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Hybrid Model building for forecasting New Product Demand in Retail Chains

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Abstract: ***Predicting the demand of new products is extremely crucial as it has a strong bearing on manufacturing decisions, marketing efforts, sales strategies, financial planning and profitability. Predicting new product growth poses the challenge of having limited historical data points to model. In addition, they have highly uncertain future demand patterns and are heavily influenced by a host of external factors that are not completely known in the initial stages of the product life cycle. This solution adopts a hybrid methodology by analyzing the influence of new product adoption, its replacement cycle, behaviour of innovators and imitators purchasing this product and the impact of leading macroeconomic indicators on its demand.***

Keywords: ***New product, innovation, imitation, adoption, replacement, macro economy.***

I. INTRODUCTION

In today's market place, where business cycles are becoming shorter and complex, rate of innovation and product evolution becoming more rapid, it is imperative for retail managers to effectively allocate their resources to win and stay ahead of competition. Retail industry is one such innovation that has revolutionized the personal shopping space, with features like accessibility, price, variety, brand, mobility, and a whole new customer experience at a much lower cost than traditional markets. Companies that invest in predicting the growth trajectory of such retail industry have an advantage of planning their resources and strategies to tap the enormous market potential of this concept. Thus it is not only important to estimate its market potential but it is crucial to predict it accurately, as misses in market size estimates can significantly impact sales strategies, revenue share and shareholder value.

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II. LITERATURE REVIEW

New product forecasting literature has promoted many diffusion models. For example, Mahajan V, Wind JY, published innovation diffusion models in 1986. Similarly Mahajan V, Muller E, Bass FM published a set of new product diffusion models relevant to marketing in 1990. Morrison J also published an article on how to use diffusion models in new product forecasting in 1996. Diffusion models estimate the growth rate of product sales by considering various factors that influence consumers adopting a product. These models are typically employed for new product forecasting.

The BASS diffusion model (1969) is a widely used methodology to predict growth of new product technology. Frank Bass published his paper "A new product growth model for consumer durables" in 1969. The Bass Model or Bass Diffusion Model was developed by Frank Bass and it consists of a simple differential equation that describes the process of how new products get adopted in a population. Mathematically, the basic Bass diffusion is a Riccati equation with constant coefficients. The theory of the BASS model is intended to be applied to the growth of initial purchases of a broad range of distinctive "new" generic classes of products. In the paper they draw a distinction between new classes of products as opposed to new brands or new models of older products. An implication of this theory with the scope stated above is the suggested pattern of exponential growth of initial purchases to a peak followed by exponential decay. This is where the hybrid model to forecast demand of a disruptive product expands its scope to not only including new classes of products but its applicability to wider range of products that are variants or newer models of existing products. An example of such a case is modelling the growth of a new product like tablets which are an adaptation of most of the functionalities of a traditional personal computer. The underlying technology in the two products stated as not very different, hence the implication of product demand exponentially declining, as suggested by the BASS model does not hold true.

There already exists a standard methodology to estimate the demand for new products in retail. This have been in the market for long enough and hence has a rich historical base which can be used to apply conventional econometric modeling techniques like Auto regressive models with other independent variables to model its demand for the next forecast time periods. The same methodology cannot be applied to new products due to the lack of historical data points.

There is hence a strong need to develop a robust hybrid model considering various factors influencing new product growth to forecast its demand.

III. METHODOLOGY

This solution adopts a hybrid methodology by analyzing the influence of new product adoption, its replacement cycle, behaviour of innovators and imitators purchasing this product and the impact of leading macroeconomic indicators on its demand.

A. Components of the model

Innovation - Innovators adopt a new product on their own, without talking to other consumers. Initially when the product is introduced the innovation factor is expected to have a higher impact and eventually reduces over time.

Imitation - Imitators buy a new product after talking to other consumers and reading product reviews. The proportion of innovators and imitators can vary across geographies (developed versus emerging regions).

Replacement - The life cycle of the new product was determined to incorporate the phenomenon of consumers replacing their products over the years with newer versions. Higher weightage was given to people who bought the new product farther in the past when compared to those who had recently bought the product, as they are less likely to go in for a replacement in the near future.

Adoption - To understand the adoption factor, cannibalization of the existing product by the new product was considered. Some significant shifts that have occurred in the personal computing space like movements from desktops to notebooks, net books to tablets, and basic phones to smart phones were studied to use as a proxy to model cannibalization of the PC market by tablets (application of the model in our context). The conversion of basic phones to smart phones was found to be a good proxy. In other words, adoption simply indicated the proportion of potential buyers who will choose new products over a similar product already existing in the market. (E.g. Tablet over PC)

The estimated projection from the steps mentioned above goes through two more stages involving adjustments for seasonality and economic variables before arriving at the final projection.

Seasonality - The model projections are adjusted with historical tablet seasonality to factor in spikes from holiday seasons, introduction of new versions etc.

