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The Evolution of Inventory Management in Manufacturing and Services Companies

Abstract

Although inventory management has significantly developed in the past years as a management discipline, its application is still minimal in the service industry and government. In contrast, it is an important tool for any company that is running a competitive business. The management of some companies considers inventory as an asset, not a liability. In addition, in companies in which the use and application of inventory models are common, they can still experience inventory problems.

This paper analyzes the weakness of the traditional and most popular inventory model: The *Economic Order Quantity model (EOQ)*. Many of the inventory models available are difficult to understand because they are based on complicate mathematical and statistical formulas. The benefits that computer software have simplifying the use of mathematical formulas are diminished because some of them do not include special applications or solutions when a variation in the assumption of the models is present. When a company implements the *Just in Time philosophy (JIT)*, the management of inventory does not rest in complex formulas. Inventory experts need to emphasize the application of the models instead of the statistical derivation. They also need to be more aggressive in making managers, students and government authorities more aware of managing the inventory levels effectively. The responsibility of good inventory levels is not the sole task of the Operations Department, but the obligation of all the people in a company. Good inventory levels are now a measure of business competitiveness. The goal must be to increase the service level and at the same time reduce the inventory investment.

Background

Since the beginning of human race, people have managed inventory. First, cave dwellers stored wood as fuel for fire, light and heat. When persons visit the supermarket, they buy all the goods they will need for a whole week. These goods are placed in storage and used according to their daily needs. Every day, companies across the world manage inventory items related to their trade. Banks manage the inventory of capital as the principal raw material offered to their customers. Fast food restaurants need inventory of food to offer their services. Hospitals need an inventory of medicines and biomedical tools in order to offer good services to patients.

The products at some manufacturing and service companies have peak or seasonal demands. That is why companies use *Anticipation Inventory* (Forgarty, Blackstone and Hoffmann, 1991). *Anticipation Inventory* is defined as the additional inventory a company maintains to protect against sales promotion, vacation shutdowns, peak sales and possible strikes. *Hedge Inventory* is the inventory that is produced to take advantage of present supplier price or to avoid anticipated seasonal substantial price increases (Plossl, 1973).

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Some companies generate *Lot Size or Cycle Stock Inventory*. This inventory is created when companies produce at a greater rate than the demand, in order to gain the cost reduction benefits of mass production-including the production of assemblies and subassemblies (assemble to order). In addition, *Lot Size Inventory* is generated when the purchasing agents buy a specific amount from suppliers in order to obtain price discounts. Using *Lot Size Inventory* can cause problems when managers have to determine the *Lot Size* (Toelle, 1996). Because inventory is necessary to operate in any market and satisfy demand needs, many people see inventory as an active and necessary requirement notwithstanding its cost. That is why most businesses have a warehouse available for the inventory of items.

The inventory has two major classifications: *Distribution Inventory* and *Manufacturing Inventory*. The *Distribution Inventory* is comprised of finished goods and service parts. *Manufacturing Inventory* is comprised of raw material, sub-assemblies and assemblies; in other words, the parts needed to make the product. For years, the inventory has been seen as a buffer to absolve the variation between supply and demand. It is common for managers to accept raw material inventory to protect the company against problems in the supply delivery, quality of the parts or an incorrect delivery amount. In addition, sub-assembly and assembly inventory is necessary to protect the company against employment absenteeism, machine breakdown and scraps. Finished good inventory is necessary to protect against forecast error and to increase the customer service levels. This excess of inventory is known as safety stock, buffer or *Fluctuation inventory* .The inventory that is maintained to protect against unanticipated demands variation (Fogarty, Blackstone and Hoffmann, 1991).

Inventory Costs

Since the past decade, many experts in inventory have written many articles about the importance of maintaining low inventory levels in order to reduce cost. The point is that no matter the benefits of having inventory, the inventory is a cost driver. Therefore, inventory must be seen as a passive liability, not as an active one. The inventory

investment does not gain value, rather depreciate and constitute an opportunity cost.

