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Yield Management In Manufacturing: A Conceptual Model & Research Propositions

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Abstract:

The objective of this paper is to develop a conceptual framework for applying yield management in manufacturing. We demonstrate the existence of close links between airline and manufacturing industries as far as some decision support problems are concerned. The yield management (YM), introduced in the airline industry first and is characterized by perishable and limited resources, has counterparts in manufacturing although with some variations. We review some challenges of manufacturing industries, which arise mostly from the new business environment and are major concerns for competitiveness of business such as market share and utilization of resources. The proposed framework adopts the concept of pricing and capacity allocation from yield management and utilizes them to a broad value chain perspective from customer to supplier. Several propositions and research subjects are also introduced. This new paradigm will open up new avenues to gain more profits for manufacturers in the new era of e-commerce and flexible manufacturing system where businesses has to be increasingly customer oriented and lean while managing pricing functions.

Keywords: **Revenue Management, Yield Management, Supply Chain Management, Manufacturing, Capacity Planning**

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1) Introduction

Since deregulation in the late 1970s, most airlines have applied a collection of techniques, called yield management (YM). Yield management, or what is now called revenue management, allows the airlines to allocate their fixed capacity of seats to various fare categories in the most profitable manner possible. Actually, seats are considered as perishable items. Typically, demand is divided into two segments of business and non-business (leisure) customer, and therefore the capacity is also apportioned between discounted vs. non-discounted seats. [24]

By reviewing the practice of airline industry, one can find such dilemma of unfulfilled capacity in many manufacturing areas has similar effect of increasing cost of production, which results in higher price than expected and consequently losing the market to the competitors. This similarity is our motivation to adopt a similar approach for manufacturing. Obviously, a discipline developed and deployed in one industry cannot simply used in another industry in the hope of similar benefits.

We are especially interested in Iranian auto industry as a leading manufacturing sector. The new challenges, such as market share and overcapacity in this industry persuade us to develop some modified YM discipline to fit this industry.

The idea for the new framework came from four major trends in global environment and its related optimization techniques.

- Current practice and reports on the problem of utilization and productivity in major industries in the global market as well as Iran industry.
- Customer orientation and customized order fulfillment as a basic requirement for manufacturing industries.
- Deployment of Lean management and supply chain network management as a vital experience of industrial practice
- Demand and market share management through utilization of price motivation systems.

Table (1) illustrates the problem area and management approaches defined in literature. The suggested framework in this paper provides a guideline to combine the core concepts of approaches into a new business concept. Our approach starts with defining a concept of

customer segmentation in order to match their potential purchasing power. This means a procedure to find an appropriate price to flourish the potential demand. These types of problems are covered by pricing and revenue management approach.

Table 1. trends & approaches

Problem area's	Approach
Demand management	Pricing & Revenue management
Customer specific product	Flexible manufacturing & MTO practice
Capacity utilization	Yield management
Lean enterprise	Supply network planning & collaboration

In this approach, the new concept of selling capacity instead of product helps the plants to plan for their capacity rather than predefined products. Then, if an unused capacity is not assigned to customers, it will not produce a specific item and consequently it is a perishable asset.

On the other hand, there is usually no alternative and procedure to motivate customers to take advantage of using unfulfilled capacity in discounted offers. The question of capacity utilization is next decision area located in this framework utilizing the YM approach to fulfill the available capacities

It is necessary to mention in this paper, we develop the concept of manufacturing revenue management, only. The mathematical analyses as well as quantitative results are presented in a paper on cost-capacity tradeoff by authors.

The next section presents the literature background for the problem. In the section 3, similarities and differences between airlines and manufacturing industries as well as the general trend of manufacturing are discussed. Then, we develop an appropriate framework for manufacturing YM and also we describe the main propositions for the proposed model in section 4. In the Section 5, we examine several factors that interrelates the relationship between supply management & YM in manufacturing concepts. We develop additional research propositions by integrating a wide array of literature in related fields. The concluding section of the article provides guidelines for modeling and empirical testing, offers managerial implications, and outlines future research directions.

2) Literature Riveiew

Even though YM has been widely used in service industry, it needs to be redefined for decision making in manufacturing section. In this section, we review the literature regarding the market trend and general aspect of revenue management first. Then, four specific areas of interest, forecasting, over-booking, seat-inventory control and pricing in airlines are discussed with more details.

For a general literature review in revenue (or yield) management one can refer to [21] [25]. A similar review is done by Bitran et al. [7]for dynamic pricing.

For distinction between make-to-stock (MTS) and make-to-order (MTO) operations and the trend, see Caldentey et al. [9]. The critical link between production and marketing functions is investigated by Barut and Sridharan [4]. Several researchers dealing with the MTS manufacturing environment studied the issue of allocating scarce inventory among competing classes of customers [12]. In the service operations management area, similar subject is studied by researchers, such as competing classes of demand in the context of airlines , hotels or rental car agencies [17] [28] [10].

