Far East Journal of Mathematical Sciences (FJMS)

http://www.pphmj.com
http://dx.doi.org/10.17654/MS105010079
Volume 105, Number 1, 2018, Pages 79-94 **ISSN: 0972-0871**

FORECASTING SALES DEMAND OF NEW PROTON CAR USING BASS DIFFUSION MODEL

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Abstract

Forecasting new product or service is a critical process in marketing strategies and product performance for an organization. There are several forecasting methods to forecast new product or service and the common method use in industry nowadays is Bass diffusion model. Since the publication 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 paper applied basic Bass diffusion model to make analysis and forecast for vehicle demand in Malaysia. The objective of the proposed model is to represent the level of spread on the new car among a given set of the societies in terms of a simple mathematical function that elapsed since the introduction of the new product. With the limited amount of data available for the new product, a robust Bass model was developed to forecast the demand. We discuss the selection of analogy product, selection of parameter estimation method and selection of different valued potential market.

Received: January 31, 2018; Revised: March 6, 2018; Accepted: April 17, 2018
Keywords and phrases: analogy, Bass diffusion model, vehicle demand.

A procedure of the proposed diffusion model was designed and the parameters were estimated. Results obtained by applying the proposed model and numerical calculation show that the proposed Bass diffusion model is robust and effective for forecasting demand of new product. This study concludes that the newly developed Bass diffusion of demand function has significantly contributed for forecasting the diffusion of new product.

1. Introduction

New product demand forecasting is a process that determines a reasonable estimate of sales attainable under a given set of conditions. New product can mean different things to different people. New product can be divided into six different definitions, which 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. When dealing with the new product demand, there are some problems that must be considered. Firstly, new product forecasting has low credibility and low accuracy level because of lack or no historical data as it is just based on assumptions. Secondly, time require to develop forecast of new product is longer because it requires more manual attention. Lastly, data uncertainty and data scarcity occurred when it comes to new product.

During the last few decades, many studies on demand forecasting but not much has been done on forecasting of new product demand. New product forecasting serves as a reality check by providing visibility to what is likely to happen. The forecast of new product demand forecasting is expected to be useful for company to know better the performance of their new product and take action about any in coincidences. In this paper, we focus on new product demand forecasting which receives less attention among the researchers. The main objective is to make analysis and forecast for automobile industry. Vehicle is categorized as consumer durable product which fall under the Bass diffusion model's requirement of product purchases that be spread out over time. This paper begins with introduction,

literature reviews, research methodology, analysis, results and discussion and ended with conclusions.

2. Literature Review

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of the social system [6]. In [5], Mahajan and Muller stated in their research on innovation diffusion and new product growth models in marketing that the objective of diffusion model is to represent the level of spread of an innovation among given set of prospective adopters over time. The purpose of the model is to depict the successive increases in the numbers of adopters and predict the continued development of a diffusion process which already in progress. *Innovative* models of diffusion focus on communications external to the social system such as advertising and personal selling [3]. The *imitative* models of diffusion focus on communications internal to the social system such as word of mouth reports and observation of other users [4]. The Bass model is by far the most common diffusion model used in marketing, and it is a mixed model capturing both innovative and imitative effects. This model assumed that the potential adopters of an innovation are influenced by two types of channel communications. One factor is the adopter receiving innovation from mass media and other external factors as innovators. The adopters normally receive innovation from word-of-mouth and observation or other interpersonal factors are called *imitators*. In building Bass model, the basic assumption is that the probability of an initial purchase takes place at time *t*, given that no purchase has yet been made is a linear function of the number of previous buyers.

In [8], Wenrong et al. applied Bass diffusion model to forecast the number of mobile service subscribers in Asia Pacific. They compared basic Bass model with diffusion by analogy and in estimating parameters, adaptive nonlinear square and genetic algorithm were used. The results show that basic Bass model performs better than diffusion by analogy. It is a common practice when forecasting using quantitative analogies, where experts are

asked to identify situations that are analogous to the target situation and for which the data are available. Kim et al. [4] then applied basic Bass model to forecast the diffusion of new technology in a market and showed that the model can be used in new technology product forecasting. In [7], Radojicic and Markovic also forecasted demand for new technology product in television using the basic Bass model. They found that the model can be used to predict the peak sales of new product forecast and able to forecast the timing of the peak sales.