The main components of *Inventory Costs* are preparation cost, ordering cost and stock-out to activity related to the action of cost. Preparation cost is the cost associated with making an order. It includes the time dedicated to write the order (filling the form, including the specifications), processing the invoice, the paper form, invoice form and telephone calls to the suppliers. Ordering cost is associated to the cost generated because one item is in storage. Its main components are cost of capital, insurance, taxes, obsolescence, pilferage, deterioration, security, and space. The stock-out has two components: backorder and non-backorder cost. Backorder costs are related to the cost incurred when no items are available to satisfy a demand and the customer waits until the product is available. The principal cost elements are: the rain check forms, the time wasted in the apologies and the loss in goodwill. The other component, non-backorder cost is the cost associated when an item is not available and the customer does not wait for the availability of the product. In this case, the only cost elements are goodwill and the lost of sales. The existence of these costs shows that if the levels of inventory are managed inappropriately you will end up with inventory in excess or stock-out.

Inventory in excess will increase storage cost. In addition, the customer will receive this product with less quality because it is probably deteriorated. Stock-out reflects the inability to respond to the demand. It affects the goodwill and sales will be lost. The excess inventory and stock-out inventory affects the competitiveness in a company because this inventory is a consequence of the inability to respond to the demand changes. If the managers want to compete in an international business, they need to supply efficiently and be flexible to the demand changes. It is necessary to make changes in the shop floor in order to reduce the production cycle time.

When a company produces finished goods in small-size lots and has small production cycle times, the possibility to produce at the same rate of the demand increases. As a result, the possibility of inventory excess or stock-out decreases significantly. When any company increases the responsiveness to demand, the competitiveness increases dramatically. The inventory is an enemy of competitiveness because when a company has problems with inventory, the ability to respond to demand decreases in comparison to the competition. For these reasons, research and new theories of inventory have been developed in recent years.

Economic Order Quantity (EOQ) and other Inventory Models: Application and Weakness

With the development of the inventory models, the need of an inventory specialist has been increased in the past 15 years. In addition, Inventory Management is now considered a specialty and a management position in many companies. Inventory management encompasses the principles, concepts and techniques for deciding what to order, how much to order, when to order (purchasing or production orders and how and where to store it) and when it is needed (Fogarty, Blackstone and Hoffmann, 1991).

Some universities are now offering inventory management as a discipline. Therefore, many mathematical models are now available to determine when to order and the quantity to be ordered. Many books that cover expressly this topic are available. The topic has been elaborated by Fogarty and Hoffmann (1991), Plossl (1986) and Waters (1991). The books written by these authors include the research and work made by experts in Inventory Management like Sylver and Meal (1973), Peterson and Sylver (1979), Magnanti and Yanasse (1984). The most popular model to manage inventory is the EOQ model, evaluated by Ramasech in 1990 and Federgruen and Michal in 1994.

The EOQ is a model to determine an order size that will minimize the inventory cost and is obtained with the following formula: $\sqrt{DaCo/Ch}$ is an annual forecast of the demand, *Co* is the ordering cost and *Ch* is the average annual holding cost per unit. To determine the best time to make a *Reorder Point* (ROP), you can use the following formula: $d_L + ss$, where d_L is the estimated demand during replenishment lead-time and *ss* are the level of safety stock to be used. That's why in recent years the need of experts in managing inventory has increased.

Work positions like Inventory Manager and Inventory Analyst are common in some companies, especially in manufacturing. Despite this effort, many companies continue managing high levels of inventory. One reason is that some managers see inventory like a building or equipment. For this reason inventory in excess is seen as positive. Another reason is that all the mathematical formulas developed by researchers are very difficult to understand and apply (Brown, 1994 and Federgruen &Tzur 1994). In addition, the most popular inventory models have four elements with a probability to fail. If one of these elements fails, the results generated by the formula could not be corrected. The four elements are demand forecast, demand pattern during lead-time holding and ordering cost components.

