Modularization of Product Development in Global Manufacturing Companies

The Interrelations between Product Architecture and Product Development Organization

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Zurich, 26 October 2011

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With love, this book is dedicated to my wife Fotini.

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Stelios Gasnakis

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Management Summary

Modularization in product development has attracted increasing interest among practitioners and academics in recent years. It contributes to the strategic flexibility required for a company to be able to compete in an international and dynamic environment. A company that implements product modularization successfully profits as a result of an increase in product variants, easier product upgrades, and reduced development and production cost and time.

However, an exploratory preliminary study of this thesis has shown that companies face major challenges in the modularization of product development. Challenges arise with respect to the modularization of the product architecture and the related product development organization, in particular organizational structure, product development process, and knowledge management. There is lack of practical knowledge regarding the interrelations between the dimensions of product architecture and the dimensions of product development organization.

Modularity cannot be termed under-researched. A host of literature exists. On the one hand, a large body of research literature focuses on analyzing the modularity at the level of product architecture. On the other hand, other research analyzes the modularization of the product development organization, in particular organizational structure, product development process, and knowledge management. However, limited work exists linking the dimensions of product architecture and product development organization and analyzing the interrelations between them in the field of product development.

In addition, the limited research that links the dimensions of product architecture and product development organization shows different results. A dominant research stream assumes a convergence between modular products and the product development organizations. This stream claims that modular products lead to modular product development organization in terms of organizational structure, product development process, and knowledge management. Furthermore, representatives of the dominant research stream claim that a one-way causality from modular products to product development organizations exists. In response to this dominant stream, an opposing research stream developed. Authors of the opposing stream state that modular products do not lead to modular product development organizations in terms of organizational structure, product development process, and knowledge management. And that a two-way causality from modular products to product development organizations exists.

The aim of this dissertation is to analyze empirically the modularization of product development in global manufacturing companies with special regard given to the

interrelations between product architecture and product development organization in order to determine implications for research and practice. The analysis is based on five detailed empirical case studies of the manufacturing industry.

The empirical analysis has shown that the two research streams with respect to the interrelation between modular products and product development organization can coexist, although it seems contradictory. The basis of the theory extension is that a modular product contains different types of modules, such as specific modules, company internal standardized modules, and industry standardized modules. These different types of modules lead to different interrelations between modular products and product development organizations. Further, the theory extension differentiates between system level and modular level, since these two levels also lead to different interrelations between modular products and product development organizations.

The thesis ends by providing recommendations for how to implement modular strategies in product development with respect to the product architecture and product development organization. The implications for practice are summarized in four principles covering design options in terms modularization strategy, intra-firm and inter-firm product development organizational structure, product development process and knowledge management.

1 Introduction

The aim of this dissertation is to empirically analyze the modularization of product development in global manufacturing companies with special regard given to the interrelations between product architecture and product development organization in order to determine implications for research and practice.

This chapter explains the problem statement and the relevance of this thesis topic for research and practice. The targets and the scope of this thesis follow. The chapter ends with a description of the applied research design and methodology of this dissertation and an outline of the structure of this work.

1.1 Problem Statement

Multinational manufacturing companies conduct business in an international and dynamic environment. Three main trends characterize this international and dynamic environment:

1. Trend: Strong market segmentation resulting in explosion of product variants

The global mass market has become a strongly segmented market over the years.[1] At the beginning of the twentieth century, Ford and Crowther (1922) stated that "Any customer can have a car painted any colour that he wants so long as it is black",[2] an idea no longer valid. In most industries, the global market is strongly segmented, comprising multiple customer groups with different requirements that change over time.

In order to respond to strong market segmentation, companies must develop products that accurately meet the requirements of different customer groups. The one-size-fits-all product for the entire global market is no longer successful. In recent years, the trend towards strong market segmentation has resulted in an explosion of product variants in manufacturing industries.[3]

2. Trend: Rapidly changing and diverse technologies resulting in shorter product lifecycles and complex products

The speed of technological change has increased over the last few years. New technologies replace mature technologies in shorter time periods, causing a reduction of the average product lifecycle[4] in many industries. The typewriter is a good example. The

[1] Toffler (1970) was one of the first authors who predicted the decline of mass markets (Toffler, 1970, pp. 19-35)
[2] Ford & Crowther, 1922, p. 72.
[3] Franke et al., 2002, p. 1; Wiendahl et al., 2004, pp. 3-4.
[4] Product lifecycle is the time period from product market introduction till the phase-out of product (Levitt, 1965, pp. 81-84).