Since there are not many previous studies of Bass model on the new product vehicle demand forecasting, this paper focuses on developing Bass model for forecasting new vehicle demand. The objective is to implement the basic Bass model in new product demand forecasting.

3. Methodology

3.1. Bass diffusion model

Bass model was developed by Bass [1] and widely used for new product forecasting. The main point in Bass model is about adoption and diffusion of innovative products or technology. This model usually uses a market analysis as the tool for forecasting future sales or demand for new product. There are two potential users seeking information for the products when new product is launched into the market. They are innovators who acquire information from the mass media and other external influences, while the imitative users get information from interpersonal influence such as word-of-mouth communications and observation. The influence of these two types of users was used by Bass.

From these two potential users, he came out with a theory of diffusion:

'*The probability that an initial purchase will be made at time T given that no purchase has yet been made is a linear function of the number of previous buyers*'. (Bass [1].)

Mathematically, the model can be written as:

$$P(t) = p + \left(\frac{q}{m}\right)Y(t), \tag{1}$$

where $P(t)$ is the probability of purchase at time t, $Y(t)$ is the number of previous buyers, m is the total number of buyers, p and q are the coefficients of innovators and imitators, respectively. Then, after some algebraic process, Bass [1] showed that the number of purchasing at time t as:

$$S(t) = pm + (q - p)Y(t) - \left(\frac{q}{m}\right)[Y(t)]^2, \tag{2}$$

where $S(t)$ is the sales at time t, and pm is the total number of buyers that initiate by innovators, $S(0) = pm$. The optimal time at peak sales and the size of peak sales are obtained by taking first derivatives of the Bass model, and from Bass [1], t^* time at peak sales is given by

$$t^* = \ln \frac{q}{p}\left(\frac{1}{p+q}\right). \tag{3}$$

The size of peak sales is given by

$$S(T) = \frac{m(p+q)^2}{4q}. \tag{4}$$

3.2. Parameter estimation

In Bass model diffusion, accurate forecast can be achieved by estimating the parameters and the parameters are p (innovators), q (imitators) and m (potential users). An analysis of parameter value shows that if $p \le q$, then the adopting curve will reach its peak points and the diffusion of the products is successful, if $p \ge q$, then the adopting curve will not reach its peak points. In estimating the parameters, from Bass [1], an analogue is used:

$$S(t) = a + bY(t-1) + c(Y(t-1))^2, \quad t = 2, 3, \ldots,$$

where $S(t)$ is sale at time t, $Y(t-1)$ is cumulative sale through period $t-1$ and a estimates pm, b estimates $(q - p)$ and c estimates $-\left(\frac{q}{m}\right)$: $-mc = q$,

$\frac{a}{m} = p$, then $b = q - p = (-mc) - \left(\frac{a}{m}\right)$; $cm^2 + bm + a = 0$, or $m = \frac{(-b \pm \sqrt{b^2 - 4ac})}{2c}$ and the parameters p, q and m can be identified by using regression and ordinary least square method. From Mahajan et al., there are two conditions when estimating parameters of new product demand, i.e., the availability of historical data and the non-availability of historical data. Historical data is defined as 'not available' when there are three or less data available. In such a case, the method employed is the management judgment and diffusion history of analogous products. Historical data is defined as 'available' when there are more than three data available and the least square method and regression method can be applied.

Previous researches had used different methods in parameter estimation including ordinary least square, nonlinear regression least square, maximum likelihood estimator (MLE), and genetic algorithm. However, in their study, they focused on new technology product such as television and mobile phones. Therefore, this paper focuses ordinary least square and nonlinear regression as method of parameter estimation on automobile industry in Malaysia.

4. Analysis

4.1. Case study

The automobile industry plays an important role in all countries around the world. It is an important source of national income, a leading earning foreign exchange through exports and a supporting industry for labor and employment. In facing a strong market competition, many companies tend to decrease their overall cost while maintaining high customers' satisfactions. Perusahan Otomobil Nasional Berhad (Proton) is one good example of automobile industries in Malaysia. It was incorporated in May 7, 1983 to manufacture, assemble and sell motor vehicles and related products, including accessories, spare parts and other components. Proton produced the first Malaysian car, Proton Saga, commercially launched on July 9, 1985

and since then, Proton still produces new models like Saga, Waja, Perdana and many more. The latest model produced by Proton is Preve which was launched in April 2012. However, since this study was conducted on 2012, we take Inspira as new product as Inspira was launched in November 2010.