Many of the models require a forecast of the demand, in order to determine the optimum order quantity and the best time to make a replenishment order. All forecasts have an error margin. If the forecast model has a significant error margin, the forecast of the demand will be far from the reality. Heath and Jackson (1994, p.28) concluded, "Production managers in many industries are aware that the forecast error is a major factor that determines the production and distribution cost". Therefore, when any person uses this forecast in the inventory formulas, the results will be that a wrong quantity will be ordered in the wrong time. The company will end up with inventory in excess in some times and stock-out in other times. Consequently, the operations costs will increase.

Many of the popular models assume a normality pattern of the demand. This is not always true. If a product has a different demand pattern and a traditional model is used without adjustment, the person responsible will end making a replenishment order in the wrong time (Segerstedt, 1994 and Yeh, 1997). The determination of *Co* and *Ch* depend of intangible information and estimated information. If any of these components in the formula were calculated incorrectly, the EOQ formula would not be an appropriate tool to determine how much and when to order. Some managers miss this reality because they ignore the inventory costs. In addition, some marketing managers could see high inventory levels as a good strategy because it will increase the possibility that when a customer arrives, the product will be available from inventory. This strategy reduces the possibility of stock-out in items. This technique is known as the *Just in Case* (JIC) approach as opposed to the JIT. This technique does not take in to account the possibility of high inventory costs. In fact, the stock-out cost could be less than the holding cost.

Managers using the JIC approach do not recognize that high inventory levels could generate costs because some of them are not out of pocket (not tangible). Because these costs are intangible, some managers do not consider them. That's why they show little interest to evaluate the inventory levels. In many occasions, it is better to assume a risk of low inventory to decrease the holding cost because the change of stock-out is less. Inventory in excess decreases the capabilities of companies to be World Class (Miller, 1995). In addition, some managers will order new items when the inventory levels reach zero. Then, using "rain checks", the managers try to resolve the problem and forget that a rain check is a cost that represents their inability to respond to the demand when it occurs.

The best time to make a replenishment order, according to theory and used by inventory personnel, is when inventory levels reach the reorder point. The inventory models that use this technique are known as *Continual Review Inventory Models*. Some detractors of these models indicate the lack of time, money and resources as reasons to ignore these models. It is very difficult to be aware of the reorder point if the company has many items on inventory and few personnel. Computer programs and the two-bin technique can contribute to make the applications of the models easier. Notwithstanding how necessary can be the use of these models, when we know that the reorder point (that is based in a normal demand pattern of the demand during lead time) does not have a normal demand pattern during the lead time, the company will probably end with an excess or a shortage of inventory.

Many persons responsible to manage inventory models do not make statistical tests of the demand during lead-time before the use of the inventory models. Another group of inventory models recommend replenishment in a fixed period instead of when the inventory levels reach the reorder point. These models are known as *Periodical Review Inventory Models*. The application and use of these

models are easier than the continual review models because they do not require to be alerted to the reorder point moment. The only thing needed is to make an order when the established fixed period is reached. The models require more safety stock than the previous models because the risk of stock-out between each revision period is greater than the demand during lead-time (replenishment time).

Some authors (APICS Education Committee, 1987) recommend using a combination of the continual and periodical review inventory models. The mix is known as the *Hybrid Models*. All models mentioned in this paper, especially the *Hybrid Models*, require the use of complex mathematical formulas. In the majority of companies in the service sector, no inventory model is used to determine the best time to make a replenishment order. The best time for those companies to make a replenishment order is when inventory reaches the zero levels. In other words, when a customer asks for a product and it is out of stock the question is: Can you conclude that this is a mistake? ; probably not. The fault of knowledge about the theory of inventory and its cost could justify it. In addition, the complexity of the inventory models with many statistical formulas, a complex assumption and test, the cost to maintain the inventory models (software and training) and the absence of expert in inventory management can contribute to this reality.

