DEVELOPMENT OF DEMAND FORECASTING MODEL FOR NEW PRODUCT

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To my beloved mother Maziah binti Ab Rahman

My late father Abu bin Abdullah

Along, Ngah, Nodi, Ayu, Adik

My supportive supervisor

Lecturers and friends

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ABSTRACT

Forecasting new product sales or service is a critical process in marketing strategies and product performance for an organisation. There are several methods to forecast new product sales or service and the common method used in industry nowadays is Bass Diffusion Model. Since the development of the Bass Diffusion Model in 1969, innovation of new diffusion theory has sparked considerable research among marketing science scholars, operational researchers and mathematicians. This research uses basic Bass Diffusion Model and the model is modified to analyse and forecast the vehicle demand in Malaysia. The objective of the proposed model is to represent the level of spread for the demands of new cars in the society in terms of a simple mathematical function. Since the amounts of available data are limited, a modified Bass Diffusion Model is developed to forecast the demand of new products. The selections of analogous product, parameter estimation method and different value potential market are discussed. A procedure of the proposed diffusion model is presented and the parameters of the model are estimated. The results obtained by applying the proposed model and numerical calculation show that the modified Bass Diffusion Model is robust and effective to forecast the demand of new product sales. This research concludes that the proposed modified Bass Diffusion Model has significantly contributed to forecast the level of spread for new product.

ABSTRAK

Ramalan jualan produk baharu atau perkhidmatan adalah satu proses genting dalam strategi pemasaran dan prestasi produk untuk sesebuah organisasi. Terdapat beberapa kaedah untuk meramal jualan produk baharu atau perkhidmatan dan kaedah yang biasa digunakan dalam industri pada masa kini adalah Model Resapan Bass. Semenjak pembangunan Model Resapan Bass pada tahun 1969, inovasi teori resapan baharu telah mencetuskan penyelidikan yang agak banyak di kalangan sarjana sains pemasaran, penyelidik operasi dan ahli matematik. Kajian ini menggunakan Model Resapan Bass yang asas dan model ini telah diubahsuai untuk menganalisis dan meramal permintaan kenderaan di Malaysia. Objektif model yang dicadangkan adalah untuk mewakili tahap penyebaran bagi permintaan kereta baharu di kalangan masyarakat dari segi fungsi matematik mudah. Oleh kerana jumlah data yang ada adalah terhad, Model Resapan Bass terubahsuai telah dibangunkan untuk meramal permintaan produk baharu. Pemilihan produk analogi, kaedah anggaran parameter dan nilai potensi pasaran yang berbeza telah dibincangkan. Prosedur model resapan yang dicadangkan telah dipersembahkan dan parameter kepada model tersebut telah dianggarkan. Keputusan yang diperolehi dengan menggunakan model yang dicadangkan dan pengiraan berangka menunjukkan bahawa Model Resapan Bass terubahsuai adalah kukuh dan berkesan untuk meramal permintaan jualan produk baharu. Kajian ini menyimpulkan bahawa Model Resapan Bass terubahsuai yang dicadangkan memberi sumbangan yang bermakna untuk meramal tahap penyebaran produk baharu.

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LIST OF SYMBOLS

m	-	Potential market
p	-	Coefficient of innovation
q	-	Coefficient of imitation
$F(t)$	-	Cumulative distribution function
$f(t)$	-	Probability density function
$S(t)$	-	Sales at time t
$Y(t)$	-	Cumulative number of adopters
$S(t)^*$	-	Size of peak sales
t^*	-	Time of peak sales
$\frac{dx}{dt}$	-	Derivative of the unknown function x
x	-	Background value of $\frac{dx}{dt}$
$x^{(0)}{}_{(k)}$	-	Actual value
$\hat{x}^{(0)}{}_{(n)}$	-	Predicted value
$x^{(1)}{}_{(k)}$	-	Accumulated generating operator (AGO)
BDM	-	Bass Diffusion Model
GA	-	Genetic Algorithm
OLS	-	Ordinary Least Square
MAPE	-	Mean Absolute Percentage Error
MMAPE	-	Modified Mean Absolute Percentage Error

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an introduction to the research. It begins with background of the study, the problem statements, objectives and scope of the study. This chapter also includes expected contributions of the study. Finally the organization of the thesis ends this chapter.