4.2. Purpose of study

New product forecasting serves as a reality check by providing visibility to what is likely to happen. The forecast of new product demand forecasting is expected to be useful for companies to know better the performance of their new products and take action whenever necessary. In the past few decades, many studies were made on new product forecasting, but not much has been done on new product forecasting with limited data. Hence, this paper focused on new product forecasting with limited data in automobile industry. Inspira is the new product that we choose because it was the latest model in the company and new model to the world. As mentioned above, the purpose of this study is to explore the different methods to estimation parameters in automobile industry. So, we apply ordinary least square and nonlinear regression method to historical data for estimating the parameters p, q and m. We also want to investigate the changes of the model forecasting under different analogous products.

5. Results and Discussion

Forecasting by analogy is a forecasting method that assumes that two different kinds of phenomena which share the same model of behaviour. For example, one way to predict the sales of a new product is to choose an existing product which “looks like” the new product in terms of the expected demand pattern for sales of the product. When use Bass model, we must estimate the parameters p, q and m. In case of limited historical data available, the parameters cannot be estimated. For this, the method of analogy was used for the chosen existing product which is similar in a few aspects and estimate the parameters based on their historical product. In choosing the analogous product, there are several factors that need to be considered. The analogous product must have similar characteristics with the

new product in terms of structural features, sales pattern, growth pattern, and level of need. In this study, method of analogy was used to forecast the demand of Proton users depending upon the limited data available from Inspira as Inspira was launched in November 2010. From Mahajan et al., historical data Inspira are not available since there are only one year past data. For that reason, method of analogy was applied in estimating the parameters. In method of analogy, the diffusion estimates of parameters can be obtained by using the diffusion history of analogous product. Hence, 12 analogous products from Proton which are Satria, Iswara, Wira aeroback, Wira, Perdana, Waja, Gen 2, Savvy, Neo, Persona, Saga BLM and Exora were used. Among the products obtained, models that sales are less than 5 years that is having data less than 5 years will be excluded because of insufficient observed periods for the application of statistical forecasting methods. Therefore, models that were used are Satria, Waja, Perdana, Gen2 and Savvy. These cars are said analogous to Inspira because they are in same automobile industry and same company. From the similarity, we can infer that they included in the same segment and their demand will increase at the same rate. Hence, we assume that the diffusion parameters of these analogous products are the same as Proton Inspira.

Estimation by using ordinary least square method

Ordinary least square method was used because of more sufficient historical data from analogous product. The estimation results of m, p, q and their r-squared value are shown in the table below with different historical data.

Table 1. Parameter estimation using ordinary least square method

Model	m	p	q	r-squared	MAPE (%)
Satria	30530	0.1012	0.8842	0.853	49.61
Waja	173284	0.0397	0.5457	0.871	42.29
Perdana	14903	0.0359	0.5179	0.610	46.50
Gen2	69836	0.0606	1.1286	0.985	86.50
Savvy	23793	0.1164	0.7864	0.942	51.02

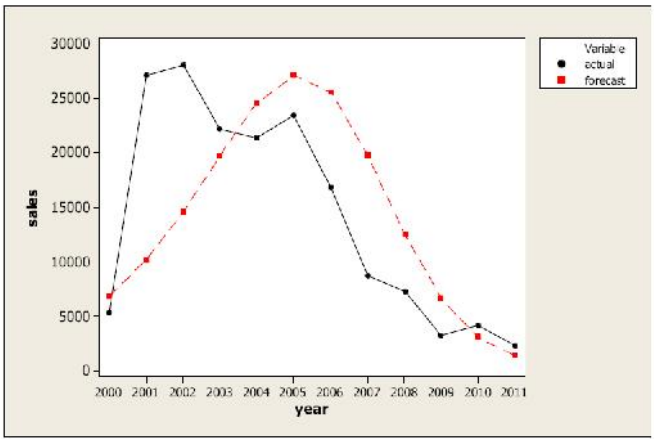


Figure 1(a). Current sales of Waja.