The work done in this area is referred to as perishable asset revenue management (PARM)[34] [8].Although in general the goal of both stock rationing and PARM is the same, there are substantial differences between the two. In stock models, the planning horizon is infinite and the resource (inventory) can be replenished throughout the horizon. In PARM, however, the time horizon is finite and the resource (capacity) is fixed within the time horizon. In stock rationing goods inventory is used to buyer for uncertainty in future demand. Whereas, in PARM there can be no goods inventory to buyer against uncertainty. Thus, models developed for stock cannot be used for capacity problems possessing the characteristics of PARM. With the PARM approach, homogenous units of fixed asset are allocated to competing product classes with respect to their profit contributions. This process requires companies to selectively accept incoming orders [17] [10] [15]. It may be feasible to segment customers and charge a different price for products based on order lead-time, in turn making the price of the product time sensitive. The need for segmenting customers has been identified as a key strategy for improving supply chain effectiveness by practitioners[1].

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Now, we review the literature in specific areas of forecasting, over-booking, seat-inventory control and pricing.

Forecasting

Accurate forecasting is extremely important for airlines & manufacturing because of its direct impact on revenues. The earliest models were for forecasting final demand for itineraries, for use in over-booking calculations.[2] This required forecasts for passenger bookings, cancellations and no-shows. Early work in this area investigated the Poisson, Gamma and Negative Binomial models for final demand [5]. Several variations for estimating cancellations, no-shows etc. were investigated and later research showed that the normal distribution is usually a good continuous approximation for aggregate demand [6].

To conduct more realistically models of the variance of the final demand, other processes such as the stuttering Poisson and the batch Poisson process have been proposed[24][2]. Two other areas that require attention are un-censoring demand data and disaggregate forecasting [3]. Several approaches build a picture of the total demand, not from censored booking data are introduced [30] [21].

Disaggregate forecasting is also desirable because aggregate forecasting may not yield accurate forecasts for less traveled itineraries, and specially for rare itineraries and these group of customers include an important part of the total demand. Further, disaggregate forecasting has been argued to yield more accurate estimates of aggregate demand [30]. Finally, we should mention the research by Weatherford et al. [34] regarding the evaluation of different forecasting methods.

Over booking

The objective in over-booking is to admit the right number of requests such that capacity utilization or flight seats are as full as possible, given the presence of cancellations and no-shows. The trade-offs involved are between admitting too many request, resulting in excessive denied boarding against not admitting enough customer and flying empty seats. This problem had been part of airlines practices well before yield management, although airlines denied the practice of over-booking for a long time [29].

Early over-booking research used statistical models for predicting single-fare show-ups to compute over-booking limits [5],[20],[16]. Some work was done on the multiple-fare overbooking problem [6].
All of these models were non-dynamic in the sense that they did not

incorporate the passenger cancellation and reservation processes subsequent to the over-booking decision. Multiple fare-classes add another level of complexity. The usefulness of dynamic models is in obtaining structural results, indicating the optimality of control-limit type policies [29].

To best of our knowledge, no overbooking in manufacturing is available in literature. Talluri et. al [31] indicates that although overbooking is widely practiced in the businesses world, it is somewhat distinct from the core pricing and capacity control problems.

Seat inventory control

By seat-inventory control, it is meant how to allocate seats among the fare classes. In other words, given available capacity and forecasts of future demand for all fare classes, the problem is accept or reject a booking request within a fare class for an itinerary. The respective trade-offs for the accept/reject decisions are denial of service to a future higher paying customer in case pf full flight, vs. not being able to sell all seats before the takes off. The statement sounds simple, but the actual computation of such a decision can be extremely complicated. Seat inventory control and its related extensions are the core theory of YM. In inventory management, it is formulated as newsboy problem [26].

The earliest seat-inventory control models focused on single flights, starting from Littlewood's rule for two-fare classes [21].Much work was done on testing the assumptions under which Littlewood's rule is optimal and on empirical testing of its performance . Belobaba extended Littlewood's rule to multiple fare classes and proposed the Expected Marginal Seat Revenue (EMSR) rule, which is not optimal in general apart from the two-fare case but is very easy to implement and usually gives good results for common demand distributions. [21][31].

Dynamic programming approaches were applied under a set of arrival processes assumptions. Several extensions of the single-flight problem were investigated by relaxing some assumptions[33].

An extension of seat-inventory control which becomes increasingly important is considering commodities and also the network of flights [11]. Single-leg control does not optimize network-wide revenues. Thus, airlines attempted to develop control rules to increase revenue from the network. The first approaches were deterministic and

involved solving either min-cost network-flow formulations or linear programming approaches [31].

Pricing

From airline view point pricing is an important part of the Yield management practice and at the strategic and planning level, it has always been important. There is an extensive literature on airline pricing from an economic perspective, which addresses issues at an industry level. Tactical or yield management level pricing is now seen as important because the opening and closing of booking classes for seat-inventory control can be seen as changing the fare structure for customers, [27] [19] [18]. Not much can be found in literature regarding the joint capacity allocation/pricing and market segmentation.

3) Similarities of Yield Management In Airline & Manufacturing Industry

The main contribution of researchers in yield (or revenue) management is in airline industry as well as hotel and entertainment industry, while there are not enough works in the area of manufacturing. We focus on the application of YM to manufacturing, especially car industry, due to the importance this section of economy. To adopt the techniques developed for airline industry for manufacturing, it is necessary to identify the similarity and differences between them. The following similarities exist between airline industry and manufacturing.

- Capacity is perishable
- Capacity is limited and cannot be easily changed
- Demand is stochastic

On the other hand, a manufacturer has some characteristics, which do not match up with the airlines.

