JOURNAL OF TECHNICAL REPORTS IN ENGINEERING AND APPLIED SCIENCE

Contents available at: www.jotres.com

A literature review on: Demand forecasting method for decision making

Jaykishan Gupta, Prateek Kumar Kori, Purnesh Kumar Sahu
Chouksey Engineering College, Bilaspur

ARTICLE INFO

Article History
Received: July 2016
Accepted: August 2016
Keywords:
Demand Forecasting,
Decision making,
Review.

ABSTRACT

Service part inventories cannot be managed by standard inventory control methods, as conditions for applying the underlying model are not satisfied. Nevertheless, the basic questions of inventory control have to be answered: Which parts should be stocked? Where should they be stocked? How many of them should be stocked? This Thesis is a case study in which a pragmatic but structured approach is follow: a framework is developed and built into a spreadsheet. The resulting tool has been tested in a real-life situation, representing that considerable amounts of money can be saved. Finally, the outline is used to identify areas for future research based upon the gaps identified in the literature, review.

REVIEW ARTICLE

1. Introduction

Satya Spare Parts Stores (SSPS) has the responsibility of delivering automobile component and spare parts supplies to over Bilaspur (C.G) district service center spread throughout the agency. Mountainous terrain throughout the state, the fact that some service facilities are located on district and the poor condition of roads all serve to complicate the distribution operation. Add to this the excessively high cost of fuel and the limited resources of the government's service budget and the need for efficient transport management becomes clear. Satya Spare Parts Stores to undertake an evaluation of their transport and distribution function in order to provide a series of recommendations as to how they could reduce costs, increase efficiency and improve service delivery.

The result of the operational assessment was the development of a report detailing recommendations for improvement of the existing SSPS distribution operation. The recommendations include suggestions for an appropriate policy and system implementation, resolution of organizational process issues, which had been adversely affecting the transport operation, and the subsequent implementation of an outsourcing study to determine an effective solution for ongoing expansion of the delivery network. With the adoption of these recommendations SSPS will be expected to benefit from reduced transport costs, increased vehicle utilization allowing a reduction in fleet size, improved vehicle availability allowing a faster response to vehicle demand, and overall improved vehicle service delivery. At present the tasks of managing the day to day transport operation are taking significant time with the implementation of appropriate processes and systems this work will be greatly reduced

freeing the transport and logistics officer to concentrate on upcoming projects to increase the distribution network which SSPS services.

2. Literature Review

Adeyemi & Salami constitutes the most significant part of current assets of larger majority of Nigerian manufacturing industries. Because of the relative largeness of inventories maintained by most firms, a considerable sum of an organization's fund is being committed to them. It thus becomes absolutely imperative to manage inventories efficiently so as to avoid the costs of changing production rates, overtime, sub-contracting, unnecessary cost of sales and back order penalties during periods of peak demand. The main objective of this study is to determine whether or not inventories in the Nigeria Bottling Company, Ilorin Plant can be evaluated and understood using the various existing tools of optimization in inventory management. The study methods employed include the variance analysis, Economic Order Quantity (EOQ) Model and the Chi-square method. The answer to the fundamental question of how best an organization which handles inventory can be efficiently run is provided for in the analysis and findings of the study. Consequently, recommendations on the right quantity, quality and timing of material, at the most favorable price conclude the research study.

Kao and HSU define inventory management as being comprised of two major activities namely the control of inventory and the planning of inventories. The purpose of inventory management being to satisfy customer demands and minimization of stock handling costs in order to achieve higher stock turnover rate. Inventory control involves managing the inventory that is already in one's warehouse, knowing what products are in stock, their quantities, cost and location.

Inventory planning involves determining when to order items, how much to order forecasting demand and stock replenishment, identifying the most effective source of supply, inventory information management and inventory monitoring.

Hsieh defined inventory is assets that are intended for sale, are in process of being produced for sale or are to be used in producing goods. For many companies inventory represents a large portion of assets and as such makes up an important part of balance sheet. Inventory can also be defined as the consumables, work in progress (WIP) and finished goods stock that are kept or stored for use as need arises.