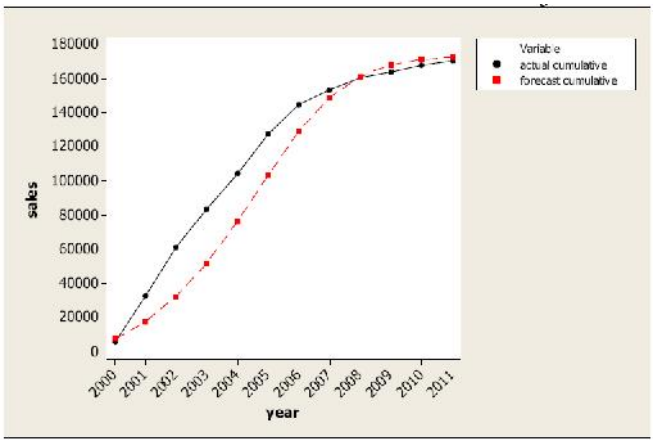


Figure 1(b). Cumulative sales of Waja.

Table 1 indicates that from five similar products to Inspira, Gen2 is not suitable because of the coefficient of imitators greater than one and the mean absolute percentage error is greater. Waja gives the best and reasonable parameter estimation as the mean absolute percentage error (MAPE) is the least, the coefficients of p and q are in between 0 and 1, market potential exceeds first purchase and r-squared value describes that 87% of the variation of the 'independent' variable can be explained by the variation of the 'dependent' variable, which means that r-squared value describes the growth rate of Waja quite well. Figure 1 presents the diffusion pattern of

Waja from Bass diffusion model from 2000 until 2011. The curve describes that the sale of Waja increases until 2005 which began to fall gradually as the market got saturated. However, while actual peak sales assume to reach 23413, forecasting peak value has reached 27147, about two years later than actual value. This is because, as the market potential changes, the inflection points approaching saturation level also change. Therefore, parameter estimation results from Waja were used in forecasting of Inspira.

Estimation by using nonlinear regression

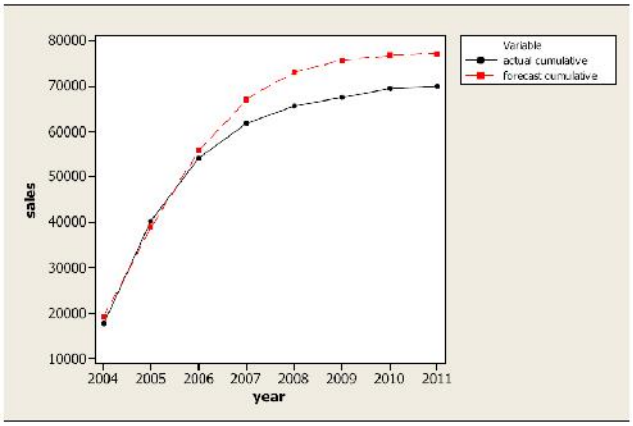
In [9], authors state that nonlinear regression is more effective than ordinary least square method. Therefore, we want to investigate the effectiveness of nonlinear regression in estimating diffusion parameters for automobile industry. In this estimation, we assume potential market is unchanged during diffusion period and can be estimated by intuitive. This paper uses SPSS 16 software to calculate the parameter estimation using nonlinear regression. Initial values of p and q are estimated using ordinary least square method. The parameter estimations are shown in the table below:

Table 2. Parameter estimation using nonlinear regression from SPSS 16

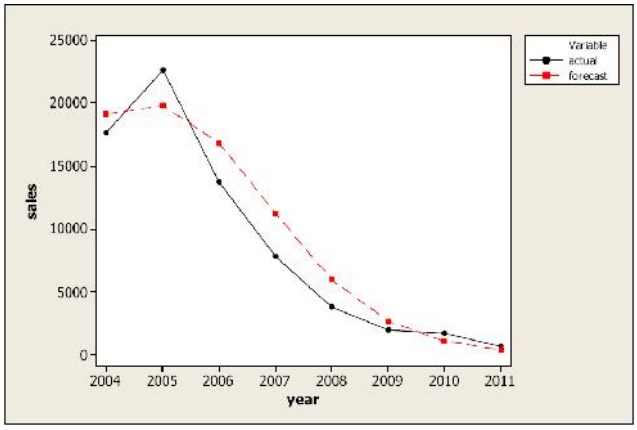
Model	m	p	q	r-squared	MAPE (%)
Satria	387192	0.032	0.348	0.710	512.40
Waja	174236	0.041	0.534	0.870	41.56
Perdana	19360	0.056	0.221	0.321	45.63
Gen2	77438	0.247	0.379	0.811	20.69
Savvy	38719	0.212	0.139	0.623	50.71