- Incremental passenger cost is negligible (meals, extra fuel etc.) compared to the already incurred fixed costs, while Incremental cost of a product is *not* negligible.

Each booked customer consumes one seat while each product consumes an amount of each resource that could potentially vary across all resources it needs and also across all products.

- Customer demand can be satisfied only when the desired itinerary made available, while the timing of demand is not correlated to whether the customer is paying more or less (it was a behavior that is being changed now a days in certain markets as well as auto industry in Iranian market)
- Higher paying customers generally book later and need higher flexibility, while product demand may sometimes be satisfied early (by making it early and holding until requested deliver date)

Such basic assumptions are valid for a wide area of manufacturing operations with order base plans. These groups of manufacturing operations are growing due to customer specific requirement and flexibility required to meet customer expectations on product aspects. In other terms, the manufacturing sector is going to sell its capacity & manufacturability to the customers.

Market Trends & MTO Practice

Changes in market structures and advances in electronic networks and information technologies during the past two decades have resulted in volatile market conditions. Developments such as mass customization, electronic commerce, and virtual logistics chains tend to reshape the traditional distinction between make-to-stock (MTS) and make-to-order (MTO) operations. Conceivably these trends may soon render most manufacturing operations to be like the traditional MTO operation Already they are forcing firms to achieve delivery speed and reliability simultaneously. Thus, these trends increase the importance of demand management as a gateway function in providing the critical link between production and marketing functions.

Policy explored at the tactical level to ensure effective management of demand and capacity, which is a critical issue especially when the goals of both marketing and production Functions are concurrently considered.

MTO firms need to establish capacity management policies in order to solve short-run capacity allocation problems caused when their demand exceeds capacity. Unlike MTS firms that hold goods in inventory as a buyer against variations in demand MTO firms essentially hold capacity in inventory to meet customer demand. The chief capacity management issue for an MTO firm is to ensure that the firm utilizes the available capacity in the most efficient and effective way possible to satisfy current demand. Unused customizable capacity

represents potential revenue lost much like an unsold airline seat. When multiple product classes are present, the capacity allocation problem becomes an order acceptance or refusal problem paralleling the yield management problem of maximizing profit from scarce fixed capacity by accepting or rejecting an incoming inquiry.

As reviewed in literature, Yield management is a business strategy first used by the airline industry designed to help them optimize their revenue. Broadly defined, Yield/Revenue Management is to sell the right inventory or capacity to the right customer, at the right time, and at the right price. Figure (1) shows the validity of YM concept for manufacturing practice.

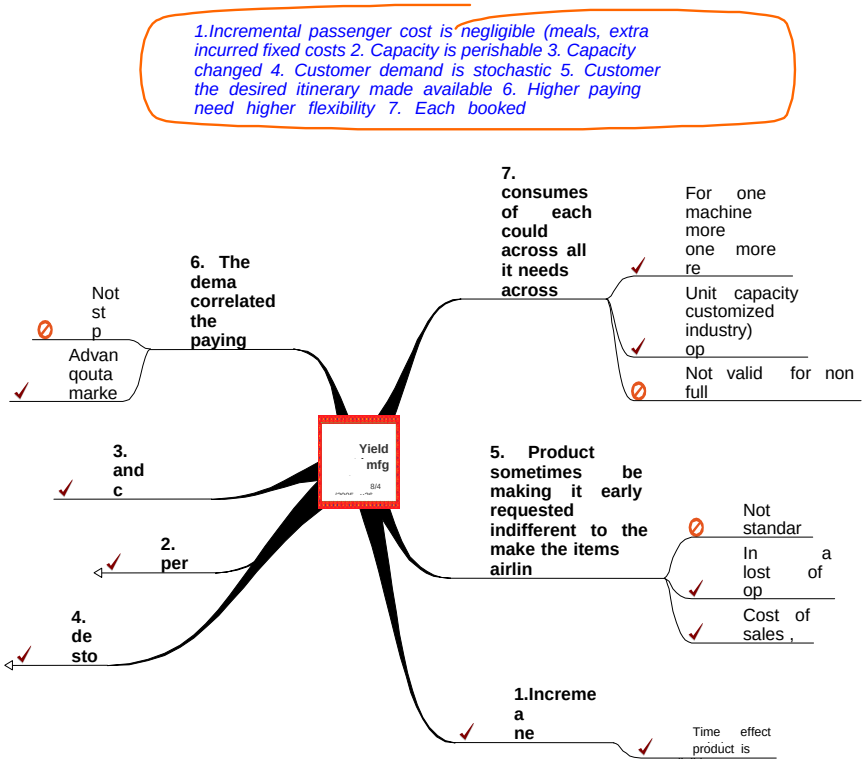

Figure (1)- Validity of yield management concept for manufacturing

4) A Frame Work on Manufacturing Yield Management

Increasing interest generally for customer responsiveness as a business strategy is encouraging more service-orientated manufacturing to explore the application of yield management techniques. Advanced yield management techniques have tended to be applied to service providers rather than manufacturing, but a build to order system resembles a service far more closely than a traditional build to stock manufacturing system.

In order to touch related subjects to traditional YM, we develop our manufacturing framework presented in figure (2). As there are differences in parameters and basic philosophy of service versus manufacturing industry, the following sections attempts to redefine the traditional YM concept in manufacturing sector. In addition, the new proposed framework will suggest a set of challenging rules in management decision-making criteria and customer behavior, which are presented afterwards.