Safety Stock

As mentioned before, *Safety Stock* is the amount of an item that is maintained in excess in order to protect us against unexpected variation in the demand during the purchasing lead-time. Using three components (lead-time, demand variability and services level), a formula is derived: *Safety Stock:* $ss = MAD \cdot SF \cdot \sqrt{(R+L/Fp)}$. *MAD* is the Mean Absolute Deviation, *SF* is the *Safety Factor*, *R* is the inventory review periods (it is 0 for Continual Review Models), *L* is the replenishment lead-time and *Fp* is the forecast period (APICS Education Committee, 1987). When the purchasing lead-time is large, the company will need more safety stock because more possibilities exist for stock out during this time. In addition, when the demand reflects an unstable pattern, the risk to have large unexpected values during the purchasing lead-time is great. As a result, more buffers will be necessary. Finally, when the service level is 100 percent, your objective will be to reduce the risk of stock out to 0 percent. This action will require a substantial amount of safety stock in order to absorb any unexpected value of the demand during the replenishment lead-time. The question to be asked is: Is it necessary to have a great amount of *Safety Stock* to be protected against unexpected demand? For some people the answer is yes.

If the answer is yes, they will have to answer three questions. First, when the managers are planning to use the buffer, do they know clearly that the risk of unexpected demand is less than 50 percent? Second, if the *Safety Stock* remains at the end of the replenishment time, do they know it could generate unnecessary inventory cost and do they know how to calculate this cost? Third, do they know that if the demand during the replenishment lead-time does not have a normal pattern you will end up using a wrong formula to determine the *Safety Stock*? If the managers know how to manage the three questions, they probably will use the safety stock with less chance of being wrong.

The Just in Time (JIT) Philosophy

Philosophies like JIT consider the inventory as waste. Waste is an activity that does not add value to the product. Waste activities are cost drivers, as consequently, they generate costs. The consensus is that Edward Deming, Shigeo Shingo, Juran and Crosby were the brains of the philosophy. Waste is any activity or process that does not add value to the product. Under this philosophy the inventory is waste. There is not space for large *Lot Size Inventory*. "In a true manufacturing system, the concept of delivering predetermined lots should be superseded by producing and delivering only those parts needed at any given point" (Miller, 1997, p.57). Therefore, under JIT, the *Safety Stock* is considered as waste, because it generates inventory cost. If the company has a production system with high flexibility and short production cycle, the company will react to the demand immediately without the need of finished good inventory. Because of this philosophy, companies in Japan started actions to reduce the

inventory levels and *Safety Stock*. Zero Inventories would be the goal. The managers initiated action to buy raw material in agreements to the needs. In addition, the purchasing orders were planned to receive them from the supplier at the time they are needed JIT.

To decrease the levels of the distribution inventory, the size of the production lots was reduced significantly. Under JIT, the schedule is based in finishing the product at the time of the sale. With this philosophy, no complicated formulas, like EOQ, are used in planning and controlling the inventory levels. The only action is to buy raw material and produce finished goods only when needed. Consequently, companies with JIT eliminate or reduce considerably the size of the warehouses. Therefore, under this philosophy the *Safety Stock* is considered as waste. Waste is a cost driver. If the companies have a production system with high flexibility and a small production cycle they can react to the demand immediately without the need of using finished good inventory. This philosophy expanded across the world in the late 70's.

In the 80's the principles of JIT expand across all companies and a new name appeared: *Total Quality Management (TQM)*. Now, it is common to find companies with JIT or TQM in which the size of the warehouse is small. In addition, it is common to find companies without JIT or TQM with large warehouses available. In these companies mathematical models, like EOQ and *Material Requirement Planning (MRP)*, are used for planning and controlling the inventory levels.

Finally, some companies use a combination between MRP and JIT for planning and controlling the inventory levels. JIT is used for planning and controlling the distribution inventory and in the shop floor for managing sub-assemblies and assemblies. MRP is used mainly for planning and controlling the raw material inventory.

Lot Sizing Inventory

As mentioned before, many companies use in the shop floor the repetitive production (assemble to order) approach. Under this approach, finished good items and parts are produced in advanced to the demand, in lots (*Lot Size Inventory*). The benefits of the repetitive production are that when a company produce in large lots the benefits of mass production are possible. Therefore, a decrease in production cost is possible. However, at the end of the month probably the company will end up with inventory because the company produced at a rate greater than the demand. Then the company will end with high inventory cost. Therefore, the benefit of mass production could be diminished by the inventory cost.

