PRODUCT LIFE CYCLE MODELLING: A SYSTEM DYNAMICS APPROACH

Norhafiza Mohd Noor
Universiti Utara Malaysia, 06010 Sintok, Kedah.
fiza@uum.edu.my

Abstract: Modelling in system dynamics is very useful as it deals with the changing processes involved in all social systems. This project as a whole is dealing with modelling product life cycles, specifically those of consumer durable products. The modelling task begins with the formation of flow diagram of the product life cycle. After that, the equations writing take place where the units on both sides must be equal to each other. Then, the structure of the model is transferred into the software based on the equations formulated earlier. Finally, the testing and validating tasks need to be done to ensure a good model. Throughout the project, we found that product life cycle modelling is very useful as it can be used to forecast sales, provided that the model built has includes all relevant factors. Furthermore, the use of the Bass diffusion theory is very useful, not only on this project, but also on other areas as well. The modelling task requires patience and hard work in order to create a model that reflects the real world. However, the use of the POWERSIM software in the system dynamics modelling makes the modelling task easier.

Keywords: Modelling, Product life cycle, consumer durable products, Bass diffusion theory POWERSIM software

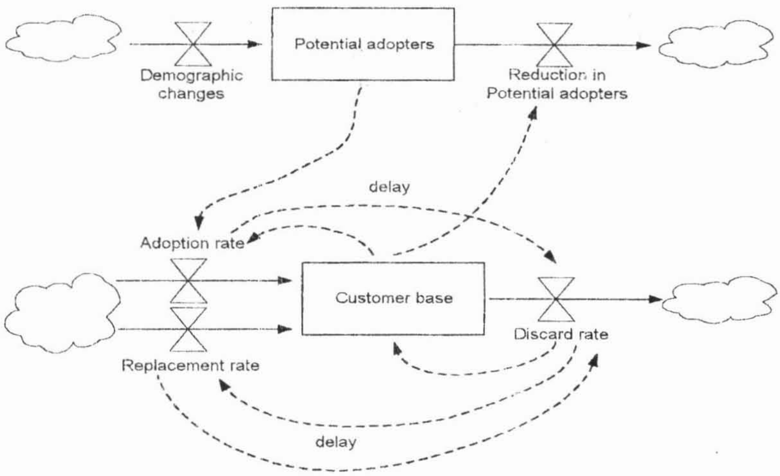
INTRODUCTION

Modelling is a vital tool for strategic planning and forecasting. It helps us to understand what is likely to happen in the future by studying what has happened in the past. Modelling in system dynamics is very useful as it deals with the changing process in all social systems. Innovation diffusion is about the flow of a product, services, ideas, concepts etc after it has been introduced. The theory of innovation diffusion was originally concerned about marketing and business management. However, as time has passed, the application of innovation diffusion theory has been broadened to other fields. In marketing, the diffusion of innovations occurs with every launch of a new type of product and it is widely believed to be influenced by both inter-personal and mass media communication. It is believed that product life cycle modelling may be able to avoid projected problem by well-strategy changes.

The author has tried to build the model as realistic as possible in order to cope with the current situation and the real world. However, due to time pressure, the model itself is very much simplified and does not necessarily completely reflect a real world product life cycle phenomenon. There are some limitations set in the project, which have been done to make the task easier. New product launch, involves many factors such as budgeting, pricing, an advertising campaign and actions of competitors. However, in this project, the author has limited the scope by just focusing on the acquisition of the new product and its eventual replacement made by the customers, which together will contribute to the total sales of the product. Other factors like budget and pricing were just ignored, as those factors need extra research.

MATERIALS AND METHODS

There are several software packages available for system dynamics modelling. For this project, we are going to use the POWERSIM software. Whatever software we choose, the process of modelling is still the same, meaning that it still has to follow the steps associating with it. A flow diagram is an important step for modelling in system dynamics. In a flow diagram, the structure of the system is revealed.