Netessine et al. cites three inventory- costing methods that a company can use to determine the costs of inventory and argues that they impact directly on the balance sheet, income statement and statement of cash flow. However the concern with determining the value of closing stock inventory or any quantity of inventory held at a particular point in time cannot be justified by only these three methods.

(a) First in, First –out (FIFO). This method assumes that the first unit making its way into inventory is the first sold.
(b) Last in, First-out (LIFO). This method assumes that the last unit making its way into inventory is sold first. The older inventory is therefore left over at the end of the accounting period.
(c) Average cost (AC). This method takes the weighted average of all available for sale during the accounting period and then uses that average cost to determine the value of cost of goods sold and ending inventory.

The choice of the method to use is therefore dependent on how a company wishes to reflect their inventory in its books of accounts.

Filippi indicates how often items must be in stock when customers require them. It is calculated by dividing the number of line items for stocked items shipped complete by

the promise data with the total number of line items for stocked products ordered

The customer service level takes into account only sales to stocked items that are filled using warehouse inventory and excludes non stock items. Customer service level should be monitored frequently in order to carry out appropriate interventions and maintain good turnover.

Angelus et al. indicated that in order to minimize the occurrence and impact of performance deviations caused by stem fitness problems, a manager must ensure that the inventory management system is consistent with the operating environment through monitoring.

The system can be characterized by many environmental variables. For example demand, costs, lead time, management policies. Decision rules may include order quantity, reorder point and safety stock level. Performance measures like turnover rate, stock out frequency and quality, inventory.

Harrison et al. researches of inventory efficiency of turnover rate concluded that there is a part an association between companies' inventories and changes in turnover rate. Occurrence in changes in turnover rate requires some knowledge to be considered in corporate strategic planning of supply chain management. Companies have to carefully consider the impact that their current policies of inventory management have qualitative and quantitative changes in turnover. As a result of increased changes, the financial benefits that may be achieved through being lean in the inventory management areas of one's business might negatively influence the financial costs incurred.

Drury 2000.This is how much stock is sold in a given period and is measured by the turnover rate which is a ratio that shows how many times the inventory of a company is sold and replaced over a specific period of time normally in the last twelve months. It is calculated by taking the annual cost of sales divided by the average inventory holding of stock. The result is an indicator of how well the company's products are succeeding in the market place. In general, the higher the number, the better, although, the right amount of inventory turnover depends on industry the company serves and its profits margins.

Angel et al. has describe on today's uncertain economy, companies are searching for alternative ways to stay competitive. This study goes through the process of analyzing the company's current forecasting model and recommending an inventory control model to help them solve their current issue. As a result, an Economic Order Quantity (EOQ) and a Reorder Point was recommended to help them reduce their product stock outs. The shortage of raw material for production always makes the process discontinuous and reduces the productivity. The ABC analysis technique for the inventory control system is first used to identify the most important multiple products and then the economic order quantity (EOQ) of each product is developed to find their inventory model equation individually.

Botter and Fortuin applied the AHP method in a case study performed in the electronic industry. The study uses the VED classification of criticality of items together with a demand classification (high, medium or low) to take or not the decision to store the item.

Brackus (2000) argue that material control is concerned with two parts of Accounting; physical property and value of the property. Brackus (2000) shows material control as one of the policy procedures employed in the management of material s and these include internal checks as in continuous, period, spot and .or any other type of control established by management to carry out activities aimed at ensuring an effective and efficient material

management procedure. Other forms of material control include ensuring high security of the store house and stock yard, good custody of keys, limiting access to premises and making of materials as in coding, to minimize theft, segregation of prescribed item.

Eaves and Kingsman evaluated spare parts demand forecasting techniques in the case of British air-force (RAF), including SBA and Croston's method, and demonstrated the superiority of the SBA method to a certain service level. Nevertheless, the adopted classification criteria are arbitrary, hindering the generalization of results. They analyzed the inventory levels of a continuous review policy based on forecasting gathered through five distinct models (SBA, Croston's, simple exponential smoothing, moving average and last year average), and the SBA model was consistently superior to the others (generating lower average inventory levels).

Ghobbar and Friend compared 13 forecasting techniques to aircraft parts demand and proved the superiority of the techniques: weighted moving average, double exponential smoothing (Holt), and Croston's method. Similar results were presented.

