A Thesis for the Degree of Ph.D. in Engineering

# Optimal Product Platform Configuration Decision in Mass Customization

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# Thesis Abstract

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Thesis Title

Optimal Product Platform Configuration Decision in Mass Customization


Thesis Summary

Platform-based product development (PPD) is a cost-efficient approach to achieve mass customization. Through PPD, manufacturers can develop various products to meet diverse customer preferences and requirements while maintaining production efficiency without compromising cost, quality, and delivery. One important problem in PPD is product platform configuration (PPC), which aims to identify and configure modules, components, or design variables on the product platform that can be shared across a product family. Two pertinent problems are: (1) how many and which type of product platform should be developed for a product family; (2) which product platform will be assigned to develop the product. The PPC decisions are endogenously linked to supply chain-related activities and will affect all the stages and sectors throughout the supply chain. Studying PPC problem from a supply chain management perspective is significant for manufacturers implementing the PPD approach. In this study, a modular platform configuration model is targeted, and various optimization methods are applied to determine the optimal platform configuration decision. More specifically, the following aspects will be targeted in this study.

In chapter 3, we study a modular platform configuration model. Modular design is recognized as the most important underlying architecture to support the product family design and product platform design. Two types of modular design approaches can be found, i.e., module selection and module integration. The platform configuration based on more module selections provides a broader solution space of possible platform configurations to meet the customer requirements exactly. However, it will increase the complexity of production process due to the proliferation of module types and part numbers. Module integration in the platform configuration facilitates the platform commonality to gain economic benefits. Traditional platform research focuses more on platform configuration based on module selection without considering the module integration simultaneously. A new model is developed to determine the optimal platform configuration for a product family while considering both module selection and integration. A hybrid-search method (HSM) combining simulated annealing (SA) and variable neighbourhood search (VNS) is developed to solve the proposed model.

In chapter 4, we examine the optimal platform configuration decision considering platform design strategy and supplier selection. Different types of platform design strategies can be found to satisfy product requirements, i.e., matching-designed, over-designed, under-designed, and hybrid-designed platforms. The matching-designed platform has a higher platform development cost and a lower customization cost while the over-designed or under-designed platform contributes different

performances in these two types of costs. Traditional research balances the cost trade-off within the design domain, and few studies include the relative procurement cost from suppliers. Involving the supplier selection problem at the earliest design stage has proven beneficial to companies. However, little attention has been paid to integrating supplier selection into the PPC problem. In this chapter, we propose a non-linear mixed-integer programming model to determine the optimal platform configuration decision while considering platform design strategy and supplier selection. A cost model including development cost, sourcing cost and customization cost is developed to illustrate the cost trade-off between platform development and customization. A solution method applying the linearization method with Gurobi solver is proposed to solve this model.

In chapter 5, we study the platform configuration problem considering demand uncertainty. Demand uncertainty is a huge challenge for supply chain management and product platform configuration. Generally, the development of product platform is ahead of new product introduction (NPI), which makes it difficult to forecast demand. Most existing research on platform configuration assumes that the demand is deterministic so that the problem can be easily dealt with. However, when considering the uncertain demand, the platform configuration decision may be changed, and the optimization problem will become more complex. How to determine the optimal PPC decision under demand uncertainty is highly important for manufacturers to develop product platform. This research gap will be filled in chapter 5. The platform configuration problem under demand uncertainty is formulated as a two-stage stochastic programming model, including the platform configuration stage and platform customization stage. A cost model including the development cost of platform, production cost and material cost for two stages, customization cost, and penalty cost of excessive platforms is developed. A linear programming embedded genetic algorithm is developed to solve the proposed model. The proposed algorithm searches the binary variables for platform configuration by using GA and determines the integer variables by solving a linear programming subproblem using Gurobi solver. Numerical experiments are conducted to illustrate the proposed model and algorithm.

***Keywords:*** platform-based product development, product platform configuration, supply chain cost model, mass customization, modular design, platform commonality, demand uncertainty, stochastic programming