Faculty of Manufacturing Engineering

ORDER PATTERN PREDICTION USING ARTIFICIAL INTELLIGENCE IN AN INVENTORY SYSTEM DESIGN

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DECLARATION

I hereby, declared this report entitled "Order Pattern Prediction Using Artificial Intelligence in an Inventory System Design" is the results of my own research except as cited in references.

Signature	:	………………………………………………………………..
Author's Name	:	………………………………………………………………..
Date	:	………………………………………………………………..

APPROVAL

I hereby, declare that I have read this report and in my opinion this report is sufficient in term of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Industrial Engineering).

Signature : ……………………………………………………………..

Supervisor's Name : ……………………………………………………………..

Date : ……………………………………………………………..

DEDICATION

I would like to dedicate this report to my beloved father Mohd Arshad Bin Iteh and my sweet mother Andon Binti Mohd Yatim because always support and pray for my success.

ABSTRACT

Achieving smmooth production is one of the major concern by the manufacturing industry. In order to have smooth production, waste must be avoided. Furthermore, the cost of investment in production can be high with contribution of Wasted activities especially high inventory management cost. Economic Order Quantity (EOQ) has been applied in inventory management in order to determine economic lot size. However, EOQ has limitation due to uncertain situation. Thus, the aim of this study to reduce cost investment in inventory. This study has three objectives, (1) to investigate ordering pattern ordering pattern which is affected the inventory, (2) to propose order pattern in inventory using ANFIS and (3) to evaluate proposed order pattern with cost investment. The study was conducted based on case study at the furniture company. The historical data of demand and supply was provided for 52 weeks. Firstly, the inventory level was investigated with the historical data based on stochastic EOQ model. From the investigation, shortage occurred because order does not make for a long time. Hence, the total cost of inventory was high. Then, investigated order pattern using Fuzzy Inference System and shortage still occurred. Thus, manual prediction order pattern was developed which to ensure the inventory just below reorder point. This purposed to ensure that every week order was took placed and shortage was avoided. Adaptive Neuro Fuzzy Inference System was used in order to find the parameters in forecasting the order quantity. The result showed that the proposed order pattern can avoid shortage and every week the inventory is below reorder point. Every week order is take place. Also, the total cost is reduced since no shortage occurs.

ABSTRAK

Industri pembuatan menitik beratkan kelancaran perjalanan dalam produksi. Pembaziran harus dielakkan dalam memastikan produksi berjalan dengan lancar. Tambahan lagi, pelaburan dalam produksi akan meningkat dengan adanya pembaziran, Economic Order Quantity (EOQ) diperkenalkan untuk mengenal pasti saiz lot yang ekonomi. Walau bagaimanapun, EOQ mempunyai had apabila di dalam keadaan yang tidak menentu. Oleh itu, tujuan kajian untuk menurunkan kos dalam mengendalikan inventori. Kajian ini mempunyai tiga objektif, (1) mengenal pasti corak pembelian dimana mengakibatkan inventori, (2) mencadangkan corak pembelian dengan ANFIS, (3) menilai cadangan corak dengan kos pelaburan dalam inventori. Kajian ini berdasarkan kajian kes di kilang perabot. Berbekalkan data kajian yang lalu selama 52 minggu kajian ini dijalankan. Pertama sekali, aras inventori dikaji dan didapati bahawa terdapatnya "shortage". "Shortage" berlaku apabila berlakunya inventori menjadi kosong sehingga tidak dapat menampung permintaan sebelum waktu pengisian semula. Setelah, corak pembelian dikaji dengan FIS juga menunjukkan "shortage" tetap berlaku. Oleh itu, corak pembelian diutarakan dengan mencadang kuantiti pembelian dapat mengawal inventori supaya berada dibawah pengulangan pembelian. Oleh itu, "shortage" dapat dielakkan. Keputusan menunjukkan bahawa daripada cadangan corak pembelian dapat menghalang "shortage" dari berlaku dan jumlah kos berkurangan kerana tiada "shortage".

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A special thanks goes to the crucial role in my life which is my parents, who always encourage in doing this master project also very supportive and always be my backbone. Last but not least, many thanks to all my housemates, always cry and laugh together. My thanks and appreciations go to my colleague in developing the project and people who have always willingly helped me out with their abilities.

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CHAPTER 1

INTRODUCTION

This chapter will elaborate the background of the study, discuss the problem statements and emphasize the objectives to be achieved with the scope of study. It is also highlighted the structure of the report.