Gomes and Wanke formulated a heuristic to obtain the parameters in (s, S) model ("s" denotes the order point) using Markov chains and steady state probably distributions for inventory positions, assuming costs of holding, ordering and shortage, and also assuming Poisson demand. Using the heuristic to solve a set of instances, the costs achieved were, in average, only 2.65% above the optimum solution obtained through simulations.

Kotabo (2002), though there are many systems for control of stock, both manual and automatic, there are really two basic approaches on which these systems are based. Recording method which may take place either when materials fall to a pre-determined level or according to eh situation discovered when levels are received on a periodic regular basis. The action level method of controlling sock by quality which involves fixing stock levels for each commodity which is recorded in the stock system . Under the action level methods of provision, commodities are ordered at unspecified intervals as and when ordering levels are related. This means that orders can only be placed usually for one item at time.

Krever et al. developed to compute the mean and variance of demand during the leadtime and more accurate approach for intermittent demands. In their approach, known as Single Demand Approach (SDA), as opposed to the more traditional Periodic Demand Approach (PDA) with time buckets, three random variables are used: amounts demanded during the lead-time, time intervals between demand occurrences, and the lead-time itself. The inventory policy adopted was the continuous replacement and its parameters were obtained by the minimization of total costs. The results showed the superiority of the Laplace distribution against the others, even against the Normal distribution previously considered by the company, gathering significant inventory cost reduction and improvement in the service level.

Laugero (2002) asserts that to illustrate the type of trade-offs encountered in material management, a particular item has to be ordered for a project amount of time required for processing the order and shipping the item is uncertain. Consequently, the project manager must decide how much lead time to provide in ordering the item. Ordering early and thereby providing a long lead time will increase the chance that the item is available when needed, but it increases the cost of inventory and the chance of spoilage on site. It also adds that, in more realistic situation, the manager would also contend with the

uncertainty of exactly when the item might be required. Even if the item is schedule for use on a particular date, the work progress might vary so that the desired date would differ. In many cases, greater than expected work progress may result in on savings because materials for future activities are unavailable.

Main (2000) further describes the materials for delivery to and from a construction site into three broadly classification; bulk materials, Standard off-the-shelf materials, and Fabricated member or units. The process of delivery including transportation, field storage and installation will be different for these classes of materials. The equipment needed to handle and haul these classes of materials will also be different.

Ouyang et al. (2006) introduced defective items into the JELS model. The study applies various modeling methods to manage the defective rate in an integrated vendor-buyer inventory model. Three cases are investigated: crisp defective rate, triangular fuzzy defective rate and statistic fuzzy defective rate. In these two fuzzy cases, the signed distance procedure is applied to estimate the joint total expected cost in a fuzzy sense. Yang presented a stylized model to find the optimal strategy for integrated vendor-buyer inventory model with fuzzy annual demand and fuzzy adjustable production rate.

Rego & Mesquita Spare parts inventory are needed for maintenance and repair of final products, vehicles, industrial machines and equipments, frequently requiring high investments and significantly affecting customer satisfaction. Inventory management is complex due to the large number of different items and low demands. This article presents a literature review on single location spare parts inventory control, embracing both demand forecasting techniques and inventory control decisions on the different life cycle stages. Overall, the literature review identified the following research opportunities on inventory management: criteria to decide to stock or not an item, how much to order in the first and the last batch, demand forecasting and inventory control models integration and case studies on real applications.

Roberta & Bernard has been used the Economic Order Quantity (EOQ) formula in both engineering and business disciplines. Engineers study the EOQ formula in engineering economics and industrial engineering courses. On the other hand, business disciplines study the EOQ in both operational and financial courses. In both disciplines, EOQ formulas have practical and specific applications in illustrating concepts of cost tradeoffs; as well as specific application in inventory. Inventory refers to the stock pile of the product a firm is offering sale and the components but make up the product. In other words, inventory is composed of asset that will be sold in the normal course of business operation. The assets which firms store as inventory in anticipation of need are raw materials, work-in-progress, finished goods. Carrying cost refers to the total cost of holding inventory. This includes warehousing costs such as rent, utilities and salaries, financial costs such as opportunity cost, and inventory costs related to perishability, shrinkage and insurance.