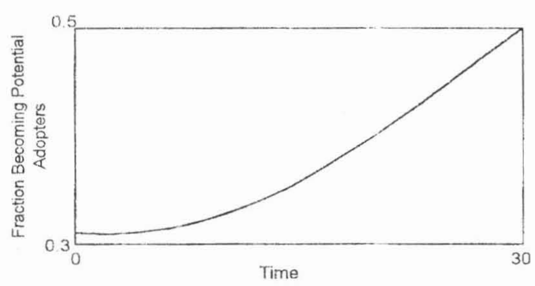


The above diagram shows the physical flow of the model. Potential adopters will become customer base through adoption rate, and as a result, there is a reduction in potential adopters. Replacement rate, like the adoption rate, will increase the capacity in the customer base. These two elements will then affect the discard rate, which on the other hand, will reduce on the customer base.

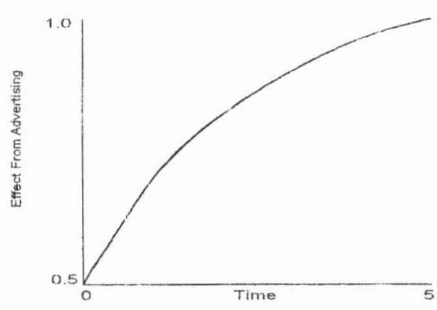
In POWERSIM, it is essential to do all the model structures, equations and calculations correctly before starting to use the software. The rate equations associated with the model are:

a) Population growth rate = population * 0.03
*note that 0.03 is the net increase rate for the UK population and it is assumed to be constant.

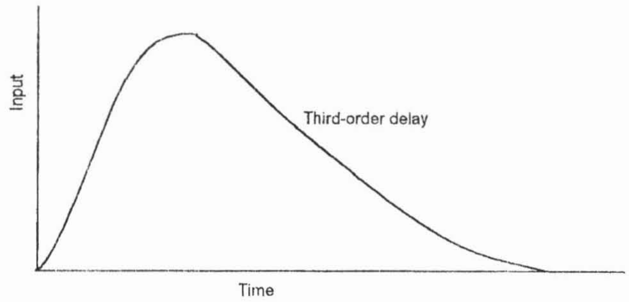
b) Potential adopters growth rate = population * fraction becoming potential adopters
*It is assume that the fraction becoming potential adopters is the fraction of households in the total population. The fraction is ranged from 0.3 to 0.5.



c) Adoption rate = (potential adopters * effect from advertising / time taken for the advertising to end) + (customer base * potential market ratio *growth factor)
* there are two factors affecting the adoption rate among adopters, namely advertising and the spread of news by word of mouth. The effect from advertising is ranged from 0.5 to 1.

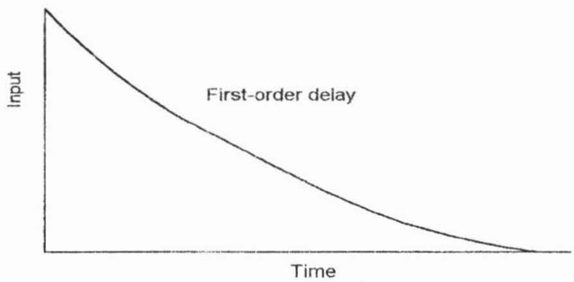


d) Discard rate = DELAYMTR (adoption rate, average lifetime of a product, 3,0) + DELAYMTR (replacement rate, average lifetime of a product, 3,0)
*the length of time taken by the adopters in order to discard the product depends on the average lifetime of the product itself. In this model, we assume that the discard process follows the Erlang distribution type 3. The reason being it is the best delay order to describe the discarding process of durable products.



e) Customer loyal rate = after discard population * (1 − fraction of losing customer)

f) Replacement rate = DELAYMTR (customer loyal rate, duration to replace,1,0)
*this is another delay process. However, the length it takes i.e. delay is shorter. Therefore, we use the first-order delay.