Economic impact –Finally variables like consumer price index and whole sales price index is incorporated for consumer and commercial segments respectively to factor in the impact of macro-economic trends on the market for new products.

B. Model Framework

In this model, data from various sources is collated and processed through the hybrid model where each of the components namely innovation, imitation, replacement, adoption, seasonality and economic impact are estimated. The output of this model estimates the total demand for the new products for the next few time periods across country groups and customer segments. The granular level models are rolled up to arrive at the projections for the region and worldwide level estimates.

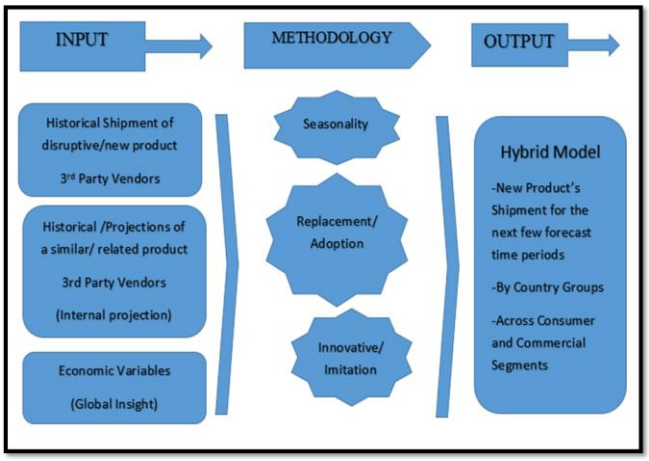

Fig. 1.Hybrid Model Framework

C. Model Equation

All submitted paper should be cutting edge, result oriented, original paper and under the scope of the journal that should belong to the engineering and technology area. In the paper title, there should not be word 'Overview/brief/ Introduction, Review, Case study/ Study, Survey, Approach, Comparative, Analysis, Comparative Investigation, Investigation'.

The generalized model equation can be depicted as follows:

Tablet shipment of a time interval

$$S(t) = f(\text{Adoption, Replacement, Innovation, Imitation}) * S(\text{Economic Variables})$$

$$S_j = \left[\lambda P_j + \sum_{i=1}^{j-1} W_{ij} * S_i + \frac{q}{m} N_j (m - N_j) + U_j\right] * E_j$$

Where,

- S_j is the total shipment in j^{th} time interval
- S_i is the ith interval shipment
- λ is elasticity derived from historical conversion from products that displayed similar adoption pattern (e.g. phone to smart phone)
- P_j is PC shipment in j^{th} quarter
- $W_{ij} = \sqrt{\left[\frac{(j-i)}{j}\right]}$ is a weight function created based on the assumption that the customer who has bought a product in earlier time interval has more probability to purchase a product again in current quarter compared to a customer who has bought the product in recent time interval
- q is imitation factor which one can derive from historical information
- m is total capable buyers of the product estimated by using historical information or similar products
- $N_j = \sum_{i-1}^{j-1} S_j$ is the cumulative shipments till $(j-1)^{th}$ time interval
- U_j is unexplained part (like: innovation etc), moving averages are used to forecast this component
- E_j is economic variable (CPI, WPI etc.) in j^{th} interval

IV. RESULT

A. Model results

The model is deployed for internal use within a retail chain. The results generated by the model are being used for business planning exercises at retail chains. The results have been consistent with the industry forecasts. The result shows the results created by the model in comparison with industry forecasts. In the diagram LCL stands for Lower control limit and UCL stands for upper control limit. They together provide the confidence band for forecasts.

C. Advantages of the model

The advantages of the proposed model are scalability, simplicity and flexibility. The key advantage of this model is that the underlying assumptions behind the forecasts can be analyzed whenever the model predicts accurately or misses the forecasts. Retail chains can then modify these assumptions as per its business understanding. Third party vendors such as don't share the model or detailed assumptions that underlie the forecast and as a result their forecasts have limited usage.

V. COMPETITIVE APPROACHES

A popular and a widely used methodology to predict new products' growth is the bass model (1969). In theory, the model is intended to be applied to the growth of initial purchases of a broad range of distinctive "new" generic classes of products. The model draws a distinction between new classes of products as opposed to new brands or new models of older products. An implication of this theory with the scope stated above is the suggested pattern of exponential growth of initial purchases to a peak followed by exponential decay. This pattern suggested by bass model proves to be restrictive when we look at prediction of new products that are variants or newer models of existing

VI. SUMMARY

The hybrid model explained above considers several relevant aspects impacting new product demand namely innovation and imitation behaviour in the market place, new product adoption patterns, and replacement cycles of buyers, seasonality and the influence of macro-economic variables. These parameters of the model can vary across geographies and customer segments making the model more flexible and robust. The underlying assumptions behind the model are known and can be tweaked according to business requirements to get more accurate results in prediction. This hybrid model is an effective solution when there are only few historical data points to model, a classic characteristic of new products. While the model was applied in the context of new product at a retail chain, the model can be leveraged for various product categories.

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