ABSTRACT

This dissertation aims at examining the product-line selection problem, with a view to develop an integrated model incorporating various factors like diverse customer preferences, supply chain constraints, and prevalent market conditions. As the given problem involves a number of complexities, we work towards the integrated model through a number of stages. Four Mathematical Programming models with different degrees of complexities are developed. Starting with a model for capturing the basis on which any customer decides on buying a product, we develop a model on product line optimization. The model is extended to incorporate manufacturing and supply chain constraints. In the final model, we attempt to incorporate the prevalent market conditions. Only the first model could be solved optimally using ILOG CPLEX 10.2. For the other three models, which are mixed integer non-linear programs, an attempt is made to characterize the optimal solutions. Heuristics are developed based on the characterization and examples are presented to illustrate the application of the heuristics. In the final section of the dissertation, the limitations of the study and the problems and issues in implementation are briefly presented. In the following paragraphs of the abstract, we put our work in perspective through a brief description of past studies and highlight the contributions of the respective models and their departure from the existing literature.

Conjoint and Mathematical Programming approaches have been used extensively in the past for capturing the consumer preference. The Mathematical Programming approaches are more versatile in their ability to capture complex behavior but have been limited to dealing with objective attributes. Conjoint Analysis, though limited by the additive utility assumption, allows for both subjective and objective attributes. In the first model that we develop in the present dissertation, we modify the existing mathematical models to account for situations where the decision maker may base her decisions on only a subset of the attributes. Identification of non-value added attributes might be helpful in reducing wastage of resources. Further, we enrich the scope of the model by accommodating both subjective and objective attributes. A limitation of the earlier mathematical programming approaches has been the use of interval scale data implying the gap between any two consecutive levels of an attribute are same. In the proposed model, we remove this drawback using ordinal-scaled data for objective attributes. The resulting MIP problem has been solved using the data provided in an earlier study in the context of a Conjoint Analysis. A comparison of the results of the proposed model and conjoint analysis is also provided.

Considering the diverse nature of the market, it is customary to offer multiple products. Studies in this area include application of conjoint analysis output for determining a number of product profiles. These product profiles are in terms of the levels of different attributes or features reflecting the preferences of different groups. Hence, variety among products is manifested in terms of different attributes or features present in a product. Each attribute in its turn, may be built-in in the product at different levels, giving rise to an increased choice for the customer. However, higher level of an attribute, yielding higher utility for the customers, typically requires higher costs. In this regard, product line optimization is concerned with the offering of a set of product variants to a large customer base such that certain objectives like maximization of buyers' utility, seller's return or social welfare can be met. Mathematical programming for

product line optimization is a well-researched topic. Contrary to the traditional mathematical programs for product line optimization where the pricing decision is determined exogenously, in the second model of our dissertation we consider simultaneous decision on pricing and product line optimization. This is because increasing price results in higher profit margin but lowers the attractiveness of the product to the customers.

The product development process is only complete after the product profiles are translated into tangible products. Each attribute and its corresponding level, as present in the product profile, needs translating into "modules", to be incorporated in the product. Any module is a tangible part of the product that serves to capture a specific level of a specific attribute. Thus, a product may be conceived as a combination of modules at different levels. Modular product platform strategy involves developing a family of products by using combinations of a group of modules, which are essentially components, or aggregates of the final product. The final product offering in terms of the modules that are to be incorporated in the product can only be determined after examining the economics of sourcing as well. Suppliers play an important role by supplying the required modules at a cost and the final products are assembled and sold to a market at a price. The costs associated with each of the suppliers and their capabilities become important factors in deciding on the configuration of the product. It is apparent that overall optimization would require simultaneous consideration of not only Product Platform development but also other supply chain constraints. Past studies indicate that these two are normally designed sequentially. Studies on simultaneous design of products and associated supply chains are relatively few. An attempt has been made in the third model of our dissertation, to develop a mathematical model for sourcing, production planning and Product line decisions. Based on analyses of the model, a heuristic solution procedure has been suggested. Finally, a simple example to illustrate the solution procedure is presented.

Existing research on product line optimization have focused mainly on designing a product line, without any explicit consideration of the underlying market structure. A few studies can be found that considers the monopolists' optimal product line offering. In this study, we examine the optimal product line decision for a firm under monopolistic competitive markets. Associated with a product offered to a segment, we consider: (a) a fixed cost of designing incurred by the firm, (b) value derived by the consumer; value being defined as the amount by which the worth of the product exceeds its price. (c) Profit earned on selling the product by the firm. The problem becomes complex when we consider cannibalization which may arise when a product, originally designed for a segment, gives a better value than the product designed for another segment and is within the maximum affordable price range of the latter. Based on the above, we develop a fourth mathematical programming formulation of an entrant firm's problem of deciding on the market segments to enter and the corresponding product designs to offer to maximize its profit. A heuristic has been presented for solving the resulting mixed integer non-linear programming problem.