Silver (2008) identifies three possible forms of lead-time. The first form is where the lead-time of each replenishment is known; the second is where replenishments arrive after a random time; and the final form is where seasonal factors may affect the time it takes for an order to be fulfilled. A supplier usually has limited capacity; therefore, order size restrictions are taken into account in this dissertation. In addition, lead-time is assumed to be a constant and known value. Any model is an abstraction of reality. The more number of dimensions to be taken into account in the model, the greater the model

will meet the requirements of the real environment.

Syntetos, Keyes and Babai proposed an additional category of items D, in the ABC classification, composed of the critical parts of just launched products, defined subjectively, which should be kept in inventory and in this category for the first six months of their "lifetime". Once the matter of the initial order has been discussed, we will consider hereafter the normal or repetitive phase of spare parts life cycle. The relevant aspect to be studied in the next section is the inventory control; basically answering the questions of when and how much to replace of each part.

Teunter and Duncan compared the following methods: Moving Average, Simple Exponential Smoothing, Croston's, SBA, and bootstrapping. Initially, the inadequacy of the traditional forecasting error measures (MAD, MSE, MAPE) was discussed and the adoption of measures based on the service and inventory level was recommended. The study realized with 5,000 spare parts for British air-force (RAF) proved the superiority of Croston's, SBA and bootstrapping techniques. The authors propose adjustments in the demand forecasting during the lead-time, so that orders are trigged when there is demand, obtaining better results than the original ones.

Van Mieghem and Rudi (2002) introduce a multidimensional capacity investment model involving a more specific, but still quite general, model of resource processing. This more specific model is a recourse linear program within a two-stage stochastic program involving uncertain demand variables in the right-hand side; following earlier work, the authors illustrate a solution approach for the investment problem based on a decomposition of the space of possible demands. This algorithm actually generates what we call a "definitive" collection of bases, which correspond to a dissection of the demand space facilitating solution of the stochastic program in the manner suggested above.

Willemain, Smart and Schwarz developed forecasting models for intermittent demands, using the bootstrapping technique to assess the demand distribution during lead-time, considering Rego, J. R. et al. Spare parts inventory ... a literature review. Prod. v. 21, n. 4, p. 656-666, 2011 657 autocorrelation and introducing small demand variations to the original series (jittering). Comparing the new model to Croston's method and exponential smoothing, they concluded that the first provides better results, especially for small historical series.

3. Performance Deviations

The literature reviews in study on inventory monitoring demonstrated a strong relationship between inventory monitoring and turnover and went further to show that an efficient inventory monitoring system assures accurate economic order quantities for stock.

Despite of the extensive work done on inventory monitoring and its impact on turnover before this research, most of this has been done on companies in the developed world; a research gap exists demonstrating the effectiveness of inventory monitoring on turnover.

This is the other variable of inventory planning that includes the systematic processing analysis and feedback of information that determines the accuracy and timely decision on the key data of inventory planning that includes demand history, costing history and stock level history.

The key ingredients of efficient information management include accurate outputs ensuring actual representation of system data that is real time. To do this information must be bench marked, captured consistently, and measured correctly. The best measure for good information management being how well system data

matches physical inventory Razi and Tam 2003.

Narasimhan argues that inventory turnover rate can be threatened when the physical inventory quantities do not match the on-hand quantities displayed by the information system. This is because information system must be able to display accurate quantities for each item as inaccuracies may lead to wrong sales promises to customers, leaving items unsold yet they are in the system or wrong procurement decisions due to wrong physical stock data.

4. Gap Analysis

The literature reviewed above shows the effectiveness of inventory and stores management practices on turnover as highlighted by several researchers from studies done in high income countries. The degree of the effect on the turnover varies from industry to industry but mainly how efficiently and effective companies implement inventory management practices. To assess the gap in information management system, a gap analysis needs to be done the gap analysis tool for assisting the organization to understand what information it holds and where it needs to improve to meet business needs in order to accurately forecast demand namely the data function gap and rationalization, in essence it looks at the extent to which the information required by the function is supported in practice, all information holdings should support some activity or should refer to some elements of the information system.

The literature indicates that having an efficient inventory monitoring system, information management system will directly have an effect on the company's turnover performance and growth.