1.1 Background

The manufacturing industry contributes economic growth in the Malaysian economy (Harun, 2014). Manufacturing industry need smooth production line in order to chase customer requirement. Lean manufacturing is now globally practiced by the industries due to promise benefits towards productivity enhancement. Hence, non-productivity activity is avoided because of the cost contribution. Toyota's Taiichi Ohno is recognized with classifying seven different types of non-value-adding action that were disturbing the organization (Eaton, 2013). The seven wastes are waiting, over-production, rework, motion, transport, processing and inventory. Table 1.1 shows the type of waste that cause insufficient in manufacturing. Inventory management cost is one of the contribution in managing and costing problem.

Table 1.1: The Seven Waste in Manufacturing Sector (Eaton, 2013)

Waste	Manufacturing
1. Waiting	Waiting for parts to reach at a process
2. Over-production	Manufacturing more quantities than can be sold or have already been requested by customers
3. Rework	Consuming to attempt a task more than once because it was done incorrectly the first time.
4. Motion	The movement of human beings
5. Transport	The movement of material and tools
6. Processing	Do activity which not gives advantage for customer and manufacturer.
7. Inventory	The costs of holding, handling, storage and placing of stock.

Every actions in handling inventory will contribute cost. Especially when the storage too large. When inventory large need more space, managing and handling the quality of the item. All the activities contribute costing. Thus, size of inventory depends on the demand. Figure 1.1 shows the bell shape of demand. Demand is unpredictable and can be high, medium and low. Hence, if demand is high, the inventory size is small. While demand is low, inventory size will be huge.

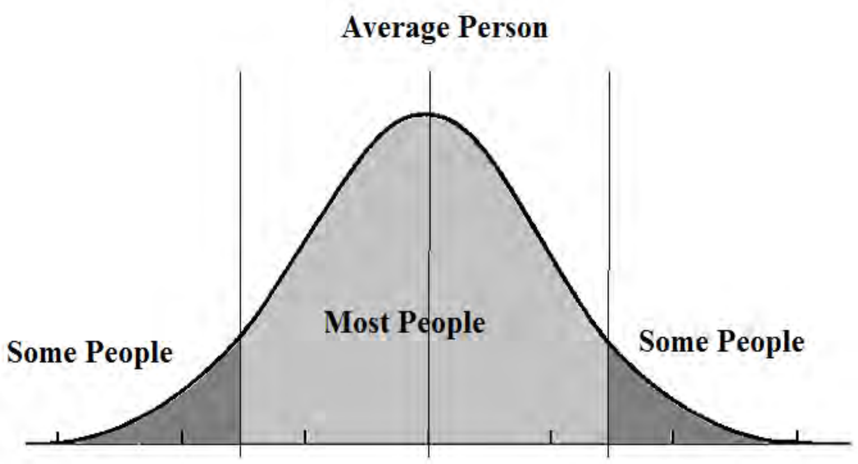

Figure 1.1: Bell Shape of Demand (Gonzalez and González, 2010).

Figure 1.2 shows the the relationship size of inventory and cost which contain the graph of carrying and restocking activity in inventory. From the carrying graph shows, the higher size of inventory, the higher the cost. While restocking shows that the less restocking activity, the lower the cost. Thus, the lower holding cost will be identified through optimum size of order quantity. This graph guides to manage the inventory with the lower cost.

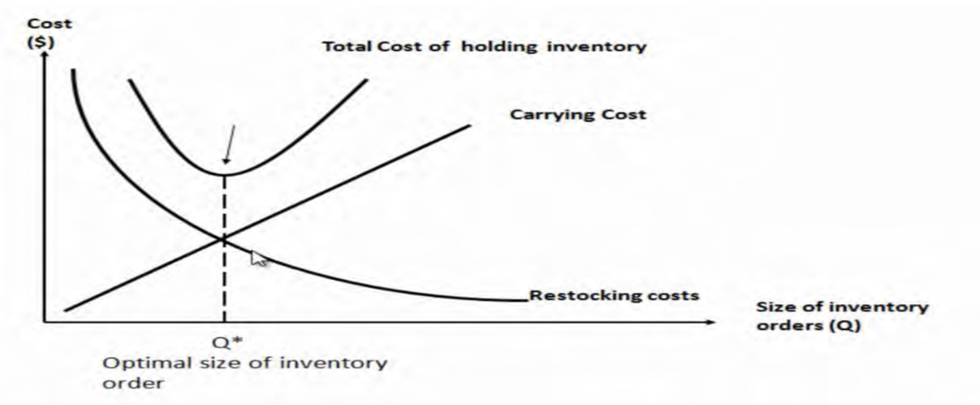

Figure 1.2: Inventory Size Versus Cost (Gonzalez and González, 2010).

