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Critical success factors in managing modular production design: Six company case studies in Hong Kong, China, and Singapore

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ABSTRACT

Many researchers have explored the advantages of modular product design, its design methods and its effects on product performance. Modular design is, for example, required for product platform, mass customization and postponement in order to achieve greater product variety and differentiation. However, a few empirical studies explicitly examine how to coordinate modular product design in a managerial way. This paper addresses it by conducting multiple case studies with six companies which have successfully adopted modular product design for five years. Seven critical factors are explored in the management of modular product design. These are pre-defined product advantage, selectively used design rules, module definition, system integration, technological newness, internal communication, and supplier and customer involvement. While most of the literature studies the technical dimension of modular design within a firm, this study focuses on the managerial side across the supply chain. It gives new insights on how to manage modular product design and proposes future research opportunities.

Introduction

Manufacturers have witnessed such an intensification of competition in the product market in recent years that they have had to find new ways to enhance their product development capabilities. Modular product design has been widely understood to improve the capability of increasing the range

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and number of product innovations without heavily sacrificing development time and cost (Salvador, 2007; Garud et al., 2003; Ulrich and Eppinger, 2000; Tseng and Jiao, 1996; Baldwin and Clark, 1997; Pine, 1997).

Many companies adopt modular product design in creating product variety, mass customization and product families and platforms (Robertson and Ulrich, 1998; Meyer, 1997). Extensive literature has highlighted the technical side of modular product design (Kamrani and Salhieh, 2002; Du et al., 2001; Baldwin and Clark, 2000), but there is a lot less research into the managerial side of modular product design readily available (Persson and Ahlstrom, 2006; Sullivan, 2003; Nobelius and Sundgren, 2002).

The managerial side of modular product design is very important. Fine (2003) argues that any decision about modular product design has to strategically consider process and supply chain coordination in order to improve supply chain performance. Nobelius and Sundgren (2002) argue that the modular product design method is greatly related to the strategic coordination across organizations and functional units. Gerwin (2004) suggests that modular product design reduces the requirement of coordination and the ability of coordination among strategic partners during product development, this requires further study. Persson and Ahlstrom (2006) argue that in adopting modular design it is difficult to balance the diverse functional requirements of engineering, production and marketing on product modules, and to coordinate people from different professional backgrounds. It is even costly to change established modular design parameters as this involves long development lead time and cost (Halman et al., 2003).

Sullivan (2003) argues that, in a multi-firm, multi-team product development project, modular design requires standardization of work content that helps assimilation of work norms across the module teams and the synchronization of work flows across teams to meet the targeted schedule. An extensive literature has also shown that, without making a conscious effort on the coordination of modular product design, manufacturers may face longer production time (Sheu and Wacker, 1997), sub-optimized product performance (Nobelius and Sundgren, 2002), extra time for testing and system integration (Fleming and Sorenson, 2001), poor product innovation (Galvin and Morkel, 2001) and higher development costs and time (Brusoni and Prencipe, 2001). However, a few attempts have been made to examine how to coordinate modular product design across suppliers, customers and internal functional units on an empirical basis.

This paper aims to fill this gap by exploring critical success factors of coordinating modular product design through multiple case studies. It reviews the literature on modular product design, supporting the development of research questions. The research methodology and critical factors are discussed through multiple case analyses. Implications and conclusion are finally provided.

Literature review

Modular product design

Modular product design implies a product design approach where a product is assembled from a set of smaller modules that can be designed independently but function together as a whole (Baldwin and Clark, 2000; Sanchez and Mahoney, 1996). Modular product design tends to minimize the interdependency/interaction of each product component through comprehensively specifying the interfaces and functions of each module (Ulrich and Eppinger, 2000).

Designing modular products reduces the complexity of a product system by dividing it into sets of independent modules (Baldwin and Clark, 2000). Thus, designing a complex product is similar to designing and building a set of less complex modules which provide flexibility of design and testing. In addition, when product modules are fully specified, separated and standardized, they allow a range of component variations to be substituted into the product architecture (Sanchez and Mahoney, 1996). Adding a few new product modules or mixing and matching existing modules, rather than wholly developing new products, can create new products. It fundamentally helps manufacturers to launch new products by either offering more product variants to customers, or providing large product modules for customers to assemble new products on their own within limited inventory and production costs (Pine, 1997). Table 1 summarizes the benefits and drawbacks of modular design as identified from the available literature.