

**COST OPTIMISATION OF MALAYSIA MEDICINE INVENTORY
THROUGH DEMAND FORECASTING AND NONLINEAR INVENTORY
MODEL**

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DEDICATION

For my beloved father and my late mother,

My supervisor and my friends.



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ABSTRACT

Managing inventory effectively is important for any organization, especially in the field of health service which plays major role in social development. However, inappropriate handling and management of inventory has the potential to severely hamper the health care services to patients. In view of this issue, practicing a systematic inventory management is very important to achieve the objectives of minimizing the investment in inventory while balancing supply and demand. Therefore, current study proposed and evaluated an inventory control model by integrating nonlinear inventory model, forecasting techniques and decision tree for pharmacies in Malaysia. The forecasting techniques were used to predict the optimum order quantity and nonlinear inventory model applied to minimize the total inventory cost in order to achieve the research objectives. The end result of the inventory control model was evaluated by decision tree analysis. Secondary data were collected from Malaysian Statistics on Medicines reports. The collected data were analyzed by QM for Windows software and Microsoft Excel. This research concluded that forecasting techniques play major role in minimizing the total inventory cost. Furthermore, a nonlinear inventory model was developed based on number of inventory order and applied to the forecasted and actual data to compute total inventory cost. It shows that the nonlinear inventory model and forecasting techniques proposed in this research were very suitable in predicting the budget for drugs in future. Finally, this research is highly potential in providing benefits in terms of business practices and the development of science which provides ideas on inventory system for pharmacies in Malaysia particularly using forecasting techniques and nonlinear inventory model.



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ABSTRAK

Pengurusan inventori yang berkesan adalah sangat penting untuk sesuatu organisasi, terutama sekali dalam bidang perkhidmatan kesihatan yang memainkan peranan penting dalam pembangua kesejahteraan sosial. Walaubagaimanapun, pengendalian dan pengurusan inventori yang tidak teratur akan mengganggu perkhidmatan kesihatan kepada pesakit. Oleh kerana itu, pelaksanaan pengurusan inventori sistematik adalah sangat penting dalam mencapai kos pelaburan inventori yang minimum sekaligus mengimbangkan permintaan dan penawaran. Oleh itu, kajian ini dikendalikan dengan bertujuan untuk mencadangkan dan menilai suatu model kawalan inventori yang berteraskan model inventori tak linear, teknik-teknik ramalan dan *decision tree* untuk farmasi-farmasi di Malaysia. Teknik-teknik ramalan digunakan untuk meramal kuantiti tempahan yang optimum dan model inventori tak linear digunakan untuk mengira jumlah kos inventori minimum dalam mencapai objektif-objektif kajian ini. Keputusan – keputusan akhir kajian ini dinilai dengan menggunakan analisis *decision tree*. Data-data sekunder telah dikumpul daripada laporan *Malaysian Statistics on Medicines*. Data – data yang berjaya dikumpulkan dianalisis dengan menggunakan *QM for Windows software* dan *Microsoft Excel*. Hasil utama kajian ini mendedahkan bahawa teknik-teknik ramalan memainkan peranan penting dalam meminimumkan jumlah kos inventori. Tambahan pula, suatu model inventori tak linear yang berasaskan kuantiti tempahan inventori telah dibangunkan dan diaplikasikan dalam data-data ramalan dan sebenar untuk mengira jumlah kos inventori. Ia menunjukkan bahawa model inventori tak linear dan teknik-teknik ramalan yang dicadangkan dalam kajian ini lebih sesuai untuk meramal bajet di masa hadapan. Akhir sekali, kajian ini mempunyai potensi yang tinggi dalam memberi manfaat dari segi urusniaga perniagaan dan kemajuan sains dalam bidang sistem inventori untuk farmasi-farmasi di Malaysia terutama sekali dengan menggunakan teknik-teknik ramalan dan pangaturcaraan tak linear.