1.2 Background of Study

Forecasting is the science of predicting future outcomes. In particular, it also can be defined as process of predicting the values of a certain quantity over a certain time horizon based on past trends and a number of relevant factors. Forecasting is a common activity in various organizations and plays an important role in our daily life. Forecasting can be seen applied to areas such as weather, earthquakes, stock market, and economics. One of the main issues in forecasting is its accuracy. It is impossible to make forecast with zero error, but we can do our best to minimize the error. Nowadays, with fierce competition forecasting was played a main role in many economic and managerial fields. Forecasting methods are either qualitative or quantitative. Qualitative forecasting is one which relies mainly on judgments and opinions which may or may not be based on numerical data. On the other hand,

quantitative forecasting uses mathematical or simulation models based on historical data or relationships between variables. Frequently a qualitative forecast is made based on intuition or gut-feeling, then modified using qualitative data for more precise result.

Demand forecasting is an iterative process and a critical part of the supply chain that links supply to demand so that service providers have products available when and where they need them. It is essential for a firm to enable it to produce the required quantities at the right time and plan well in advance taking into view various factors of productions. Moreover, it is often critical in better planning for labour and allocation of national resources.

New product demand forecasting is a process that determines a reasonable estimate of sales attainable before the product is introduced under a given set of conditions. New product can mean different things to different people. Crawford and Benedetto (2008) stated that new product can mean six different things. They are new-to-the world products, new-to-the firm products, additions to existing product lines, improvements and revisions to existing products, repositioning and cost reductions. The need for accurate forecast new product is evident to an organization. However, achieving an accurate forecast is not easy in spite of the availability of many forecasting techniques. In this research, we focus on new product demand forecasting which receives less attention among the researchers.

Kahn (2006) stated that new product receive less attentions especially when counting number of publications on each respective topic. Today, there is a range of statistical tools available to enable managers to carry out forecasting using historical data. When sales pattern are relatively stable, more data should lead to more accurate forecasting. However, when it comes to a new product, forecasting becomes more difficult as a company has no available historical data directly relating to the product. Various studies have proposed different models to forecast new product sales. There is little systematic understanding and few guidelines about which model works best and there is no clear evidence of which of them would be best to recommend for accurate forecasting.

With growing economy, market competition becomes stronger. Facing such challenges, companies try to decrease their overall cost while attempting to maintain high customer satisfactions. One of the effective methods is to make forecast for the future demand in advance to predict sales which is used for successive operation planning and management. Accurate and effective demand forecasting can produce precise prediction of future sales which can significantly reduce management cost, inventory cost and transportation cost. When there is historical data, we are able to identify the number of demand each year and can control the production. When dealing with new products, there are some problems that need to be considered. First, new product forecasting has low credibility and low accuracy because there is no historical data to base on. Rather many conclusions are based on assumptions only. Second, the time to forecast new product is longer because it requires more manual attention. Finally, researchers face the problem of data uncertainty and data scarcity when it comes to new product. This research deals with all these problems of forecasting vehicle demand and to determine which method is the most appropriate for forecasting new product.

This study focuses on demand for new car models in Malaysia. It is hopes that the results will become real contribution for automotive industry to know their performance on new product. In Malaysia, there are two automobile industry organizations; Perusahan Otomobil Nasional Berhad (PROTON) and Perusahaan Otomobil Kedua Sendirian Berhad (PERODUA). Proton was incorporated in May 7, 1983 and launched the first Malaysian car, the Proton Saga, commercially on July 9, 1985. Since 1985, Proton still has been producing new models like Saga, Waja, Perdana and many more. Perodua was established later after the success of Proton and become second largest automobile manufacturer. In 1992 Perodua was established and launched their first car, the Perodua Kancil in August 1994.

During the last few decades, while many people had studied forecasting, new product demand forecasting has received less attention among the researchers. In view of this, this research will study the new product demand forecasting using specific method and will experiment with some of the applications for forecasting for selected new products in Malaysia.

1.3 Problem Statement

Proton and Perodua are the national car makers in Malaysia, which see demands of their various models increasing every year. Because of high demands, the companies produce new models and add features to enhance their existing products to gain consumer satisfaction. The problem is that they do not have specific time frame when they are supposed to produce new product or make modifications. Currently they just randomly assume that they will need to produce new car model or make modifications to the existing models five years after the launch of a new car. This study will investigate and develop a model to help Proton and Perodua in their decision of new products. The research questions include;

1. How to determine the maximum sales of the new product?
2. How to determine the time of peak sales of the new product?

1.4 Objectives of the Study

The main objectives of this research are to;

a. Model new product demand using new quantitative methods.
b. Develop a new Modified Bass Diffusion (MBD) model for forecasting new product demand based on selected industry.
c. Use a combined MBD and Grey model for improving forecast accuracy in forecasting new product demand.
d. Develop an experiment using MBD model for Proton and Perodua cars.
e. Develop a computerized system to perform MBDM forecasting or Proton and Perodua cars.