Table 2 indicates that from five similar products to Inspira, Savvy is not suitable because of the coefficient of imitators greater than coefficient of imitators, and Satria also not suitable due to large value of MAPE. Gen2 gives the best and reasonable parameter estimation as the mean absolute percentage error (MAPE) is the smallest, the coefficients of p and q are in between 0 and 1, market potential exceeds first purchase and r-squared value describes that 81% of the variation of the 'independent' variable can be explained by the variation of the 'dependent' variable, which means that r-

squared value describes the growth rate of Gen2 quite well. Figure 2 presents the diffusion pattern of Gen2 from Bass diffusion model from 2004 until 2011. The curve describes the sale of Proton Waja increases in 2005 which began to fall gradually as the market got saturated. However, while actual peak sales assume to reach 22617, forecasting peak value has reached 19861, the same peak year with actual but less value. This is because, as the market potential changes, the inflection points approaching saturation level also change. Therefore, parameter estimation results from Gen2 were used in forecasting of Inspira.



(a)



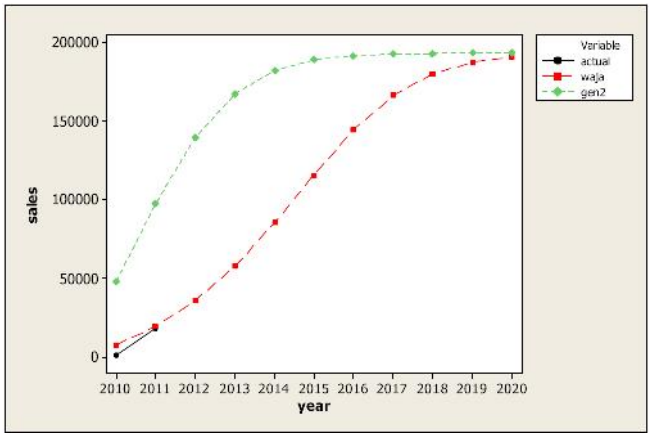
(b)

Figure 2. (a) Current sales of Gen2, (b) cumulative sales of Gen2.

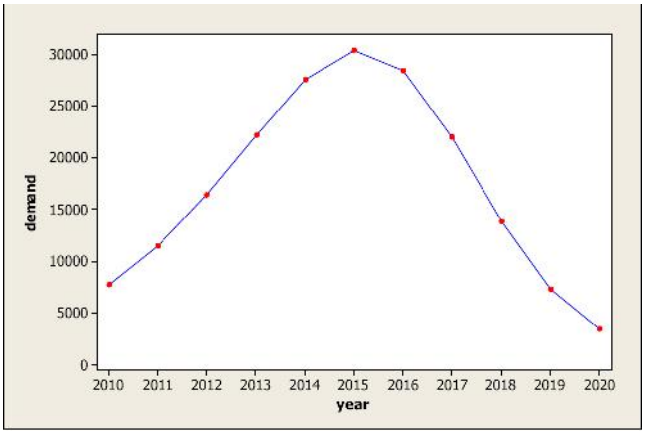
New product forecasting analysis

Bass diffusion model is famous in forecasting new product. In this study, we use Inspira as a new product. Since there is no historical data for new product, we employ the comparative procedure with the similar product or technology in the same organization for estimating the parameters. The similar products were discussed in section above. Estimation parameters using ordinary least square give Waja as the best similar product, and estimation parameters using nonlinear regression give Gen2 as the best product. Hence, we used these two products to estimate parameters for Inspira and choose the best parameter estimation and similar product. The forecasting results for Inspira are shown in Figure 3(a).

Figure 3(a) indicates that forecasting results for Inspira from Waja historical data are more accurate than Gen2. As shown in the figure above, actual data and forecasting data for Inspira using Waja historical data are quite similar than Gen2. Diffusion pattern using Waja illustrates the S-shape curve in product growth showing that the product increases and gets saturated as it reached the maximum sales. Therefore, we conclude that the best similar product is Waja and ordinary least square as the best parameter estimation method. The p and q parameters from Proton Waja were used to forecast sales for Proton Inspira. Figure 3(b) indicates that after the new product was launched in 2010, the sale increased every year and reached its peak in the year 2015. After that, the sales will slowly drop which means the new product has reached its saturated state. Figure 3(b) depicts that our forecast on new products follows the Bass diffusion process as the pattern of the adoption follows the diffusion pattern.