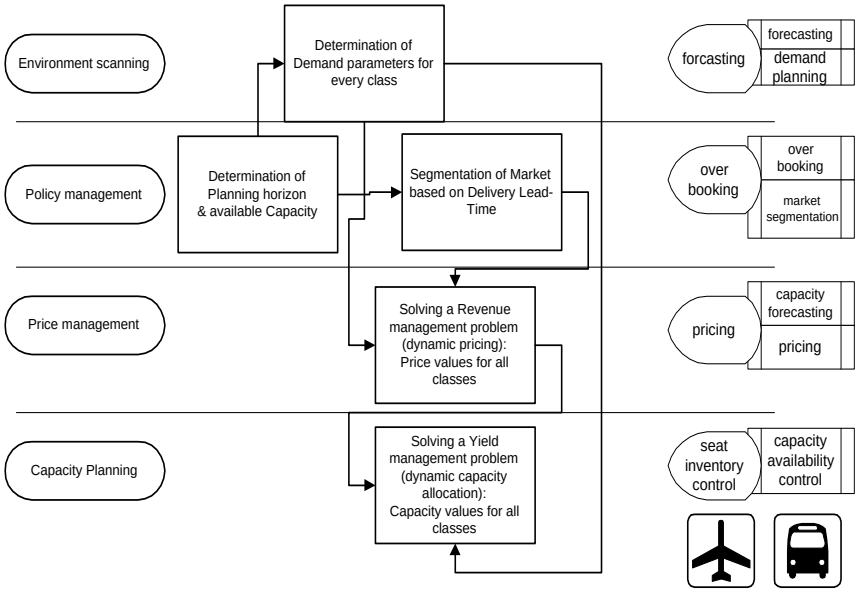

Figure 2. A schematic view on Manufacturing Yield management process

Forecasting in manufacturing

In manufacturing industry, demand forecasting has little changed over the last twenty year. The Box Jenkins Model is the basis of market and model forecasting for most manufacturers. Strategic forecasts do employ techniques that adjust future demand expectations, based on the general economic climate, previous peaks and cycles in customer demands. However, they are not used by either sales forecasting or production planning once into the budgeted year of sales and production. Techniques that are more sophisticated could be employed but manufacturers would have to gather more information on real sales rather than production and dealer orders for the change to be worthwhile [23].

The main difference between traditional planning in service industry and manufacturing is the ordering process. The planning in manufacturing starts with an aggregate estimate of demand and the distribution management of products is done through a sales hierarchy that cause a systematic Lack of Manufacturer Knowledge of Market Demand [35] [14]. These speculative orders therefore amount to noise in the system when trying to understand 'real' demand. This lack of knowledge is compounded by the feedback loop being so long from sales to production planning.

This lack of knowledge of sales behavior makes forecasting extremely unreliable, in particular the expected uplift generated by a promotion. There is the problem of relatively infrequent purchases aggregated at the market level where the data is usable. The dealers or distribution network agent itself has their own demand forecast and monitor progress against target every week; although due to information delay there exist Forrester effect in their forecasting system.

Capacity Forecasting

An extra dimension involved in manufacturing industry is forecasting the availability of physical capacity for various periods. This problem does not arise in airlines, since the reservations system accurately tracks available capacity at any time, although customer cancellations and no-shows create uncertainty in the actual available capacity for an aircraft.

The capacity-forecasting problem in manufacturing industry is hard because of several reasons. Even if the orders are registered and available capacities can be obtained whenever required, it is difficult

to define an exact availability of capacity due to scheduling changes after arrival of new orders.

The good news is that models for YM may not require very accurate models of available capacity at all time scales. One may need only a crude estimate of the residual capacity for manufacturing. Such estimates might be reasonably obtained from aggregate data such as orders processed, capacity assigned.

Demand Planning

Requirements and cost of obtaining the data vary by the industry types. Typically, the manager before using any forecasting methods must address the following issues such as what to forecast, Level of aggregation, unconstrained methods, number of periods, data to use, measuring the impact of forecasts/revenue management. Although, the choice of the variable depends on the industry, it should be easy to collect and should help the YM in setting the price structure for the perishable inventory. Regardless of the procedures and data acquisition effort, the main subject to implement YM in manufacturing sector is a paradigm shift from make to stock way of thinking to a make to order approach. This growing concept can be observed by monitoring researches on MTO approach such as FMS, JIT, lean manufacturing and group technology. Customer related approach related efforts in information technology world have made CRM and E-commerce the most growing sales for software providers.

Market Segmentation in Manufacturing

Different customers are willing to pay different prices. There are customers that you can attract with lower prices, but offering a reduced level of service (i.e. wait longer). For example, a car seller should have multiple pricing structures to attract different segments of customers. However, how can you prevent higher paying customers from moving into the lower paying segment, thus eroding your revenue? Segment ‘drift’ can be prevented by limiting accessibility to price grouping. The car industry has a ready-made price segmentation that cannot be easily violated. Retail customers at present cannot access the prices paid by fleet buyers, nor can the individual get the deal offered to a leasing company that use a pre planned contract.

