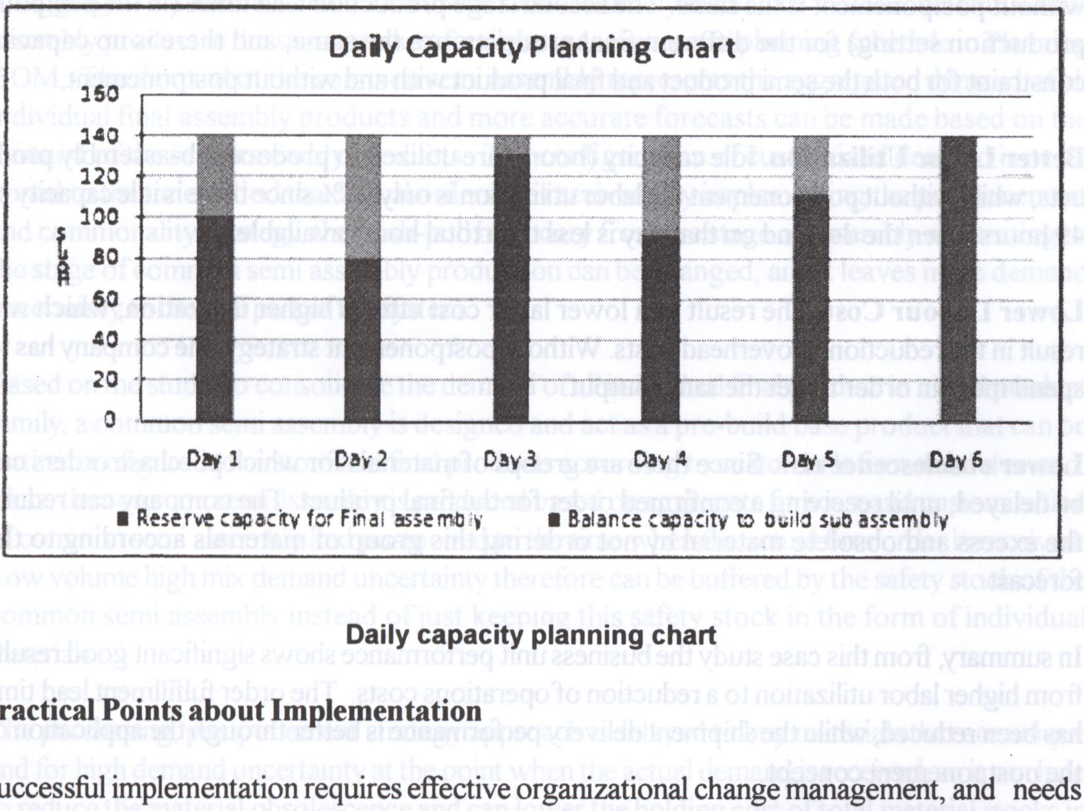
After identifying the point of postponement one product group was selected for a pilot run. This product group consists of eight products where the sales value of this product group accounts for 60 % of total sales.

Manage Supply to meet Demand through Planning BOM

A Planning BOM was set up in order to drive the right material to arrive at the right time and in the right quantity. The key attributes to input into BOM are purchasing lead time, manufacturing processing time, and fixed days supply to aggregate demand.

Capacity Balancing

A simple capacity balance on the assembly operation was used to determine where the breakpoint occurred.



Daily capacity planning chart

Practical Points about Implementation

Successful implementation requires effective organizational change management, and needs to fit the company's strategic, political and cultural identity, and work through key personnel. Understanding the corporate organization with its strengths and weaknesses should drive strategic decision making and the mode of execution.

Therefore the following consultation steps were taken:

Present all the data, with a proposal to higher management for approval for a trial run, and present all data and the problem analysis to the technical and management team. Communicate to customers on the product group selected to start a trail run, by explaining the new

BOM structure and the benefits and risks. Work with IT on details. Hold daily meetings with the team at the beginning of each shift.

After the trial run period was completed the data was summarized and the key benefits of the postponement strategy were identified as follows.

Order Fulfillment Lead Time This can be improved from 13.76 days to 8 days from the time the company receives a customer's order. Without postponement, the products are different at the beginning of the entire production process. With postponement, the production process is separated into two stages: during the first stage, only those operations that are common to all end products are carried out, and product differentiation decisions are made at the beginning of the second stage. It is assumed that the total production lead time with and without postponement is the same. The second stage production lead times (in the postpone production setting) for the different final products, are the same, and there is no capacity constraint for both the semi product and final product with and without postponement.