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LIST OF SYMBOLS AND ABBREVIATIONS

MAD	-	Mean Absolute Deviation
MSE	-	Mean Squared Error
MAPE	-	Mean Absolute Percent Error
EMVs	-	Expected Monetary Values
NLI	-	Nonlinear Inventory Model



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CHAPTER 1

INTRODUCTION

1.1 Introduction

Managing a complete list of inventory is effectively important for any organization, especially in the field of health service which plays an important role in social development. Inventory usually represents a pharmacy's largest current asset (Rohatgi & Agrawal, 2016). However, inappropriate handling and management of inventory has the potential to severely hamper the health care services for the patients. This could be due to several factors such as inadequate storage space (Sardroud, 2012), over ordering and double handling (Donyavi & Flanagan, 2009; Saka, Olaore, & Olawumi, 2019), and incomplete and lack of up-to-date information regarding on-site stock (Navon & Berkovich, 2006).

Therefore, planning and implementing inventory control is very important in a pharmaceutical organization. Inventory monitoring is critical, which should maintain effective exchange for subsequent effective use in production or for services (Adeyemi & Salami, 2010; M. Mohiuddin, Sequeira, Antilla, & Patterson, 2018). (Abd Karim, Nawawi, & Salin, 2018; Bell & Stukhart, 1987) supported this statement by claiming that, an effective inventory control can ensure that the right quantity with great quality of materials can be easily supplied in a timely manner. They also concluded that, by having such an inventory management system the materials are easily obtained at reasonable cost and are available when needed. As a result, pharmacy managers will be well aware of both demand and availability of vital medicines in a hospital pharmacy. Having the essential medicines always in the pharmacy with the right price is necessary to meet the patients' demand as well as to

provide high quality patient care (Adane, Gizachew, & Kendie, 2019; A. K. Mohiuddin, 2020; Svingen, 2019).

Apart from that, having an effective inventory control can make a significant contribution to a company's profitability as well as increase its return rate on total asset investment (Adeyemi & Salami, 2010). Despite the different kinds of inventory items of a business, the proper inventory control technique can help to determine the sustainability of any goal focused business efficiently (Haribhai-Pitamber & Dhurup, 2014). For an example, inventory control indirectly runs a periodic review of expensive and vital drugs which brings out about 20% savings in pharmacy store budget (Mawengkang, 2020; Rohatgi & Agrawal, 2016).

In fact, inventory management can be improved by collaborating with forecasting process. Most of the inventory systems have always focused on the right forecasting techniques, even though it is only a minor part of the overall inventory management problem (Orchestro, 2015). Forecasting is the art and science of predicting the future events (Heizer & Render, 2011; Luc, Couprie, Lecun, & Verbeek, 2018; Luc, Neverova, Couprie, Verbeek, & LeCun, 2017). It has been used to predict the uncertain nature of business trends in an effort to help managers make better decisions and plans (Hanke, Wichern, & Reitsch, 2005). This activity is necessary because all the organizations operate in an atmosphere of uncertainty but decisions must be made that affect the future of the organization (Render, Stair, & Hanna, 2012).

The purpose of this research is to propose and evaluate an inventory control model by using the nonlinear inventory model and forecasting techniques for pharmacies in Malaysia. It is expected that, the proposed model will minimize the inventory cost and resolve material shortage issues for the company. This chapter explains the background of the study, the problem statement, and the objectives of the study, research questions and significance of the study.

1.2 Problem statement

Keeping inventory in the pharmacy department of a hospital has its own various costs which may, sometimes, be more than the value of the commodity being carried out in stores. The value of inventory to all pharmacies continues to rise due to the increased variety and expense of pharmaceutical products (Rohatgi & Agrawal,



2016). Apart from that, medicine pricing and affordability has always been of great concern for the public and governments of developed and developing countries (Abdel Rida, Mohamed Ibrahim, Babar, & Owusu, 2017; Yang, Dib, Zhu, Qi, & Zhang, 2009). The medicine cost contributes significantly to the budget of developing countries and drug expenditure is second only to staff salaries and benefits, accounting for perhaps 50% – 90% of non-personnel costs (Quick *et al.*, 1997). High priced medicine is not only a problem for public but also a major burden on government's budgets. Thus, despite higher Gross Domestic Product (GDP) and more relative wealth of a country, emphasis on the principle of affordable healthcare is still required (Babar, Ibrahim, Singh, & Bukhari, 2010; de Paula Moura & Moura, 2016). It is therefore required that the policies concerning medicine pricing and procurement strategies must ensure affordability of medicines.