However the studies reviewed the literature focuses on resource rich settings and non in the poor setting. The effectiveness of inventory and stores management practices may behave differently or may have negative results when applied to a company in a resource poor setting. There was need to carry out this research to evaluate the effectiveness of inventory and stores management practices on turnover in a company based in a poor resource setting.

Willemain*et al*. [26] in 2004 violated these assumptions in generating a comparative evaluation between Croston's method and ES. Various simulated scenarios covered a log normal distribution of demand size, and both positive and negative autocorrelations and cross correlations in the intervals and sizes. Through making comparisons only at times of positive demand, in all cases Croston's method was found to provide more accurate estimates of the true demand. The authors concluded that Croston's method is quite robust and has practical value beyond that claimed in Croston's original paper. However, an important observation was the fact that results from industrial data showed very modest benefits as compared to the simulation results.

The usefulness of Croston's method was also investigated by Rego and Mesquita[19] in 1996. A simulation analysis was conducted to determine the minimum interval between transactions that was required for a modification of Croston's method to outperform ES. Using a Poisson arrival process and a number of demand size distributions, comparisons were made between the errors observed at every point in time and only after a demand occurred. It was observed that the modified method outperformed ES when the average interval between demands is greater than 1.25 periods and the greater the interval the more marked the improvement. In addition, longer forecasting horizons were seen to improve the relative performance of the method while any variability in the demand size has only a small effect on the improvement.

Ouyang[18] in 2006 provided an extension to Holt's two-parameter smoothing method

for the case of intermittent data. Consideration is given to time series which naturally occur at irregular time intervals, such as the inventory applications covered in this research, as well as cases where the frequency of reporting changes from annual to quarterly, for example, or where occasional data observations are simply unavailable in an otherwise regularly spaced series. In many applications the extended procedure requires only about twice the resources of the regular method.

Periodic systems are put forward as preferred by stock controllers due to the convenience of regular ordering days for the stockist, as well as for the supplier who can plan efficient delivery routes. Ten periodic inventory policies are compared using real-world data from a spare parts depot and in each case five demand forecasting methods are used to determine values for *s* and *S*. The comparisons include simple rules developed by practicing stock controllers which relate alternative sets of (*s*,*S*) values to ranges of annual demands and the value or criticality of the item. Using two performance measures, namely annual inventory cost and the proportion of demands satisfied immediately from stock, the authors conclude that a 52-week moving average forecasting method is best, followed closely by Croston's method.[16]

With respect solely to slow-moving line items, Harrison[10] in 2009 considered renewal theory from the point of view of the supplier to forecast all-time future demand for spares where demand is declining or is about to decline in the immediate future due to the phasing out of the equipment to which the spares are fitted. At a point in time the spares will not be produced as part of a normal production run but must instead be produced during special production runs and will therefore be expensive to produce. For some items the costs of setting up a special run may be so great that it is worthwhile producing enough spares during the last production run to satisfy all future demand.

5. Conclusion

Satya Spare Parts Stores (SSPS) reveals Operational Constraints in areas of operations management, fleet management, management information, human resource and aspect which include how customer service levels, high costs of sales, uncertainty of customer demands, Long supplier Leads times and inaccurate procurement needs estimation. This study intends to undertake analysis on the success of inventory and stores management practices on turnover performance of Satya Spare Parts Stores and undertake a series of recommendations as to how these variables could reduce costs, increase efficiency and effectiveness and improve service delivery of Satya Spare Parts Stores.

The Firm is operating in a market with severe global competition. Strategic market research has exposed that customers want a wider range of services at lower costs. This means among others that the level of service agreed upon achievement of a product depends on the *application* of the product, rather than on the product itself.

References

[1]. Adeyemi S.L. and Salami A. O. (2010), Inventory Management: A Tool of Optimizing Resources in a Manufacturing Industry A Case Study of Coca-Cola Bottling Company, Ilorin Plant, J Soc Sic, 23(2): 135-142

[2]. Angel Raphella. S Mr. Gomathi Nathan. S Ms. Chitra. G,(2014) Inventory Management- A Case Study, International Journal of Emerging Research in Management &Technology, Volume-3, Issue-3, ISSN: 2278-9359.