The important in controlling inentory is balanced the size of inventory and frequency in ordering. Basically this approch is very assisting in minimize total cost of inventory.

1.2 Problem Statement

Starting from EOQ as the basic model developed, many researchers are defining the economic lot size and symbolized one of the best vital issues in production planning. EOQ is applied in managing inventory. Basically, every new order is fully delivered when inventory is zero. The ordering cost for each order placed is fixed regardless of the unit numbers of order. Furthermore, the cost for every unit in the storage known as holding cost. The important in defining optimal number of units to order is to get lower cost in purchasing, ordering and delivery cost. Figure 1.3 shows the connection between safety stock, lead time, order quantity and order point. Order quantity commonly fixed. The order point is determined by the average demand during the lead time. If the average change in the order point, effectively was there has been a revolution in safety stock.

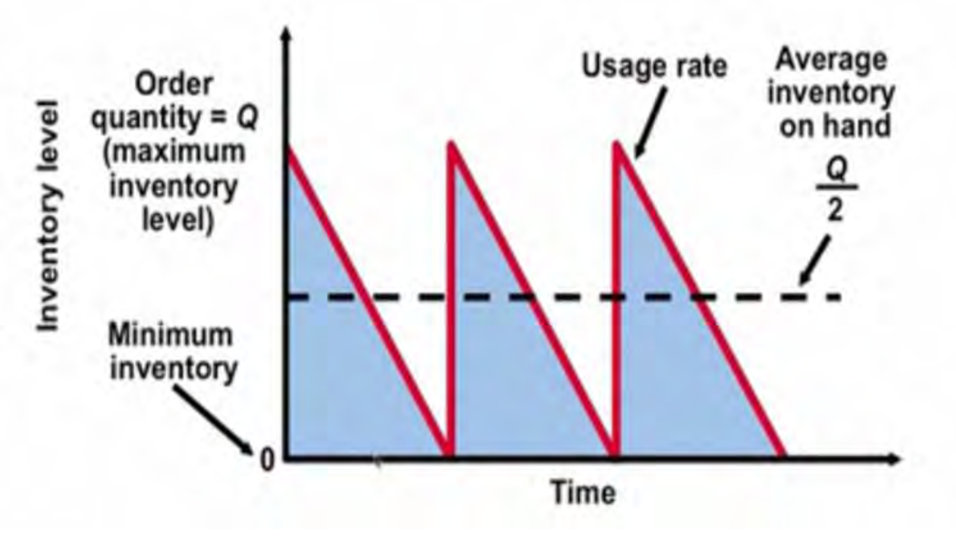

Figure 1.3: Stochastic EOQ (King, 2011).

However, through stochastic EOQ has several weaknesses. When the situation come with uncertain demand and supply. The situation as shown in Figure 1.4 difficult to calculate with EOQ. In real situation, demand is unpredictable. While supply is not always available due to customer requirement. Applying stochastic EOQ become more complicated when face with uncertain case. Shortage will happen when applying stochastic EOQ in managing inventory. Shortage is avoided because can cause problem while fulfil customer demand and cost for shortage is high. So, total cost will be increased.