The purpose of this research is to propose and evaluate an inventory control model by using the nonlinear programming with budget constraint and forecasting techniques for pharmacies in public hospitals in Malaysia. It is expected that, the proposed model will minimize the total annual inventory cost and resolve medicine wastage issues through optimum order quantity.

1.3 Research questions

This study seeks to answer the following specific research questions regarding the above-mentioned problem and purpose:

1. What is the most accurate forecast demand for the selected inventory?
2. What is the optimum total cost of inventory?
3. What is the best decision alternative to optimize the inventory control?

1.4 Research objectives

The following are the specific objectives of this study:

1. To determine the most accurate forecast demand for the selected inventory.
2. To find the optimum total cost of inventory.
3. To choose the best decision alternative to optimize the inventory control.

1.5 Research scope

This research focuses on the pharmacy inventory in Malaysia's public hospital. The information in this analysis was derived from Malaysian medicines statistics records from 2014 to 2016. Forecasting techniques were used to estimate the evaluated data in order to find the optimal overall product prices.

1.6 Significance of research

This research concluded that forecasting techniques play major role in minimizing the total inventory cost. Furthermore, a nonlinear inventory model was developed based on number of inventory order and applied to the forecasted and actual data to compute the total inventory cost. It shows that the nonlinear inventory model and forecasting techniques proposed in this research were very suitable in predicting the budget for drugs in future. The results indicate that the forecasting techniques give the best estimate in purchasing the drugs in future.

Therefore, the NLI and forecasting techniques proposed in this research are highly potential to predict the budget for drugs efficiently. This will enable the management of public hospitals to prevent any financial issues in drug purchasing in the future.

Last but not least, this research is highly potential in providing benefits in terms of business practices and the development of science which provides ideas on inventory system for pharmacies in Malaysia particularly using forecasting techniques and nonlinear inventory model.

1.7 Organization of the thesis

The writing organization explains the transition of research progress according to chapters. The following is the explanation of the content of each chapter in this thesis.

1.7.1 Chapter 1: Introduction

In this chapter, the background of research title is elaborated and discussed. As the understanding of research background is clear, the problem statement is identified from the gap that exists in the research background. Research questions are formulated and relevant research objectives are presented. The suitable scope for the research was selected and the significance of research was highlighted thoroughly.

1.7.2 Chapter 2: Literature review

This chapter reviews the aspect of inventory and forecasting so that it can give a clear knowledge of relevant research regarding this research topic. It consists of the understanding of nonlinear inventory model and forecasting related to inventory management. Besides that, previous work on the inventory model and forecasting has also been elaborated in this chapter.

1.7.3 Chapter 3: Methodology

This chapter discusses the methodology that had been used to accomplish the aim of this research. The techniques used answer the research questions and research objectives. This chapter reviews the aspect of research approaches, research strategies, and data collection method.

1.7.4 Chapter 4: Data analysis

This chapter deals with data analysis and interpretation. It starts with inventory data, accuracy measure of forecasting, forecasting analysis, inventory analysis and decision tree analysis. The monthly purchasing data of top four drugs of public hospitals in Malaysia over the period of 2014-2016 was collected and analyzed to achieve all the research objectives.



1.7.5 Chapter 5: Discussion, recommendations and conclusion

In this chapter, research findings and result discuss further and have short summary at the end of the discussion. The limitations and problems that encountered during the whole process of collecting data, suggestions and further research also included in this chapter.

1.8 Conclusion

This chapter explains the basic outline of the research study. Essentially, the purpose of this research is to propose a nonlinear inventory model that will help to minimize the overall cost of pharmaceutical inventory in Malaysian general hospitals by using an appropriate forecasting process. This has a lot of potential for drug waste management. Finally, this study will provide benefits in business practice and scientific growth by providing an understanding of Malaysia's pharmaceutical inventory system. Any business will have an impact on the efficiency and effectiveness of inventory management. This will have an impact on the company's overall profitability.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the literature on the inventory and forecasting modeling's concepts and theories. Researcher will collect all the information or methods which are necessary to calculate optimal cost for inventory management in an organization. Some Management Science books will be references to help researcher for solving the inventory system problems. In addition, researcher also focuses on the previous studies which were conducted by previous researchers. It is important as guidelines or references while collecting data and information. Previous studies provided useful information for researcher. Purpose of this study is to identify optimal total inventory cost and resolved material shortage issues by nonlinear inventory model with forecasting techniques.

