AN EXAMINATION OF NEW PRODUCT DIFFUSION

IN JAPAN AND TAIWAN

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of the requirements of the degree of
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This thesis is delicated to my dear ah'-po
-Mrs Chiu Chang Yu Mei

For a lady who could not afford the luxury of formal education, she had great faith and unshakable belief in the power of knowledge.

She taught me how to treasure the privilege of education, something that women were not entitled to in her time, and many generations before her.

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1 SUMMARY

The main objectives of this thesis here is to examine the applicability of the Bass model in Japan and Taiwan and to explore the diffusion characteristics of the adoption of new products in these two countries. The model was applied to thirteen consumer durables, of which five were common in both Japan and Taiwan. The time series data used in this study was obtained from relevant government publications in each country.

The performance of the Bass model was assessed in three broad ways: its ability to reproduce the diffusion process by using the full set of time-series data (descriptive ability); its adequacy in predicting future sales at any stage of a product's life (predictive ability); and the stability of the model when estimated on data at quarterly, semi-annual, and annual levels of aggregation (model stability). The nonlinear least squares (NLS) estimation procedure recommended by Srinivasan and Mason (1986) was used to estimate the diffusion parameters and consequently the diffusion curves for each of the products. Measures of performance used in this thesis include the plausibility of the estimated diffusion parameters, the adjusted R^2 between estimated and actual sales, and the accuracy of estimated and actual timing and magnitude of peak sales.

With respects to the tests of descriptive ability, the obtained results provided empirical support for the model's ability to produce the new product diffusion processes in both Japan and Taiwan. Based on the entire annual data set, the Bass model produced plausible diffusion parameters and described the diffusion curves more than adequately in most cases. The reported adjusted R^2 values were above 0.8 for fourteen of the eighteen products (nine products in each country) and the graphic presentations of the estimated versus actual diffusion curves indicated that the model provided adequate approximation of the diffusion cycle in the remaining cases.

The timing of peak sales were adequately estimated in both countries. However, while the model's estimates of peak magnitude were acceptable for the Japanese products, the level of peak sales was grossly underestimated in nearly half of the Taiwanese models. In most cases, this under-prediction was a consequence of the model not capturing drastic sales increases in the peak

time period. Future research is required to incorporate other exogenous variables into the original Bass model to produce better depictions of this unique diffusion event in Taiwan.

Overall, the model's ability in describing the diffusion processes in Japan and Taiwan provides support for using it to understand the diffusion phenomenon in these two countries and to further compare their diffusion patterns with those in the literature.

The forecasting performance of the Bass model in regard to predicting the diffusion parameters, peak timing and magnitude, and next period sales was somewhat disappointing. In about two-thirds of the cases, the model did not estimate the diffusion parameters accurately until one period after peak sales. The same observation was also found in the estimation of the timing and level of peak sales. Accurate estimates of peak timing and magnitude were only obtained after the inclusion of the peak time period. In terms of next period sales, the model produced inaccurate predictions in most cases and the results did not seem to improve as the number of data points increased. Overall, the results indicate that the validity of using the Bass model as a forecasting tool in Japan and Taiwan is questionable.

When applied to quarterly, half-yearly, and yearly data, the Bass model to produce stable estimates across the aggregation levels. In both Japan and Taiwan, the model was robust in producing plausible diffusion parameters, satisfactory model fits, comparable parameter estimates, and similar annual sales estimates across all aggregation levels. Although the fit of the model was affected by the amount of seasonality in the data, it did not translate into differences in the parameter estimates or annual sales predictions.

As the majority of international diffusion studies were based on annual data, this confirmation of the effectiveness of the Bass model at lower data aggregation levels adds significant value to the existing body of knowledge on new product diffusion in international markets. Moreover, as lower aggregation levels offer benefits of shorter waiting periods for each data point, it implies that marketing practitioners and academics can gain some insight on the diffusion process within three years of the product launch.

Since the generalisability of the Bass model was validated in Japan and Taiwan, the obtained diffusion parameters for air conditioners, personal computers, facsimiles, video cassette recorders, and microwave ovens were further compared between these two countries and with results reported from other studies.