To determine the quantity for the *Lot Size* many companies use the EOQ. Sometimes, the lot size is not determined by the EOQ formula. Some suppliers offer discounts if the purchasing agent agrees to buy specific amounts. Therefore, the purchasing agent will probably buy this quantity in order to obtain the benefits of the discount, no matter the effect in the inventory cost. The justification is that any increase in the inventory costs, because the purchasing agent is not buying the EOQ quantity, is less than the saving in the purchasing because of the discount. The point here is why would the purchasing agents buy items that they don't need at a particular time. The results at the end of the month probably will be an unnecessary excess of inventory and higher inventory cost. The inventory cost will reduce the savings obtained with the discount and managers need to understand that. The savings are in some cases less than the inventory cost when these agents buy items with purchasing discounts.

Conclusions

In the past years, the efficiency of inventory management has become an area of major concern in business. The need of inventory specialists has increased dramatically. Business positions like *Inventory Manager* and *Inventory Analyst* are common in the manufacturing sector. New inventory models for managing the inventory levels are now available. However, in spite of these developments, many companies continue to experience inventory problems.

Many of the most recent inventory models are based on complex mathematical formulas. "The O (n^2) complexity of the Wagner-Whiting algorithm was considered prohibitive for many of the above mentioned settings where the model needed to be resolved

repetitively for a large number of items and/or different combinations of parameters values" (Federguren and Tzur, 1994, p.456).

To manage and understand these models efficiently a heavy background in statistics or math is needed. Unfortunately, it is very difficult to find a person with a background in both statistics and math along with an inventory-related field. In this case it would be better to hire a person with inventory experience. However, top management will not see an economical advantage on this choice. Probably they will assign this position to an inside person or an outside person with a related math expertise field.

The majority of computers software includes the traditional EOQ model. It is uncommon to find software with the features and adaptation to different environments. As mentioned earlier in this paper, the items in inventory have different characteristics that affect the assumptions and components of the inventory formula models. The point here is whether the computer model software could be considered an appropriate tool for planning and controlling the inventory levels. For some inventory experts the answer will be no. Another issue is how many companies use computer software with an inventory model that does not respond to the characteristics of the situation. Probably they do not know the consequences in the inventory levels and the cost of using incorrect models. They are entrusted with an incorrect model because some people do not understand that computers are not always correct. Unfortunately some people accept the computer outputs as always correct. Managers and people responsible on that matter need to understand that having a computer software is not a guarantee that they have all they need to efficiently manage the inventory levels. They need to analyze the output provided by the software to see if it is realistic, before making a decision based on it. Specially, they need to be sure that the items characteristics (mainly the demand pattern) conform.

It is necessary that top managers and authorities at universities give more attention to the *Inventory Management* field. The top management needs to realize that inventory is no more an active; it is a passive liability that depreciates. Therefore, if it is managed inappropriately it generates cost. Consequently, the competitiveness of the company diminishes. The authorities at the university need also to recognize the importance of good levels of inventory in order to be competitive in a global market. In addition, they must promote courses not only for students from operation and material management, but also from marketing (for retailing), business, and social science. All of them will have to manage inventory in their work.

The emphasis for better practices of inventory is greater in manufacturing than in any other industry. The interest must be in any type of industry, no matter its size, product or characteristic, including services, because they need to manage inventory in order to offer their outputs. However, in services and government companies the need of better inventory practices is not a goal. That's why it is very common to see purchasing supplies that are not needed. On the other hand, in USA stores located in Puerto Rico it is common to see snow shovels in display. These companies do not recognize that they are spending money buying items with slow or zero demand. Probably they know anything about the cost this activity can generate because most of the costs are not out of pocket, specially the obsolescence cost. "Every day, obsolete inventory amounting to hundred of millions of dollars annually, is identified by manufacturing companies throughout the Unites States. The speed at which this obsolete material accumulate can be alarming" (Lockett, 1997, p.42).