mechanical typewriter had a lifecycle of 25 years, and the next-generation electromechanical typewriter a lifecycle of 15 years. However, the full electronic typewriter had a lifecycle of only 7 years.[5] Another example of reduced product lifecycle is the hard disk drive. The drives for servers and mainframe computers have fallen from 18-24 months to about 12 months. The drives for desktop applications and laptop personal computers (PC) now have a lifecycle of 6 to 9 months.[6]

Currently, products are based on diverse technologies.[7] On the one hand, diverse technological options fulfil a certain product solution. The motor power of a car can, for instance, be based on petrol, electricity or hybrid motor technology. On the other hand, many products are based on diverse technologies simultaneously.[8] The range of new car technologies, for example, has increased over the years with more electronics, new materials or plastics and new energy sources.[9]

However, these diverse technologies increase product complexity while requiring different kinds of knowledge. Although many large companies have knowledge of multiple technologies, complex products can rarely be developed by a single company on its own. Often companies develop and produce only a portion of their products, buying the rest from multiple suppliers.[10] US car companies, for example, outsource 30% (Chrysler) to 70% (General Motors) of their components.[11]

3. Trend: Increased competitive intensity resulting in short product innovation cycles and product cost reduction pressure

Globalization increases the competitive intensity between different companies. In order to be successful in such a global environment, companies must be able to develop products over a shorter time cycle in order to launch their products at the right time. Short product innovation cycles are essential for a company's competitiveness[12] since they allow quick reactions to changing customer requirements. In recent years, the competitive time pressure has caused a reduction in the innovation cycle time in a number of industries. Chrysler, for example, reduced the innovation cycle time for a car from 60 months to 36 months or less.[13]

Global competitive intensity also leads to an increase in price competition. In the past, price competition did not begin until the product had reached a later stage in the

[5] Boutellier & Völker, 1997, p. 107.
[6] Ernst, 1997, pp. 18-19.
[7] Wheelwright & Clark, 1992, p. 2.
[8] The combination of multiple technologies is a great source for product innovations (Kroy, 1995, p. 70).
[9] Sako, 2003, p. 246.
[10] Fine & Whitney, 1996, p. 3.
[11] Fine & Whitney, 1996, p. 3.
[12] Smith & Reinertsen, 1991, p. 3.
[13] Sanchez, 1995, p. 147.

lifecycle; today, price wars even ensue over new products in the early lifecycle stage. Such competition pressures companies to reduce product costs through economies of scale right from the market launch day.[14]

Strong market segmentation (first trend) and rapidly changing diverse technologies (second trend), combined with increased competitive intensity (third trend), are forcing companies to reconsider their product development strategy. Such reconsiderations are necessary in order to remain sustainably competitive in an international and dynamic environment, and modularization is key.

Modularization in product development

Modularization in product development is a product development strategy. In simple terms, this strategy divides a product into individual units called *modules* that can be developed independently but still work as an integrated whole.[15] New products can be developed based on these modules without requiring any changes to the core modules.[16]

Modularization in product development contributes to the strategic flexibility required for a company to be able to compete in an international and dynamic environment. A company that implements product modularization successfully profits as a result of an increase in product variants, easier product upgrades, and reduced development and production cost and time.[17] Due to these benefits, modularization in product development has attracted increasing interest among practitioners and academics in recent years. However, despite the increasing interest, gaps in practice and research remain. These gaps are explained below.

Gaps in practice

In order to be sustainably profitable in an international and dynamic environment, manufacturing companies need to modularize their product portfolio. According to Langlois (2002), "The real issue is normally not whether to be modular but how to be modular".[18] Baldwin and Clark (1997) explained that "Many industries have long had a degree of modularity in their production processes. But a growing number of them are now poised to extend modularity to the design [product development] stage".[19]

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[14] Ernst, 1997, p. 65.
[15] Baldwin & Clark, 1997, p. 86.
[16] Ulrich, 1995, pp. 426-428.
[17] Baldwin & Clark, 2000, p. 91; Sanchez, 1996, p. 132; Sanchez, 2000, p. 614; Ulrich, 1995, pp. 431-432; Ulrich & Tung, 1991, p. 75.
[18] Langlois, 2002, p. 24.
[19] Baldwin & Clark, 1997, p. 84.