2.2 Management

Management can be described as coordinating and overseeing the work activities of others so that their activities are completed perfectly. It makes sure that each and every task within an organization is undertaken by the people responsible for doing them efficiently and effectively. Efficiency refers to get the most output from the least amount of input. It is also known as "doing things right" or in other words not wasting any resources. Effectiveness is often described as "doing the right thing", and it is the work that helps an organization achieves its goals. It clearly can be noted that efficiency is concerned with the means of getting things done, whereas



effectiveness is concerned with the ends, or attainment of organizational goals (Robbins, Decenzo, & Coulter, 2012).

In order to achieve high efficiency and effectiveness, four functions of management should be taken in consideration in an organization. Robbins *et al.*, (2012) describe these functions as planning, organizing, leading, and controlling. Planning refers to setting goals, establishing strategies, and developing plans to integrate and coordinate activities. Organizing involves arranging and structuring work to accomplish the organization's goal. Leading means working with and through people to accomplish organizational goal. Monitoring, comparing, and correcting work performance. Finally, controlling is monitoring, comparing, and correcting work performance. One of the main areas of management in an organization is operation management.

2.3 Operation management

Operations are systems or processes which are responsible for producing the goods or providing services from an organization. Operations management refers to the management of systems or processes that create goods or services (Stevenson, 2005). The creation of goods and services is defined as production. In manufacturing firms, the production activities that create goods are tangible products but in an organization that does not create a tangible product, where its production function may be less obvious. These outputs are called services. Regardless of whether the end products are goods or services, it should be organized systematically. In view of this point, quantitative methods in decision making play a major role in operation management. Particularly inventory models are highly potential in determining the financial status of an organization through inventory management itself.

2.4 Inventory

Inventory consists of usable but idle resources. The resource may be of any type for example men, materials, machines, etc. For example, if a company purchases a machine or appoints an expert in anticipation of the requirement of their services in future, these resources work as inventory. In general, as an economic alternative, inventory management and or machinery or expert advice is not carried where



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necessary. When the resource involved is material or goods, it is referred as stock or simply as “Inventory”. The term is generally used to indicate raw materials in process, finished product, packaging, spares and others’ stocked in order to meet an expected demand or distribution in the future. Though inventory of materials is an idle resource, it is not meant for immediate use, it is almost essential to maintain some inventories for the smooth functioning of an enterprise. Traditionally, inventory has been considered a necessary evil, some of which have led to very costly interventions, many of which have been wasted as a result of capital. Inventory control aims at maintaining the balance between these two extremes.

2.5 Inventory management

Inventory management is needed in any business. The proper inventory control technique can help to determine the sustainability in the business process. According to Stevenson, (2005), inventory is a stock or store of goods. Naturally, many of the items a firm carries in inventory are related to the kind of business it engages in. Manufacturing firms carry supplies of raw materials, purchased parts, partially finished items, and finished goods, as well as spare parts for machines, tools, and other supplies. The inventory models are referred to as independent-demand items, that is, items that are ready to be sold or used. There are also dependent-demand items, which are components of finished products, rather than the finished products themselves.

Adeyemi & Salami, (2010) defined inventory management is pivotal in an effective and efficient organization. It is also vital in the control of materials and goods that have to be held (or stored) for later use in the case of production or later exchange activities in the case of services. In their study conducted in Nigeria Bottling Company, Ilorin Plant, the conclusion that Adeyemi & Salami, (2010) drew is that effective inventory management can make a significant contribution to a company’s profit as well as increase its return on total assets. Therefore, inventory management is compulsory for the continuity and survival of any goal focused manufacturing organization.

On the other hand, Mwansele, Sichona, & Akarro, (2011) in their text also stated that inventories are idle stocks of goods stored and waiting to be used. For a manufacturing firm, there must be some inventory of raw materials and work in



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