The cross-national analysis indicated that while the coefficient of external influence p was significantly higher in Japan than Taiwan for air conditioners, video cassette recorders, and microwave ovens the coefficient of internal influence q was higher in Taiwan than in Japan in all cases. Also, when applying the learning model to all five products, the learning effect coefficient was only substantial for the two business-oriented products, i.e. personal computers and facsimiles. For the other three consumer durables, the faster rate of adoption in Taiwan was not the result of learning from Japanese consumers. In terms of future research, other relevant variables could be incorporated into the original Bass model to explore the underlying factors that govern the faster diffusion process in Taiwan.

Finally, a cross-study comparison was conducted with the purpose of finding out how the new product diffusion patterns in Japan and Taiwan differ from those reported in the literature. While the Japanese diffusion parameters were more closely aligned with European estimates, Taiwan was found to have a comparably lower external coefficient, p, and much higher internal coefficient, q, than Europe. In contrast to Takada and Jain (1991)'s findings where faster rate of adoption (as reflected in high q values) was observed in Japan and Taiwan than in the US, this study found that the Japanese diffusion patterns are more comparable with other industrialised European economies than with Taiwan. While the level of interpersonal influence has remained high in Taiwan, it seems to have decreased in Japan over the years. This observation appears to suggest that new product diffusion is not necessarily a constant phenomenon over time, with factors such as economical development and product characteristics impacting on diffusion patterns.

The scope of any study is finite with the main consequence being limits on the generalisability of the findings. Future research should focus on expanding the range of countries and common

product categories studied across them. In particular, the inclusion of fast moving consumer goods, a dynamic and innovative area in these countries, would be of much interest. Furthermore, it would be interesting to fit the model to brand level data in the same way as the study by Healey (1996).

The tests of predictive ability were only conducted at the annual level of aggregation and therefore, generalising to half-yearly, quarterly, or other levels of aggregation is not possible. This is of particular importance as diffusion effects such as seasonality would vary at these different aggregation levels. In practice, the model would be used for forecasting using shorter time periods.

The models estimated in this study were (with the exception of the learning model) all based on the original Bass (1969) model. Extensions of the model to include marketing mix variables, repeat purchases, and multiple product generations, and other external factors may help to better depict the Taiwanese diffusion curves, in terms of capturing the drastic increase of sales prior to and during peak sales, improve the forecasting performance of the model, and to provide useful insights into the diffusion characteristics in these countries.

2 INTRODUCTION

The diffusion of new products and services is an important marketing issue given the vast number of new products, brands, and brand extensions being developed and launched every year. Shorter product life cycles mean companies have less time to recoup development costs and optimise elements of the marketing mix. Accordingly, any prior information about the particular innovation or market is essential in aiding decision making.

As important is the development of models that can forecast sales and diffusion patterns prior to product launch and during the early stage of the product's life. Furthermore, understanding the diffusion dynamics of different geographic regions is a prerequisite for success in an increasingly global environment that retains many cultural nuances. All of these issues are addressed to some extent in this thesis, but it is the last of these which is the main focus.

The Bass diffusion model of new product growth (Bass, 1969) is a mathematical model which focuses on the process by which an innovation is adopted within a social system over time. The original model has three parameters: external influence, p, which represents the impact of factors external to the adopting population such as mass media and advertising; internal influence, q, which includes both verbal and nonverbal interpersonal effects within the adopting population; and the expected total number of adopters or market potential, m. Being inherently non-linear, the model is able to duplicate the s-shaped cumulative adoption curve regularly observed for new products (Dodds, 1973; Sharif and Ramanathan, 1981; Mahajan, Muller and Bass, 1995).

Since its introduction, the Bass model has become one of the most empirically researched subjects in marketing and the consequential body of knowledge consists of several dozen articles, books, and other assorted publications. Research has shown the model is adept at capturing and describing the diffusion process of a wide variety of products such as consumer durable goods, industrial technology, retail services, educational, agricultural, and pharmaceutical products (Mahajan, Muller, and Bass 1990).