One barrier comes from the experience of market segmentations in manufacturing industry, which is not similar to airline problems. However, there is a possibility to establish for manufactured products

a similar segmentation, although perhaps with different attributes. Some of the possibilities are:

Varying lead times. (i.e. Shorter the lead time, higher the price)

Varying after sales service/warranty

Various cancellation policies targeted to different customer groups

Higher flexibility limits for higher price (i.e. ability to modify order from a range at firming point rather than specifying it far in advance)

The precise set of attributes will depend on the type of business and the business model in operation.

Over Booking in Manufacturing

Since in airline industry bookings is made in advance it can "pick and choose" the segment of desired paying customers. This brings about a dilemma; should one accept lower paying customers who usually make their reservations far in advance of their service requirement or delivery date (i.e. production date), or wait for higher paying customers who typically make their reservations last minute? Is immediate sale is better than potentially more profitable sales later?

To answer this question, one must consider the stochastic nature of products demand caused by seasonality and other variation over time. Yield management is minimizes sales lost in the systems where there are predictable fluctuations in demand. As mentioned above, seasonality is a major problem for “build to order” systems. Lost sales, due to the inability of the supply system is a key issue and some degree of capacity flexibility alone cannot provide a solution. The trick is to shift excess demand in the peak periods to fill out the free capacity. One way to do that is by using variable pricing through advanced booking and finding optimal overbooking for cancelled demand [13].

As discussed earlier, selling ahead orders is preferable to selling off peak, since it requires less revenue loss. Revenue maximization is achieved mostly by manufacturing by orders ahead of the peak, whilst selling for delivery of product off peak is more about capacity cost minimization. It is likely the cost of discounts for selling off-peak is greater than that of advanced orders for peak period delivery. This can be done by incorporating state independent industry forecast into the network scheduling which results in feeding daily capacity demand into the daily scheduling system. By doing this the YM system can optimize revenues for a number of possible capacities. For

each sale to be viable, the yield management system must work from an estimate of continued demand, and anticipate certain levels of extra demand for the range of possible capacities.

One important complication is that airlines operate overbooking. Some airlines operate a policy of non-cancellation, whilst others will accept a degree of cancellation depending on fare class. Even those who do not generally accept cancellations expect a certain level of no-shows. The flights with absolutely no cancellations but with but no-shows also oversell to make sure the capacity is filled. Therefore, the revenue management system overbooks capacity based on an expected rate of cancellation. The cancellation of orders for a build to order manufacturing system creates distortions in demand. Cancellation is random and thus does not cause drastic forecasting errors of the mix, which would be problematic for suppliers. However, it may cause problems for other capacity booking elements such as outbound logistics. The issue of cancellations is a matter of company policy for manufacturers. However, it is inconceivable all customers will be unable to cancel orders. In fact, cancellation can be tolerated to some extent. A suitable policy to manage such cancellation in manufactured products is to set a cut-off date for cancellations prior to build that will probably vary by customer segment. Good news is the possibility of applying a discounted bulk sales policy. This policy can be adjusted by offering bulk sales to another segment where such an option is not valid in airline industry.

Pricing in Manufacturing

Price adjustments are the clearest way of maximizing revenue when sales condition is good and of minimizing risk when it is not so good. With the enhanced speed from market to order bank, the price adjustment will be an essential tool for managing risk of under-utilized plant and resources.

As stated above, yield management is usually in services industry, in which the selling item is a perishable commodity. In fact, if you do not sell it within a given time period, the opportunity to make revenue from it is completely lost. This is not a case in manufacturing. For example, cars can be built without sales and stored for along period. However, the high competitive market in industry pushes every business to use each production resource as a perishable commodity. For example, if a car is sold today by a competitor and not by you then, that particular sale is lost forever and its capacity is also

perished.

The main criteria of decision-making comes from this principle that particular business model dictates the calculation of value of a resource under varying assumptions of demand. Once we identify the particular model, we should be able to compute the values. In value management terms, this value serves as a threshold that any product that is manufactured should deliver. However there another aspects of VM, namely Product Design (PD) and Market Segmentation (MS). Thus, one way to enhance the value of a resource is to enrich the set of products and remove the product feature of value management, which comply with customer requirement with the same resources to extract the most out of it.

The airlines do that by designing a large number of fares for the same market charging different fares for the same seat. The reason they are able to do this is that they build fences around the various fares like 30 days advance reservations, etc. In principal, the case in manufacturing is similar, as the Cost sensitive customers would accept to purchase a product in a reasonable period that complies with the manufacturer's preferable date of delivery. This kind of experience is widely used in car industry for some market segments such as fleet buyers & entry-level customers.

Seat inventory Control in Manufacturing

In the manufacturing environment, often the goal is to satisfy customer orders as they come, with as short a lead-time and as reliably as possible. Most planning activity preceding orders is geared towards forecasting customer demand and positioning capacity and materials in the supply chain in anticipation of this demand, usually treated as deterministic. If a customer order is feasible, meaning it can be satisfied on time, it is accepted. If not, manufacturer negotiate for different due dates or staggered deliveries or seek another arrangement acceptable to both parties.

For historical reasons, which then become business reasons, a different business model has not been adopted, namely maximizing profits by carefully selecting which customer demand to accept and which to steer to a later due date or may be even reject. The reason for rejecting an order or quoting a later due date may be that in future you expect customer demand for a higher value product or may be the future customer is considered more valuable that will be potentially

displaced by the current order if accepted.