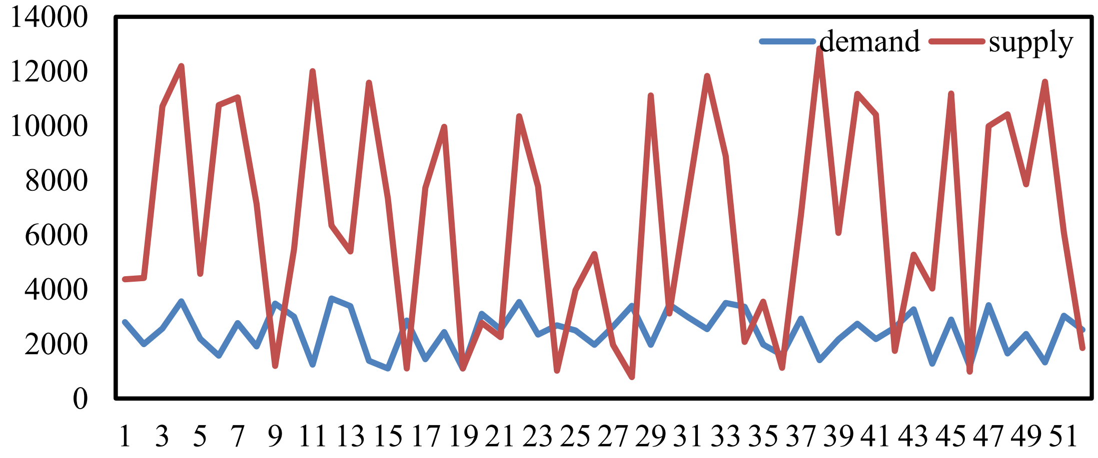

Figure 1.4: Uncertain Demand and Supply

1.3 Objectives

The objectives of this study are:

1. To investigate the current ordering pattern which is affected the inventory.
2. To propose order pattern in inventory control using artificial intelligence which is ANFIS.
3. To examine the cost of inventory investment.

1.4 Scope

This study was conducted based on historical data at furniture company. Also, focusing on inventory management. The priority of this study is to identify the minimum cost of inventory through optimum order quantity based on stochastic EOQ. Types of cost involve are ordering cost, holding cost and shortage cost. Then, propose minimum order quantity using artificial intelligence. The prediction of order quantity is based on historical data of demand and supply. The historical data of demand and supply was provided for 52 weeks. Then, the order pattern prediction was examined using historical data due to time limitation.

1.5 Project Outline

This section also can be linked to the present research that is in the process could be done and the expected achievement in the research planned could be set. This study was divided into five chapters. The second chapter will describe about the literature reviews which are focussing on the past studies that related to inventory and application of artificial intelligence in inventory problem. The references of this study are based from the books, journals, past research, article review and website. This chapter also discussed about the method were used to gain the information based from the researchers.

The third chapter, is discussing about methodology. This chapter describes on how the study is conducted using historical data which provided by furniture company. Also, explanation of inventory system and formula used in this case study. The flow in applied artificial intelligence is showed in this chapter.

Meanwhile for the chapter four, it expresses about the result and discussion. The result and analysis will determine whether the project achieves the objectives of the study. The inventory problem for current situation is investigated. The result of proposed order quantity is examined by inventory level and cost.

Lastly, the final chapter that is chapter five is discuss about the conclusion and future work of the study. This chapter includes the summary of the entire work, containing the problem statements, method used, and general results of the recommended approach to fulfil the objectives that was stated earlier.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature review explores the principal themes of the studies as well as research from various published material. The materials, namely journals, articles, books, and online resources are used as guidance and reference for the next phases of the project. The first phase of this is to differentiate type of inventory model with the problem by past reseachers. Also, how the researchers handle the problem with each type of inventory model. Second phase is how the researchers used computational intelligence to assist in solving the inventory model problem. This section also linked the past study process in solving inventory problem with Adaptive Neuro Fuzzy Inference System (ANFIS).

2.2 Lot Sizing Model

According to Aengchuan and Phruksaphanrat (2015), lot sizing is divided into three categories which are deterministic, stochastic and fuzzy lot sizing model like in Figure 2.1 shows the illustration of lot size model. For both deterministic and stochastic are divided into two groups. All these types of model has its own parameter and situation in inventory management.

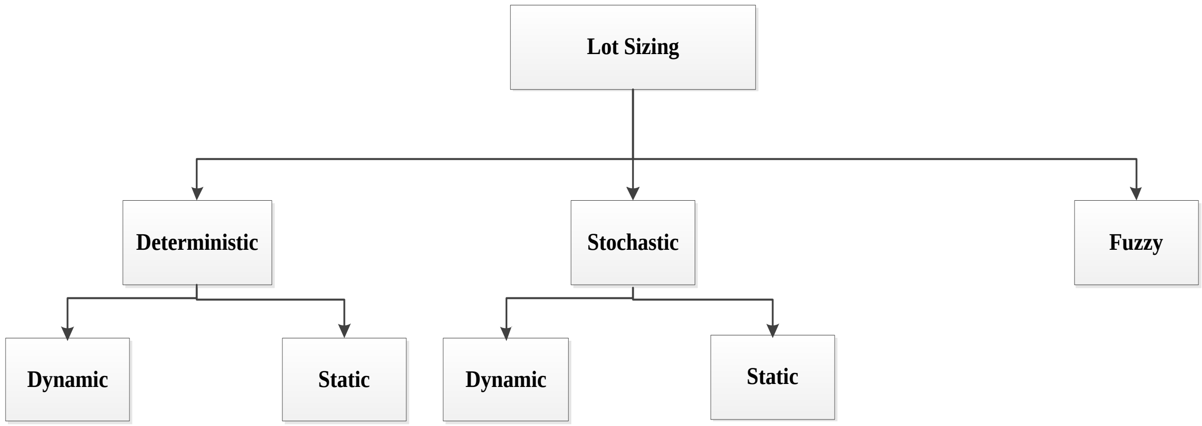

Figure 2.1: Lot Sizing Model(Aengchuan and Phruksaphanrat, 2015)