1.5 Scope of the Study

The scope of this study will focus on two subtopics; the data, in which types of data to be used will be discussed; and the forecasting models, in which the types of models used and presented, will be discussed.

1.5.1 Scope of the Data

The data used in this study are Proton and Perodua annual sales data for all models from January 2000 to December 2011. The data are obtained from Proton, Perodua and Malaysian Automotive Association (MAA).

1.5.2 Scope of the Model

In this thesis, forecasting method, Bass Diffusion Model and Grey Forecasting Model are used for forecasting new product demand. These will be applied to investigate the forecasting of new product demands for vehicles in Malaysia.

1.6 Expected Contribution of the Study

Although many researches had been done in investigating the forecasting of demands for new products, there are as yet no methods which are able to determine it for the car widely. This study attempts to find the best model for forecasting new car products in Malaysia. The expected contributions of this study are five.

First, the guidelines and procedures for using Bass Diffusion Model as the method in new product forecasting are presented. These guidelines will be useful for

the purpose of this current research as well as for those conducting a similar study. It is needed since ways and procedures on how to make forecast for new product cannot be found in detail in any literature. These guidelines also present the method and ways to determine the peak value of sales along with its timing. The details of it can be found in Chapters 3 and 4.

Second, this study presents how a forecast of a new product with no historical data may be determined by using data of analogous products. From the entire available similar products in the company, only one product will be used as an analogy to the new product. Chapter 4 shows the details on forecasting new product with no historical data and the expected output can make it easier for company to choose which product is the best as an analogy to the new product.

Third, this study attempts to develop a new model for forecasting new product with limited data and no historical data. A modified Bass Diffusion Model with Grey theory was proposed and applied to the Proton and Perodua data. This is due to the poor accuracy of Basic BDM when used on such data. The theoretical and experimental framework of the modified Bass Diffusion Model can be found in Chapters 3 and 6.

Fourth, the best model for forecasting new product is expected from this study as this study compares basic Bass Diffusion Model with the modified BDM using Grey theory. From the experiment and application to the real data from Proton and Perodua, this study shows that the modified Bass Diffusion Model with Grey theory give higher accuracy than the basic BDM. The details of it can be found in Chapter 6.

The last contribution from this study is the development of a system for forecasting new product using modified Bass Diffusion Model. This program needs to be developed as it is not available in any of the current statistical packages. This program is useful not only for the Proton data only, but can also be applied to any data with the minimum of four data. Using this program, user can choose either to

use parameters manually or automatically determine by the system. This program is useful and friendly use and they do not have to know the equation behind the program. The development of this system can be found in Appendix C.

1.7 Organization of the Thesis

This thesis consists of seven chapters, followed by reference and appendices. Chapter 1 begins with an introduction to the whole thesis, background of study, problem statement, objectives of study, case study, scope and expected contributions from the study, and lastly thesis organization.

Chapter 2 presents the literature review of this research. Various past works by different researchers are referred to and described. This review includes the details of the demand and new product forecasting, Bass Diffusion Model with its applications and some extensions, and forecasting using Grey model.

Chapter 3 discusses the research methodology used in this thesis. The chapter starts with an introduction of Bass Diffusion Model with its theoretical and empirical studies. Then the details of Grey model forecasting are discussed. The techniques of combining BDM with Grey model are also presented and forecast measurement end this chapter.

Chapter 4 focuses on results obtained from the experiment involving Bass Diffusion Model (BDM) when applied to vehicle sales data of Proton and Perodua. The aim of this chapter is to explore the development of BDM in forecasting new product. The chapter begins with exploring estimation methods such as ordinary least square (OLS) and genetic algorithm (GA), from which one method will be used for forecasting using BDM with limited and unavailable data. Discussions in this chapter end with a summary.

Chapter 5 discusses the results for the limited data case of the two automobile companies, Perusahaan Otomobil Nasional Sendirian Berhad (Proton) and Perusahaan Otomobil Kedua Sendirian Berhad (Perodua). Based on the results from limited data case, we proceed to the unavailable historical data case for Proton. An experiment was conducted to test the effect of different market potential on forecasting new product demand. The discussion in this chapter closes with a summary.

Chapter 6 describes the results of a modified BDM with Grey theory in forecasting demand for new vehicles in Malaysia. It begins with an introduction followed by the results of modified BDM model in limited and unavailable data case. Next, it discusses the effects of different market potential values on forecasting results of new vehicle. It closes with a suggestion of the best model for forecasting new product.

Chapter 7 presents the summary and conclusion of this research. Besides these, some suggestions for future research regarding extension of the combined model is also given in this chapter.

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