In such a business model that has been very deftly adopted by the airlines industry, customer do not always get a seat on its' favorite itinerary, not because the seats are not there but because customer do not want to pay the higher price for them. In manufacturing industry and particularly on an Asset Intensive (AI) Make-To-Order (MTO) such a business model is applicable. From definitions, An AI manufacturer is one whose ability to service demand is limited by the manufacturing plant capacity, as is true in some hi-tech & complex manufacturing environments. Figure (3) shows the common assumptions and definitions on YM seat inventory control & capacity planning in manufacturing, where the perishable asset management principles shall apply.

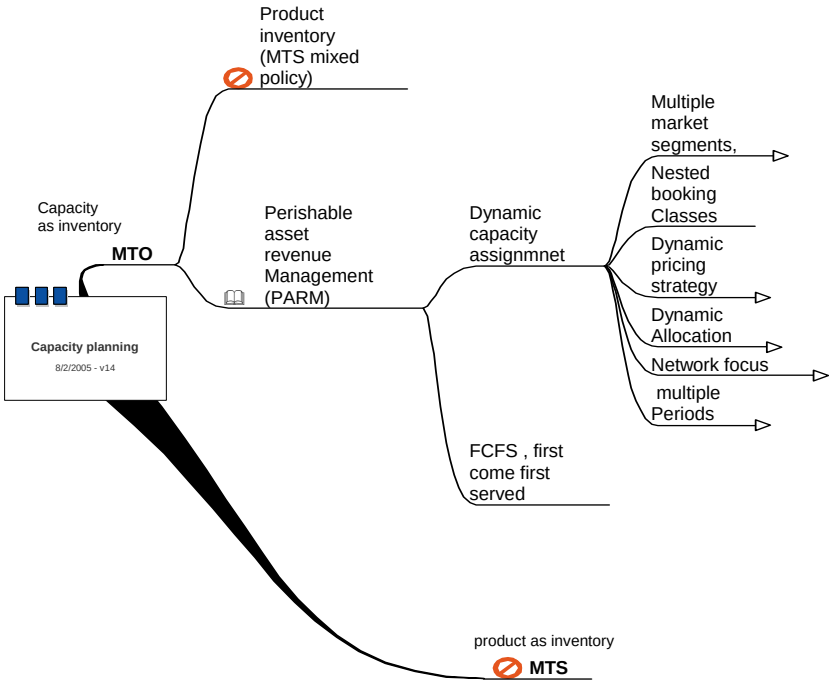

Figure 3. Common area's of Yield management & capacity planning in manufacturing

Therefore, the new concept of dynamic capacity planning in a build to order scenario has to deal with the pressure of build up of stock in the traditional system, which tries to tackle possible sales reduction. Having known that in an MTO model, every job that starts processing is tied to an actual (deterministic) customer order, such planning system may resolve both an immediate and medium term peak related pressure for utilizing plant and resources.

5) Challenges of Yield Management in Manufacturing

For the manufacturer, price changes across the entire product range will manage demand against production capacity. To make this system work, the manufacturer will monitor orders and price, and through employing decision making analysts specializing in particular product and markets, will constantly adjust base pricing offers based on sales.

In addition, effect of substitute or new product causes demand variation. Such demand behaviors will effects price changes. This is a common practice that When a product is new and or in short supply, the incentives to dealers will be low, with little discounting. On the other hand, when the product is old or in oversupply, manufacturers will run more promotions, and will also be offering large discounts to customers.

A perceived weakness is that customers will not accept different prices for the same product, and there will be subsequent impact on customer satisfaction. The argument is put forward that if one customer finds the price has dropped since their purchase the end-result will be a fall in customer satisfaction. However, customers already pay differing prices for the same product and few customers pay the same price, the level of discounts open for negotiation change over time.

The concept of price elasticity in economics allows goods to be priced for different customers or different markets at different rates. To manage actual demand in the market, the manufacturer needs to have a better understanding of the price-demand relationship and the price accepted by different customers under various conditions. Through such understanding a naturally customer segmentation will in part determine the price offer. Also, Price sensitivity will have to be

understood on a continuous basis, in order that changing market conditions are reflected in the price offering. The shorter the feedback loop from successful transaction to forecasting and price setting, the more quickly market conditions can be reacted.

Modeling price against demand management and capacity planning in manufacturing sector convey a new way of thinking toward competitive operations management. The following principles we have defined are a new modeling perspective for manufacturing industies. The fundamental changes in concepts of managing demand and capacity are the basics for modeling manufacturing YM problems. As these concepts are new in practice for manufacturers as well as the customers & dealers, therefore a set of challenging definitions should be taken care, which we present in this section.

New Challenges & Paradigms in Manufacturing Industry

The new way of looking into demand management is explained in literature as: "Pricing should be treated as a science". In the last two decades, the finance function in companies has become quantitative and theory-driven, Pricing is experiencing a similar development. Masses of data exist and the internet will lead to the availability of even more data. With the notable exception of the airline industry, these data are hardly used effectively to manage and control price decisions.

Considering that all management and internal procedures can be modified still there exists major issues that should be tackled. In terms of applying revenue management, the current pricing system fails to deliver price optimization for four key reasons, which is due to reactive and not proactive demand management:

1. No account is taken of cost of storage and interest.
2. No account is taken for willingness to wait.
3. Since currently meeting peak demand is achieved through building stock, the current focus of demand management is to sell from stock.
4. Variable price retailing is currently used to manage demand, but only in a reactive stock driven way.