By fitting the model to historical time series data, it can be used to explain diffusion patterns and test diffusion-related hypotheses, thus providing insight into the product life cycles of new products (Mahajan, Muller and Bass, 1990). For example, Rao and Yamada (1988) showed that the diffusion process of an innovation is affected by potential adopters' perceptions of the product.

The Bass model has been shown to have some value in predicting the timing and level of peak sales and the number of first purchase adopters in each time period (Dodds, 1973; Lawton and Lawton, 1979). These forecasting applications are of particular interests to marketing managers as they can be used to support decisions with regard to resource allocation (especially the marketing mix) and production.

A fruitful area of research has focused on extensions to the original Bass (1969) model. These accommodate marketing mix and other theoretically important variables, and generally involve relaxing the main assumptions underlying the model. For example, models incorporating non-constant market potential (Mahajan and Peterson, 1978), non-constant p, q, and m (Easingwood, Mahajan and Muller, 1983), repeat purchase (Lilien, Rao, and Kalish, 1981), product extensions (Norton and Bass, 1987), and marketing mix variables (Horsky and Simon, 1983; Kalish and Lilien, 1986; Bass, Krishnan and Jain, 1994) have been developed.

Apart from improved performance in terms of describing and predicting the new product diffusion process, these model extensions can be used for normative purposes. This involves the development of general decision rules regarding marketing mix and other variables over the product's planning horizon in order to maximise profits (Mahajan, Muller, and Bass, 1990, p16).

In international marketing, the normative value of Bass model extensions lies in guiding marketing mix decisions in different contextual situations (Mahajan, Muller, and Bass, 1990). For example, the learning effect model (Ganesh and Kumar, 1996; Ganesh, Kumar, and Subramaniam, 1997) assumes that the diffusion process in the lag country is affected by the rate of adoption in the lead country. If there are strong learning effects within a region, it may be profitable to concentrate marketing resources on the lead country, based on the expectation that this will have a flow-on

effect to other countries (i.e. a waterfall strategy). If the learning effects are minimal, then it could be more profitable to spread resources across the countries on the basis of market potential (i.e. a sprinkler strategy).

Diffusion researchers have also endeavoured to derive the most appropriate estimator of the Bass model's parameters in cases where historical data exists. In terms of fit, unbiasedness, and accuracy of standard errors, estimators have improved considerably since the first method of ordinary least squares (OLS) proposed by Bass (1969). The main procedure now used is non-linear least squares (NLS) estimation though maximum likelihood (ML) estimation has also been used on occasions. Methods for estimating the Bass model when little or no data is available have also been developed and tested with some promising results reported (Mahajan and Sharma, 1986; Gatignon, Eliashberg, and Robertson, 1989; Sultan, Farley, and Lehmann, 1990).

Unfortunately, to the detriment of the generalisability of the results in the marketing literature, most reported empirical applications of the Bass model have been in the U.S. and to a lesser extent Europe. As these nations are more economically developed and culturally different than other markets in the world, the obtained results might not be universally generalisable. The increasingly influential and developing Asian region is one example where previous Bass model findings may not apply. Only the study by Takada and Jain (1991) has attempted to understand the diffusion patterns of countries in this region. However, this study considered only older type consumer durable products such as televisions and air conditioners where peak sales were achieved more than two decades ago and whose relevance today is questionable.

The overall goal of this study is to continue adding to the already sizeable body of knowledge on the Bass model by extending the generalisability of the model to more recent product innovations in Japan and Taiwan. This will involve examining the Bass model's capacity to capture the diffusion process in Japan and Taiwan when calibrated on all available data, assessing the forecasting ability of the model in the two countries, and deciding if the model's estimates are stable and comparable across different levels of data aggregation.

Subsequently, the model will be used in an explanatory mode to test hypotheses related to

innovation diffusion across the two countries. The learning model will be estimated with Japan and Taiwan the lead and lag countries respectively. Finally, the diffusion patterns for Taiwan and Japan will be compared with results reported in the literature.