Better Labor Utilization Idle capacity (hours) are utilized to produce sub-assembly products, while without postponement the labor utilization is only 77% since there is idle capacity of 49 hours when the demand on that day is less than total hours available.

Lower Labour Cost The result of a lower labor cost effects higher utilization, which will result in the reduction of overhead costs. Without postponement strategy, the company has to spend more in order to get the same output.

Lower obsolescence risk Since there are groups of materials for which purchase orders can be delayed, until receiving a confirmed order for the final product. The company can reduce the excess and obsolete material by not ordering this group of materials according to the forecast.

In summary, from this case study the business unit performance shows significant good results from higher labor utilization to a reduction of operations costs. The order fulfillment lead time has been reduced, while the shipment delivery performance is better through the application of the postponement concept.

SUMMARY AND CONCLUSIONS

The result from this case study after implementing one product group shows a significant improvement in order fulfillment lead time by 12.7%, and a labor utilization increase from 60% to 74% which resulted in the overtime spending reduced from 40% to 25%.

Successful postponement implementation improves customer satisfaction while minimizing inventory costs. By improving order fulfillment lead time, the company will be better able to compete on time, while remaining cost competitive. Better labor utilization also resulted in lower labor cost. By using the postponement framework to re-sequence the process to pre build semi-assembly products the company's order release processing time will be shorter as there is already some stock at the semi sub assembly level. Improving labor utilization and operations cost results in overtime cost reduction from the capacity planning to utilization stages, and helps with idle capacity through the schedule to build sub-assembly. Operators have a full working schedule each day. In the peak period, overtime can be reduced.

Better planning and allocation of resources is enabled by reducing the forecasting horizon through using the Planning BOM, as forecast of aggregated demand is more stable than for disaggregated demand. Thus, a common semi-assembly instead of various individual final assembly product in the same product family acts as the master planning schedule in Planning BOM, The demand of the common semi assembly represents the aggregated demand of all individual final assembly products and more accurate forecasts can be made based on the demand of the semi assembly products. The configuration of customized demand is postponed to the time period that actual orders are received. By implementing the postponement and commonality strategy, the push-pull boundary from the stage of assembly and testing to the stage of common semi assembly production can be changed, and it leaves more demand uncertainty to the pull part of the system.

Based on the study, to consolidate the demand of all individual final product in a final product family, a common semi assembly is designed and act as a pre-build base product that can be further configured to customized final products according to customer's firm order demand. Thus, the common semi assembly is produced based on aggregate forecast and customization of common semi assembly and postponed to the time when the actual firm order is received. Low volume high mix demand uncertainty therefore can be buffered by the safety stock of the common semi assembly instead of just keeping this safety stock in the form of individual materials.

The purchasing, postponement strategy approach is delayed to buy materials that are unique and for high demand uncertainty at the point when the actual demand is received, so it can help to reduce the material obsolescence and can lower the holding cost of total material stocks in the supply chain. Clearly some level of inventory is necessary for an optimal process, as a buffer against demand or process variability.

Also, inventory may be cheaper than capacity; therefore, a pre-build of inventory may be justified as opposed to providing adequate capacity to handle peak or seasonal demand. Workforce size may be fixed due to unique skill requirement or labor regulations; therefore, during low demand periods rather than having idle time, production may be scheduled in excess of actual demand resulting in a sub assembly inventory build.

The design and implementation of this strategy as the first stage is a complex task requiring an intimate understanding of the fundamental production planning process capability and product characteristics. This research develops a series of management tools derived from these principles to assist with an implementation in a complex, highly constrained system. Nonetheless, these tools alone are not sufficient for a successful implementation. Successful implementation requires a series of complementary proficiencies. Shop floor supervisors are forced to micromanage both the production schedule and resource allocation. At the same time, operator utilization is considered a vital metric. When time is lost, it cannot be recovered by applying more resources.

Finally, there is no single strategy for determining postponement potential that extends across all industries. The decision must be made at the product level according to specific metrics measuring demand, inventory costs, turnover, and lead time constraints. Different companies are better able to make a transition to a postponement strategy if their product is modular and they can see the benefits in total delivered cost instead of total unit cost. A truly robust framework of this nature is not possible without accurate and adequate data of product characteristics and data quantifying the costs and benefits of both successful and unsuccessful attempts at postponement.

In conclusion, the step which covers a review and analysis of current parameters is an important step to analyse whether or not the product and process characteristics are suitable for applying the postponement strategy. It may be argued that the more we can separate the common products or processes, the more upstream the point of postponement strategy can be applied in the supply chain. This will reduce the demand uncertainty.

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