It is time for managers to recognize that these costs are present and need to be calculated and used to make decisions. For companies with items that have seasonal demand, and as a result need to maintain *Anticipation Inventory*, the model used to manage the inventory needs to consider the correct demand pattern so that the *Safety Stock* levels will be appropriate. In addition, in order to make the corresponding adjustment to the model, the demand pattern and the forecast need to be revised periodically. Because the major problem with the inventory levels is during the purchasing lead-time, managers need to understand why this is the most sensitive time for the inventory levels and the role of the *Safety Stock* at this time. The *Safety Stock* needs to be viewed as a buffer to protect it against unexpected and uncontrollable variations in the demand during the replenishment time. In other words, "It has also been demonstrated that, properly analyzed *Safety Stock* can be a valuable tool in enhancing the bottom - line profitability of the company" (Krupp, 1997, p.18).

Safety Stock does not constitute a buffer to protect the company against non-productivity activities, like poor forecast error, scraps, machine breakdown, poor warehouse control and poor supplier performance. Unfortunately, for some people those elements constitute a justification to maintain *Safety Stock*. It is time to stop the use of *Safety Stock* to protect against non-productivity activities like poor forecast error (Brander, 1997). It is better to revise and correct the forecast method. When a company has a high precision forecast model, the amount of safety stock will be reducing dramatically. The manager needs to understand how the different components mentioned above affect the calculation of *Safety Stock*. It is time for managers to quantify the cost effect of forecast error. On 1994, Heat and Petter mentioned in an article that in a discussion with top managers in the company under study the managers recognized the problem with forecast error. Notwithstanding, they were unable to quantify the impact in cost.

Inventory in many circumstances could be a great tool to equilibrate the offer and demand. However, it needs to be managed carefully in order to decrease the cost generated by excesses or shortages. No matter that some of the components cost of inventory are not out of pocket they exist and can reduce significantly business earnings. The managers in companies, other than manufacturing, need to pay more attention to the inventory levels. They need to begin recruiting experts on inventory or at least start taking seminars or courses in inventory, and make their employees aware of the need to maintain good inventory levels. Any person responsible for inventory needs to understand the importance of accuracy information used in the component of the formulas. Also before using any of them, they need to analyze the demand pattern in order to select the correct formula at the time to decide when and how much to order. In addition, they need to revise the demand pattern periodically to react to any changes.

The specialists responsible for the evolution of the inventory models need to know that a high percent of the people don't know statistics. That is why the specialists should explain the theory of inventory in a form easy to understand. It is better not to emphasize in the derivation of the formulas. For the majority of the people it is hard to understand and is very boring. It is better to explain the theoretical model first (qualitative form), and then explain how to manage it and its benefits. Software companies need to design a menu that cover all possible variations in the model, including demand pattern, in order that any person can adapt it to his needs. If the software has this feature, it will motivate the user to manage the component of the formula more efficiently. In addition, more important, the user will have to make a demand pattern analysis before using the software. The books need to be revised in order to reduce the excess in mathematical description. Some authors need to recognize that inventory management is not statistics. They need to know that the person who needs this information probably will not have a great background in math. In addition, the emphasis must be in the application of the model, not in the derivation of formulas.

Modern commercial evolution dictates that it is necessary that companies, not only use good inventory management models, but also, the correct one for their specific area. That is why every day new models are developed. However, the increase of *Inventory Management Models* has not followed the same trend as the systems technical development. The people that teach *Inventory Management* can contribute to the change. College professors have a responsibility to the universities and the community to create awareness in people about the importance of maintaining efficient inventory levels. Efficiency is a necessary element that must be included in the development of any new management models. One of the most usual perceptions that managers have, and that must be substituted, is that levels in inventory should always maintain a positive upward trend: "There is often an optimistic view that the unused inventory will eventually be used and that is really not hurting anything to let it on a shelf for a little longer 'just in case' "(Locket, 1997, p.43). However, professors need to be more active in conferences, writing in newspapers and professional journals to diffuse this view. This must be a practical and useful dialogue, not a theoretical one geared strictly towards the derivations of formulas. It is their responsibility to teach students and managers that the final objective is to increase the customer service level with a minimal investment in inventory. Inventory generates cost but it is possible to increase the service level while reducing inventory levels.

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