Pricing Against Lead -Time

Using lead-time segmentation of customers as a price lever allows maximization of revenue from customers prepared to wait the least time, whilst allowing relative discounts for those who order ahead to

the benefit of capacity planning.

Maximization of revenue per slot in the order registration data bank, through price changes, can reflect order peaks and maximize revenue at peak whilst persuading to buy off peak. This approach needs to be taken with care, in order not to damage sales at peak.

Whilst changing price in response to changes in demand is clearly related to lead-time, Yield management is not just segmenting by lead-time. As in the selling of holidays, prices can be modified at any point determined by the overall current level of sales and/ or expectation of sales.

Peak demand pricing against lead time

Accordingly pricing against lead-time should be the priority, since orders at peak should be ordered ahead rather than moved. As a principal a moved and delayed sale may be a lost sale due to competitor market penetration. The principle does not suggest to forward the delivery but also to push back expected orders in future. This behavior is a proactive way of managing demand where in current practice the manufacturer do not care for handling potential future customer.

Pricing Against Individual Customer

Real-time systems, combining actual sales and transaction data, customer data, CRM, and individualized promotions, could give an offer tailored to individual high value customers, which also may promote certain slots over others in a way that assists capacity utilization.

This offer comes from state analysis of sales, time of sales commit from customer and features requested. This approach deals with assignment of resources to customer instead of product sales. The concept makes the customer satisfied in terms of last minute changes in product feature list. The range of options and time frame for readjustment of customer order have to be finalized according to flexibility of manufacturer and it’s related supply network.

Pricing Against Capacity Utilization

The system must be dynamic and able to change the offer based on existing orders. As discussed earlier, optimization should mean that minimum capacity utilization could be achieved at lower volumes if required, i.e. the break even point is lowered. The balance of volume

against profitability of sales is really a question of the fundamental economics of the any industry such as auto industry. The fight for market share of new car sales is really a fight for share of the ongoing product population, and the after-sales and servicing Business that this provides

For the manufacturer, price changes across the entire product range will manage demand against production capacity. To make this system work, the manufacturer will monitor orders and price, and through employing decision making algorithms for particular product and markets, will constantly adjust base pricing offers based on sales. The methodology have to consider two elements of mid term capacity plan and daily capacity utilization factor due to lack of registered orders.

Pricing Against Market Segments

The customer does accept pricing by lead-time in almost all sectors. As cited, examples include air travel, holidays and car rental. Price conscious customers make a system far less stable and require more complex price differentiation. However, product differentiation and channel differentiation manage this price sensitivity at present. One factor that will determine the price sensitivity is buyer power. The more powerful buying groups, such as large fleet buyers in auto sector, will be highly price sensitive and may not be resistant to the introduction of demand and time-based pricing. The principle for pricing against market segments shall be managed through a combination offer of lead-time and unfulfilled capacity offer where the approach results to a win-win scenario.

Pricing Against Market Channels

For a dealer or wholesaler, lead-time based pricing allows justification of price differentials. Dealers can also sell ahead, making sales for a future period, for the customer and manufacturer benefit, but also securing future income at the same time.

However, there needs to be consideration of how pricing by lead-time, would impact upon monthly share targets. This is really a debate on how monthly share targets are measured, and the relative importance placed on volume over profitability of sales in the current month compared to sales generated for future periods. The principle for motivation of channels interest in YM concept is to define a procedure to share the profits of higher utilization of capacity against expected utilization factor that results to higher profit for all business partners.

Pricing Against Product life Cycle

A key point is that the use of price and promotions should be highly directed. Otherwise, use of discounting to achieve certain market share objectives has the long – term effect of devaluing the product and its desirability. With this policy, Residuals will harm and eventually a prestige product will become a volume product. As the core concept of new paradigm is to realize the effect of manufacturer – customer collaboration in favor of both groups, the model should formulate a principle for reducing the long-term effect on product life cycle through smooth price changes in a planning period.

Dealers Effect on Pricing

Dealers/wholesaler can adapt to new systems, and they are certainly used to variable transaction prices, incentives and targets. Pricing by demand already occurs at the dealer. However, it is difficult for the dealer to assess real demand, because volumes of sales at this level are low, and there is subsequently a lot of 'noise' in the demand at the dealership level. Therefore, much like the Forrester effect seen in the ordering system (figure 4), dealers will tend to overcompensate to account for perceived trends. The whole picture is not available in terms of the complex demand trends that develop in a market, whereas the aggregated demand at the market level will show these trends.

The dealer can directly benefit from the enriching of the mix price if they receive a share of the increased profitability. Therefore, if demand causes a rise in price, currently the dealer will retain a higher level of subsidy and bonus; this changes to a higher profit per unit.