Levels represent accumulations in the resource flow, by taking both the inflow and the outflow into consideration. Unlike the rate equations, level equations are easier to manage. They are created automatically by POWERSIM. There are five levels in the model, namely population, potential adopters, customer base, after discard population and awaiting replacement population. The final two are internal levels in a third-order delay and first –order delay respectively.

RESULTS AND DISCUSSION

Figure 1 shows the complete model for this project.

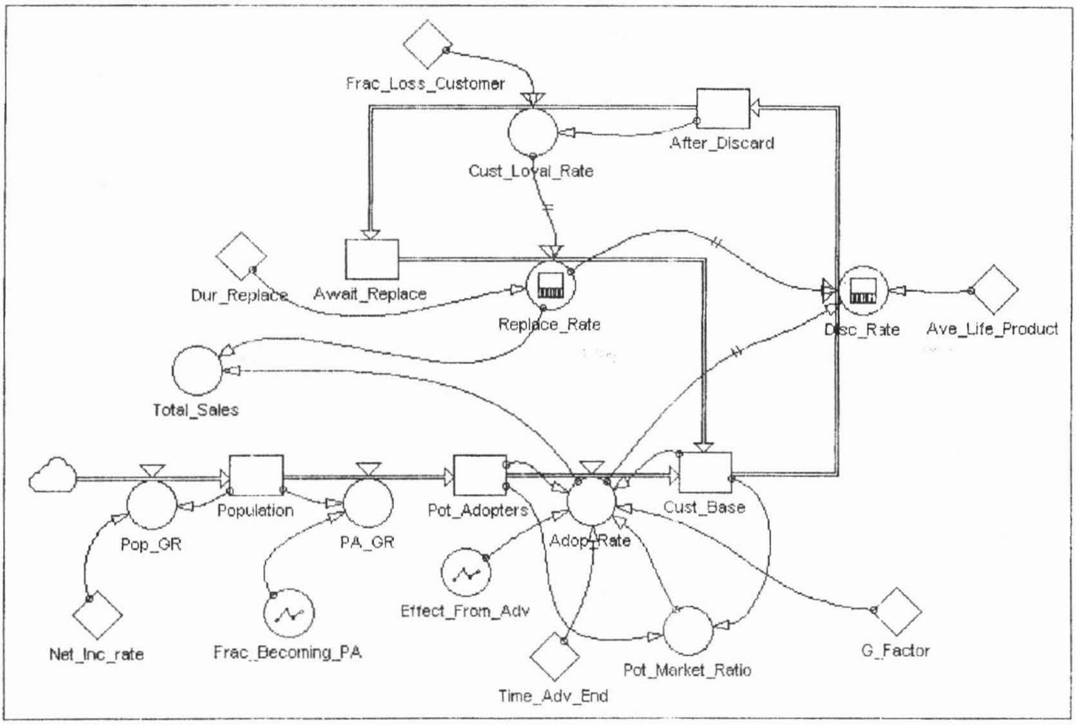


Figure 1: Model diagram of product life cycle

Once the model has been created, it is still considered wrong until the validation task being place. There are a few tests available and we are concentrating on the behaviour reproduction test. Using this test, the model should create a behaviour mode, which is not inconsistence with the actual system behaviour. A good model will generate output behaviour that is consistent with the real world. Figure 2 shows the behaviour of the repeat purchase model [2].

