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Robust Concept Set Selection for Risk Control in Product Development Project

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Abstract

New product development (NPD) project is with high uncertainty and known as a high failure rate in terms of technical performance or market performance. Concept selection serves as one of the crucial decisions in a NPD project, since the chosen sole concept at the early stage as in regular practice functions as cost driver as well as profitability driver. With the argument that the concept set selection, rather than a single concept selection, should be made for reasonable risk aversion, this paper, based on the previous research of the authors, proposes a detailed modeling effort to enable a robust set-based concept development. Utility theory integrated with uncertain technical levels of product attributes is introduced to express the selection decision risks, and information quality model is set up to connect the quality information with NPD budget. An illustrative case scenario of UCAV demonstrates the applicability of the proposed robust concept set selection framework for NPD risk control.

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1. Introduction

Concept selection at the early stage of new product development (NPD) project is always one of the most important decisions [1]. Common NPD practices tend to froze a single product baseline at the conceptual design stage to be developed for the fulfillment of requirements from the target market segment. However, the highly dynamic market demands and technology trends make this “internal certainty” extremely risky in the context of “external uncertainty”.

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That is, early selection decision of product concepts actually introduces a great amount of uncertainty to the project due to information scarcity so far. The "best" alternative is identified by comparing with alternatives to the selected criteria, and then the other alternatives are considered "inferior" and discarded. However, estimations at the early stage have a high tendency of being inaccurate due to vague knowledge of the alternatives, thus the selected "best" alternative could have a high probability of actually being inferior to the other alternative, e.g., technical infeasibility or poor profitability, if more accurate information on the alternatives could be acquired. In this sense, the early frozen of product baseline has a high probability of leading the project to total economic failure. Therefore, the authors of this paper argue that the inaccuracy of an early estimation due to insufficient information should also be taken into consideration, no matter which criterion or their combination is chosen. Thus the selection of design alternatives should be treated as in a statistical sense, rather than in a deterministic sense.

Unlike many other companies which tend to quickly converge on a solution (a point in the solution space) and then refine it iteratively to meeting the requirements, Toyota delays the selection of the best alternative by co-developing a set of possible designs (a set in the solution space), which is termed *Set-Based Concurrent Engineering* (SBCE) [2]. SBCE assumes that reasoning and communicating about sets of ideas leads to more robust and optimized systems, which finally provides greater overall efficiency than point-based design. Pugh's *controlled convergence* [3] also supports such set-based decisions. Meanwhile, set-based PD shares the same philosophy with the established paradigm of platform-based product development [4], while the former is focused on enhancement of project performance through risk control, and the latter on reduction of cost and lead time through commonality for product competitive advantage [5].

Therefore, it is reasonable to conclude that set-based NPD practices have a higher probability to avoiding converge on the inferior choice especially for development of high-novelty products. Some of this paper authors have proposed a reasonable framework to guide optimal set-based product development process with budget constraints in a quantitative manner [6]. In this paper, the detailed modelling of information quality and concept selection risks in a generic NPD project is presented, and an illustrative case of Unmanned Combat Air Vehicle (UCAV) is employed to verify the proposed framework by locating the robustest scenario solution with maximum overall utility and minimum development risk within the given NPD budget.

2. Fundamental modeling of concept selection decision in NPD

2.1. Definition of concept selection risk

There are two measures of the risk in the estimation and comparison of design alternatives [7]: 1) the choice made is not the best based on the information available; and 2) Once a decision is made, the outcome will not turn out as expected.

In this research, these two risk measures are respectively referred to as *robustness probability* (RP) and *technical performance risk* (TPR). Risk reduction could be achieved by acquiring new information. The higher information quality requires more cost and time but improves the estimate for reducing previous risk. To handle this tradeoff, an optimal policy should be investigated to present a budget allocation profile for the PD processes to maximize the risk reduction for a given total NPD budget.

2.2. Multi-attribute concept selection decision with customer utility

The Multi-attribute utility theory (MAUT) is a method to provide analytical support to the decision-making process. In MAUT, the multi-attribute product model (the generic ideal model of any ongoing product in NPD project) assumes that any of the design alternatives can be represented by a group of hierarchic attributes. Meanwhile, Kano's method categorize product attributes of a product into *must-be*, *basic*, and *excitive*, and each category demonstrates a different customer utility trace [8].