[3]. Angelus, A., E. L. Porteus. 2002. Simultaneous capacity and production management of short-life-cycle, produce-to-stock goods under stochastic demand. Management Science 48(3) 399–413.

[4]. Botter, R., Fourtuin, L., (2000) Stocking strategy for service parts – a case study. International Journal of Operations & Production Management, v. 20-6, p. 656-674,.

[5]. Brackus, D. (2000), *A Model of US financial and Non – financial economic Bahaviour,* journal of money , Credit and banking , (12), 259-293.

[6]. EAVES, A. H. C.; KINGSMAN, B. G., (2004) Forecasting for the ordering and stock-holding of spare parts. Journal of the Operational Research Society, v. 50, p. 431-437.

[7]. Filippi, C., G. Romanin-Jacur. 2002. Multiparametric demand transportation problem. European Journal of Operational Research 139 206–219.

[8]. Ghobbar, A. A., Friend, C. H., (2003) Evaluation of Forecasting Methods for Intermittent Parts Demand in the Field of Aviation: a Predictive Model. Computers & Operations Research, v. 30, p. 2097-2114.

[9]. Gomes, A. V. P.; Wanke, P. (2008) Modelagem da gestão de estoques de peças de reposiçãoatravés de cadeias de Markov. Gestão & Produção, v. 15-1, p. 57-72, 2008.

[10]. Harrison, J. M., J. A. Van Mieghem. 2009. Multi-resource investment strategies: Operational hedging under demand uncertainty. European Journal of Operational Research 113 17–29.

[11]. Hsieh, C.H. (2002). Optimization of Fuzzy Production Inventory Models. Information Sciences, 146(1/4): 29–40

[12]. Kao, C., and Hsu, W.K. (2002). A Single-Period Inventory Model with Fuzzy Demand. Computer and Mathematic with Application, 43: 841-848.

[13]. Kotabo, K. (2002). *Management of Finance Company*, Sixth Edition. International Thomson Business Press, London

[14]. Krever, M. et al. (2005), Inventory control based on advanced probability theory, an application. European Journal of Operational Research, v. 162, p. 342-358.

[15]. Laugero, J. (2002). *Financial Management and Policy,* Eleventh Edition. Prentice Hall Lin A Simon and Schuster Company, U.S.A.

[16]. Main, L. (2000), *"Account Received management policy: Theory and Evidence"*, The journal of finance, 169-200.

[17]. Netessine, S., G. Dobson, R. A. Shumsky. 2002. Flexible service capacity: Optimal investment and the impact of demand correlation. Operations Research 50(2) 375–388.

[18]. Ouyang, L.Y., Wu, K.S., and Ho, C.H. (2006). Analysis of Optimal Vendor–Buyer Integrated Inventory Policy Involving Defective Items. Int J Adv Manuf Tech, 29(11/12): 1232–1245.

[19]. Rego J R D, Mesquita M A D, Spare parts inventory control: a literature review, (2011) Producao, v. 21, n. 4, pp. 656-666 doi: 10.1590/S0103-65132011005000002

[20]. Roberta S. R. and Bernard W. T., Operations Management: Quality and Competitiveness in a Global Environment, 5nd ed., John Wiley & Sons, 2006.

[21]. Schroeder RG 2000. Operations Management- Contemporary Concepts and Cases. USA: International Edition

[22]. Silver, E.A. (2008). Inventory Management: An Overview, Canadian Publications, Practical Applications and Suggestions for Future Research. INFOR, 46(1): 15-28.

[23]. Syntetos, A. A.; Keyes, M.; Babai, M. Z., (2009), Demand categorization in a European spare parts logistics network. International Journal of Operations & Production Management, v. 29-3, p. 292-316.

[24]. Teunter, R. H.; Duncan, L., (2009), Forecasting intermittent demand: a comparative study. Journal of the Operational Research Society, v. 60-3, p. 321-329.

[25]. Van Mieghem, J. A., N. Rudi. (2002) Newsvendor networks: Inventory management and capacity investment with discretionary activities. Manufacturing & Service Operations Management 4(4) 313–335.

[26]. Willemain, T. R.; Smart, C. N.; Schwarz, H. F., (2004), A new approach to forecasting intermittent demand for service parts inventories. International Journal of Forecasting, v. 20, p. 375-387.