(a)



(b)

Figure 3. (a) Cumulative sales of Inspira, Waja and Gen2, (b) cumulative sales of Inspira.

Forecasting from different potential market

Variability of market potential gives different forecasting results. Bass diffusion model assumes that market potential unchanged during the entire diffusion period. Total of Proton car users from 2000 until the end of 2011 is 1935960 and the number of Inspira users from its launch until December of 2011 has reached 18180, which is 1% of the total Proton car users. As Inspira has just started, the market will greater, so, this study uses 10%, 20%

and 30% of total Proton car user to estimate the market potential. Market potentials m being 193596, 387192 and 580788. Estimation of coefficients p and q are from result estimation of Waja using ordinary least square when $p = 0.040$ and $q = 0.546$. Result of Inspira forecasting is shown in the figure below:

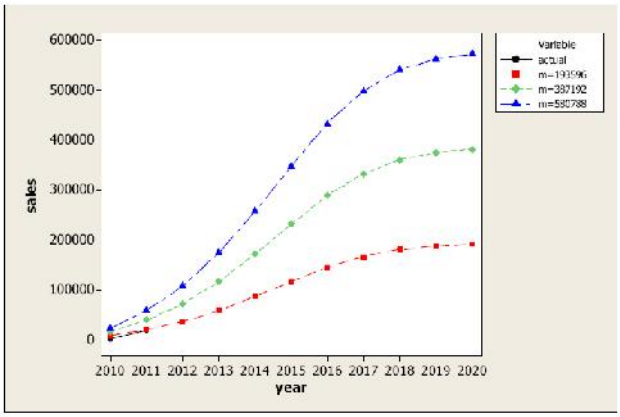


Figure 4. Cumulative number of Inspira using different market potential.

Figure 4 shows the diffusion curves of Inspira using different market potentials. As shown above, actual value and forecasted value are bigger in 2011 when using $m = 378192$ and 580788. The forecasted value is more near to actual data in 2011, when $m = 139596$. The result of this value could be that of Inspira accepting less than 20% of Proton car users.

6. Conclusion

Nowadays, researchers pay more attention on Bass diffusion model as a tool to forecast and investigate the growth of new product or services. In this paper, we used basic Bass diffusion model to make analysis and forecast Inspira users. We discuss the selection of analogy product, selection of parameter estimation method and selection of different valued potential market. Data that were used are adoption number of Proton car users in Malaysia from 2000 until 2011. First, method of analogy was employed due to the lack of historical data for Inspira. Then we study diffusion pattern of analogous product and estimate the parameters of suitable similar product. In

estimating parameters, we apply two methods as ordinary least square and nonlinear regression. Next, coefficient of parameters that got from suitable product was used in forecasting Inspira. In this study, we also look into effect of forecasting results on variability of potential market, *m*. According to this study, we found that ordinary least square method gives the best parameter estimation than nonlinear regression as the method also was used in almost parameter estimation for Bass diffusion model in other study. After applying ordinary least square to historical product, our finding shows that Waja is the best analogous product for Inspira. Hence, parameter estimation from Waja was used in forecasting Inspira. Results point out that demand for Inspira will increase after it gets introduced to market and reach its maximum demand at 30389 which is on 6th year after it launched and decrease gradually after peak demand. At this point, company will take initiative to maintain their performance as the demand goes down, sales also will go down. This study also reveals that using different values of potential market gives different forecasting results. The result of this study shows that Proton Inspira is accepting less than 20% of Proton car users as potential market.

There are few limiting factors in this study that could be resolved in further studies. As stated earlier, our forecasting is only based on basic Bass diffusion model that only involves imitators and innovators as the influencing factors to new product. Other external factors which may influence demand for new product are not included. For our future research, we will make a further study on other influencing factors in automobile industry.

Acknowledgments

This research was supported by the Ministry of Higher Education (MOHE) and the Faculty of Industrial Science and Technology, Universiti Malaysia Pahang. These supports are gratefully acknowledged.

The authors thank the anonymous referees for their valuable suggestions towards the improvement of the manuscript.

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