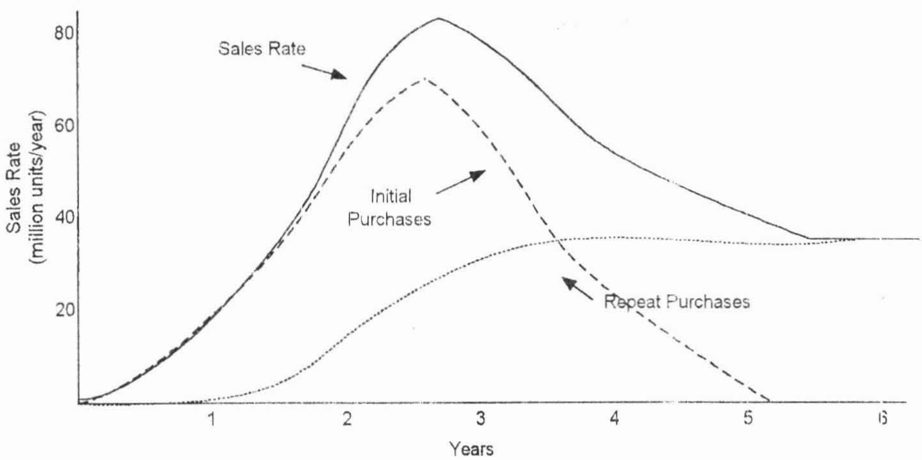


Figure 2: Behaviour of the repeat purchase model [2]

When there is a replacement, the customer base in the consumer market will increase and at the same time, the sales of the product will also increase. From the graph (figure 2), we can see that the behaviour of the initial purchases and the repeated purchases are mixed together and that lead to the total sales.

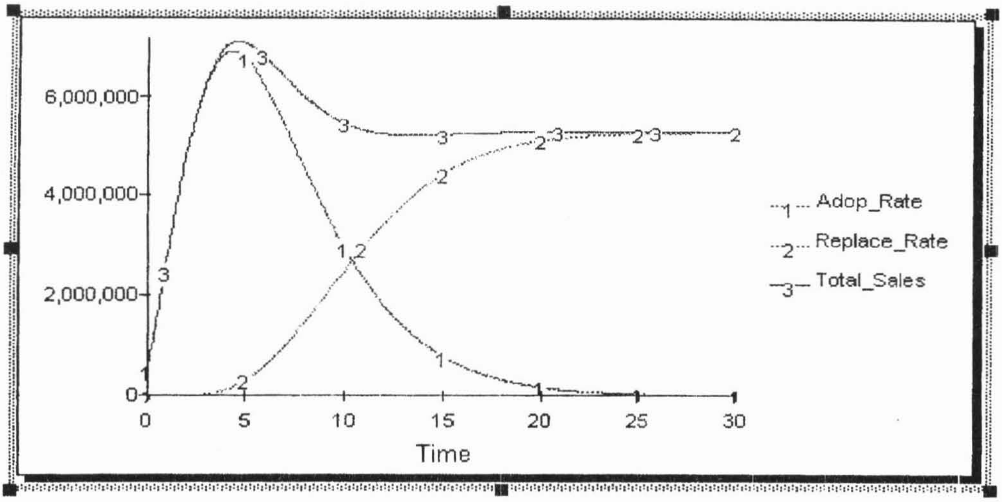


Figure 3: Behaviour of adoption rate, replacement rate and total sales

Figure 3 illustrates the adoption rate and the replacement rate, which then create the total sales in the model. It is clearly shown that the output follows the same behaviour of the repeat purchase model.

The conclusions that can be drawn after the completion of this project are:

- Product life cycle modelling is very useful and can be used to forecast the sales of the products provided that the model built includes all the relevant factors such as pricing, advertising, demand, supply and competitors.

- The Bass diffusion theory is very useful in product life cycle modelling as it explains the initial purchase behaviour in the product life cycle. Moreover, the use of diffusion of innovation theory is not only useful in modelling the product life cycle but also in other areas such as the spread of disease in infectious disease modelling.

- The use of the POWERSIM software in the system dynamics modelling is very useful and convenience. POWERSIM makes the modelling task easier and more manageable.

- The modelling task is not easy and one should always compare the model to reality in order to assess the results. The task to build the model, in addition, requires patience and hard work in order to make the model more appropriate and useful in the real world. Furthermore, the numerical constant used in the model must be logical. If not, the results obtained from the model will show absurd behaviour.

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