2.2.1 Deterministic Lot Sizing Model

Normally, deterministic stochastic use heuristics method in solving realistic lot-sizing model problem (Dixon and Silver, 1981). The original model of static deterministic lot sizing model known as Economic Quantity Order (EOQ). The objective of EOQ is to minimize the sum of holding cost and ordering cost. Pentico et al., (2009) had develop new approach which is develop calculations for the EOQ with half backordering that are more like those for the EOQ with full backordering to improve a comparable model for the EPQ with partial backordering. The complicated situation in inventory will appear during determine the optimal ordering and shortage quantities. This is because the optimal quantities cannot chase the demand requirement. Hence, this situation will affect the end result which lost occurred.

EOQ model has been develop in weakening item over finite time distance when demand is quadratic decreasing function of price. Numerical examples and sensitivity of the model is analysed for all types of price-varying demand function. This approach is used to discover the optimal ordering quantity and optimal sales prices where can maximum the vendor's total revenue (Sankar Sana, 2011). Based on Senyigit and Erol (2009), the formulation is starting with simplest deterministic case. In deterministic case, predict the demand and price are known while lead time is equal to zero. Use the objective function in order to identify minimum total relevant cost with the demand as constraint.

Moreover, quality of the product also can effect the inventory management. According to Ullah and Kang (2014), the imperpection product will causes work in process inventory. Thus, the optimum inventory lot size calculation and cooperate with inspection and rework consideration by using matematical model. The mathematical model is Group technology Order Quantity (GTOQ). Then, form a new model as GTOQIR. Where the notation at Table 2.1.

$$GTOQIR = \sqrt{\frac{2AD + iDRs^2}{i(1 - P_b)^2\big((C_M + Rm_1 + IR) + (Rm_r + IR)P_{1r}\big) + Di\big(\big((m_1 + m_r P_{1r})(2C_M + Rm_1 + Rm_r P_{Ir})\big) + (1(1 + P_{Ir}))}}$$

The equation above uses for ideal lot size that assessment has consequenced influence on lot size like increasing the assessment time, decreases the ideal lot size value. The model of QTOQIR model suggestively decreases the work in process inventory carrying cost and apply in manufacturing environment with high demand rate and machining time.

Table 1.1: List of Parameter Used Based GTOQIR Formular

Parameter	Description
Q	production lot size per cycle
D	demand rate of god quality product
S	setup time per cycle (unit time per setup)
m_1	machining time per unit for lot size Q in phase 1. (unit time per unit product)
m_r	machining time per unit for rework products (unit time per unit product)
P_{10}	percentage of products rejected as poor quality in phase 1
P_{11}	percentage of products qualified as good quality in phase 1 percentage
P_{21}	percentage of products qualified as good quality in phase 2 percentage
P_{20}	percentage of products rejected as poor quality in phase 2 percentage
P_{1r}	percentage of products rework able in phase 1, $QP_{1r}=Q(P_{20}+P_{21})$ percentage
P_b	percentage of poor quality products at the end of cycle
P_g	percentage of good quality products at the end of cycle
T_c	cycle time
T_p	total processing time
T	average manufacturing time for each product item
C_M	cost of raw material per unit ($/unit of product)
C_p	cost of purchase per unit of time ($/unit of time)
C_s	cost of setup per unit of time ($/unit of time)
C_i	cost of inspection per unit of time ($/unit of time)
C_{wip}	work in process holding cost per unit of time ($/unit of time)
C_H	inventory holding cost per unit of time ($/unit of time) total
C_{total}	total cost per unit of time ($/unit of time)
$\bar{I}$	average storage inventory
$\overline{w}$	average monetary value of the WIP inventory ($)
i	inventory holding cost per unit of time ($/unit of time)
c	average unit value of each product cost (unit of money ($) per unit)
R	rate charged per unit of cell production time including all overheads, moving cost, loading/unloading cost, etc. (unit of money ($) per unit of time)