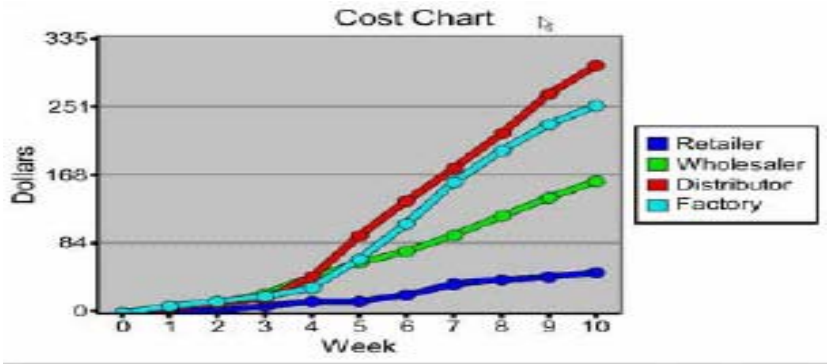

Figure 4. Bullwhip effect on cost of a typical value chain (source: forrestorconsulting.com)

Because of the possible benefit described above, reward and payment structures will have to be realigned in new business structure, Otherwise there would be an increase in dealer income variability. Thus, the lack of stability in income level would need to be compensated. The basic principle to recover dealer risk in this scenario is to model a structure of profit sharing and bulk sales discount together with a knowledge sharing of demand behavior to receive both more of all bonuses and margins, and receives reasonable gross incentives to discount.

Propositions for Quantitative Model

In previous sections, we have shown that proposed framework can be applied in manufacturing through usage of a set of principles. We realize that a new effort have to be applied to quantify the framework in to a mathematical model. Even though modeling of problem may use the fundamental formulation of YM but a set of parameters, variables and interrelationships have to be defined. The following propositions suggest the important variables for the problem and their expected relationship for our suggested framework.

Proposition 1: The shorter the lead-time for any specified class, the greater the price for an equal remained capacity.

Proposition 2: The grater the price for a segment , the less the demand function.

Proposition 3: The grater the demand for a certain segment, the grater the capacity assigned for the segment.

Proposition 4: The greater the risk of demand for a segment, the greater the price.

Proposition 5: The greater the planned capacity for a segment, the less the probability of lost sale; and the less the planned capacity for a segment the greater probability of losing revenue.

Proposition 6: For any unsatisfied capacity, there is an upper bound for discount on an equal revenue amount

Proposition 7: For any specified discount policy, there is a relationship between coefficients for optimal prices versus optimal capacity allocated

Proposition 8: for dealers with advance capacity purchase (ie. Booking) there is a price policy criteria that motivates advanced selling of unsatisfied capacity.

The set of propositions we have offered are the major points we have reached in our recent research [22]. The interesting point is the possibility of future research on specialization of the concept on different manufacturing sectors. In addition, a supply network YM framework will help the lean enterprises to take the benefit of network utilization, which is more cost-effective than applying YM for every manufacturer on a stand-alone basis.

6) Conclusions

In this paper, we developed an approach to the problem of capacity and price management in manufacturing on a Yield management framework through a set of principles, which allows a revenue optimization and asset utilization decision-making procedure. We have covered the problem of capacity planning with advance order for manufacturing companies facing the problem of productivity and utilization of their facilities. We have found such dilemma of unsatisfied capacity demand in many manufacturing areas has made the cost of production higher than expected. Such a problem with recommended flexibility for production facilities initiates the planning of capacity more suitable than product plans. Therefore, the capacity that will be unused if is not assigned to a customer and does not produce an item is a perishable good in our approach.

On the other side, there is usually no alternative and procedure to promote customers to take the advantage of using unfulfilled capacity in discounted offers.

Table 2. Terminology comparison

Air Line YM	Manufacturing YM
Seat	Capacity
Customer Class	Time bucket
Two class customer	Planning horizon
Availability of Seats, hard to change	Capacity changes, Possible in mid term
Reservation period	Lead Time
Flight date	Delivery date
Class Variable cost fixed	Time bucket variable cost fixed
One Seat per customer	Operation time per customer
Seat for each class	Capacity for each period

Taking into account the above points, we have defined a framework for manufacturing YM approach with a set of principles in

new business environment. Even though, we have defined and applied manufacturing challenges in to our model and offered some rules to apply to quantitative models, there are still challenges to investigate management policies & put qualitative market characteristics into account.

We also, introduced the effect of manufacturing challenges for the new coming global environment where the information on demand & competitor makes the first role for a successful & competitive company. We showed that such challenges can be answered by introducing the concept of capacity sales instead of product sales. This new concept has been put in to a set of principles for demand generation procedure by offering the risk & benefits to customers & dealers (you may call whole sellers). The concept that we have introduced might be used on a supply chain network YM problem while making a robust utilization of facilities through adjustment of manufacturers with customer demand.

Parameters of the new framework we have introduced are very few items that can be supported by information system on sales front end. Those parameters that we have presented in this article are the most favorite and least items that may help managers to Lead their market rather than follow the demand.

A set of propositions are proposed which is a basis recommended for further quantitative research. However from operations research point of view, further study have to be conducted to extend the resulting solution set & propositions between the conceptual statements and related mathematical functions & variables. The area of research on development of framework is not limited to apply the approach into a quantitative framework But also the management toolbox and decision making culture is another area of research. The broader research area is the extension of framework to answer the questions of demassification in Third wave or knowledge age introduced by Toffler [32]; The “Optimize product is a perfect one for individual”. However, the manufacturing yield management approach is in line with manufacturing planning requirement of third wave, a set of Customer relationship rules have to be defined to refer information age rules & principles of 21^{st} century, which is another area of research.

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