New Product Development: A Case Study of Product Platform

by

Namseog Byeon

B.S., Aeronautical Engineering
Seoul National University (1986)

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Signature of Author _____
MIT Sloan School of Management
May 8, 1997

Certified by _____
James M. Utterback
Professor of Management and Engineering
Thesis Supervisor

Accepted by _____
Rochelle Weichman
Director, Management of Technology Program

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ABSTRACT

This thesis evaluates a company's product development strategy using the frameworks of product family evolution and platform performance metrics. Many studies have shown how successful companies develop new products in an intense global competition. Product family evolution and platform performance metrics provide insights of how efficiently a company develops new products and how effective the products are.

This case study of a home appliance product showed two different patterns of product family evolution and platform strategies. Generational change-intensive evolution and vertical platform leverage strategy were found during the market growth period. As the time-to-market factor was considered important to exploit the growing segments, new products within a market segment were developed rapidly replacing old ones by leveraging platforms vertically. After the market became saturated and mature, the pattern of product evolution shifted to diverse variety-driven competition and platforms were leveraged horizontally. With horizontal platform strategy, the company developed several products within short time intervals by leveraging key subsystems and components across several market segments and reduced costs by increasing economies of scale. Defining patterns of development was identified as an important element in formulating platform strategies and product development plans. Patterns of product development were also found useful in guiding the designs of robust product architectures.

Platform strategies could be pursued further by combining vertical leverage and horizontal leverage. A company can design a robust product architecture by simulating customer-focused specifications and incorporating them into a base platform in the fastest growing segment. Following this, the company can develop multiple products simultaneously by leveraging the base platform horizontally as well as vertically to broaden product variety and reduce costs.

Thesis Supervisor: James M. Utterback
Title: Professor of Management and Engineering

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1. Introduction

1.1. Overview of Thesis

The recent increase in global competition has forced companies to introduce new products to the marketplace. Experiencing rapid growth and intense competition during 1980s and 1990s, companies that develop new products faster and more efficiently gain the competitive advanatage. The appliance industry in Korea is one example of how intense global competition has influenced new product development strategies.

Many recent studies have shown how successful companies have developed new products. As one of the results, product family and platform frameworks have been found useful. Product family evolution map and product platform evaluation metrics developed by Meyer et al.(1995) provide insights of how efficiently a company can develop new products and how effectively the products contribute to the company's success.

The major objective of this thesis is to assess a particular company's product development strategy using product family evolution map and platform evaluation metrics. A case study is conducted for a major home appliance product of a consumer electronics company in Korea. The implications for managing new product development are examined in depth. As a result, concurrent multiple product development concept is developed as one of new approaches to product development.

1.2. New Product Development Environment

In the past decade, as more companies have joined the international economy, competition has become more intense. The globalization of industry and intense competition has forced companies to develop new products at a fater rate to gain the

competitive advantage. The automobile industry and consumer electronics are good examples of how the growing competition has prompted on new product development.

Increasing customer demands also prompts companies to develop new products. With the sophistication of customer demands, companies are trying to meet particular customer needs by developing new products. At the same time, rapidly changing technologies offer companies options to meet diverse market demands and make it possible for companies to develop new products.

Facing the challenges of the competitive environment, many companies has adopted new approaches to product development. However, some companies are more successful than others in implementing new approaches. Many questions have been raised from the new approaches to product development. Among them, two concerns stand out: How to broaden product variety while accelerating product development? How to implement rapid product development achieving benefits fully from new product development?

Product Variety

Though warning that product variety is not always the only solution, Kekre and Stinivasan (1990) argued that there are significant benefits of product variety. A broader product variety can lead to a higher market share as well as to increased profitability. According to Sanderson and Uzumeri (1995), Sony leveraged its product variety to retain dominance in the portable stereo market. This explains why many companies are striving to expand their product lines by developing new products.

The concern, however, many companies are facing today is not simply how to add new products to its product line but how to expand product variety while compressing product development time. The conventional belief is that expanding product variety slows down product development. Product variety adds complexity to the product development and extends the product development cycle.

Rapid Product Development

Most new product development approaches focus on reducing the product development cycle. Many recent studies have shown that faster product development is one of the most important competitive advantages in the present global competition. In today's fast-paced, fiercely competitive world of new product development, speed is of utmost importance. Companies are increasingly realizing that the old, sequential approach to developing new products simply doesn't work. Instead, companies are using concurrent development processes changing from serial to parallel processes and overlapped processes (Takeuchi and Nonaka 1986; Smith and Reinertsen 1991; Wheelwright and Clark 1992).

One of the advantages of rapid product development comes from increased sales and market share. If a new product is introduced early, the product's sales life is extended. The earlier a product is introduced, the more readily it can gain and retain a large market share. Both extended sales and larger market share lead to greater chances of high profitability. Another advantage is that rapid product development gives a company competitive options. With shorter product development time, a company can not only introduce a product to the market early but also start the development process late according to the changes of customer demands or technologies.

On the other hand, companies often fall into the trap of an accelerated development cycle without knowing the benefits of new product development. Many companies in the consumer goods industry such as packages goods and consumer electronics continuously pour new products into the market. However, shorter product life cycles contribute less sales than before and companies do not reap the entire benefits from new product development. New products sometimes cannibalize existing products without increasing total sales. This raises a critical issue of how effective new products perform in terms of real business measurement such as sales and market share.

Companies could easily fall into the traps of wasting resources without reaping real results if they do not measure the performance of product development. Von Braun (1990, 1991) argued in his simulation that shorter product life cycles might result in the decline of sales volume and represent a significant increase in risk exposure. He also concluded that with shorter development cycles, inadequate understanding of possible market developments, or insufficient product planning might result in increased failures, bad timing, locking into the wrong technologies, and other severe and costly mistakes.

One of the fundamental questions for new product development is how it contributes to the performance of the company. Meyer, et al. (1995) addressed the questions and proposed simpler metrics to evaluate product development performance. Once a company identifies product development performances of its products, it may accordingly manage product planning, design and integration. This will finally lead the company to the re-development of a product/market strategy.

1.3. Objectives of Thesis

This thesis assesses the product development strategy of a major Korean home appliance company building upon the research in areas explored by Meyer, et al. (1995). New approaches to product development that are applicable to other industries are also drawn. Particularly, this thesis addresses the following questions:

- What is the pattern of new product development in this particular company?
- What was the product development performance?
- What are the implications for managing new product development?
- How should this company improve its approaches and strategies in new product development?

2. Product Platform, Product Family, and Product Development Performance

2.1. Product Platform and Product Family

A typical pattern of product development shows that generally a leading company first develops an innovative new product which is later followed by competitors. Many follow-on products are developed to reduce cost and to enhance functionality of the initial product as competitors offer similar or better products. Eventually, the cost reduction and functional improvement arrive at the market and/or technological limits and another new innovative product is developed generating a flow of new follow-on products. This simple product evolution process shows the concepts of product platform, platform extension, derivative product and product family.

Product Platform, Extension and Derivative

A *product platform* can be defined as a "set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced" (Meyer and Lehnerd, 1997). A *platform extension* is a product that particular subsystems within the original product platform are substantially changed and/or that new subsystems are added without disturbing the primary subsystems and interfaces in the existing platform. A *derivative product* is a series of follow-on products that improve the functionality and/or cost incrementally (Meyer, et al., 1995).

The product platform concept is not new. Many studies have shown the usefulness of the concept in industrial practices in relation to product/market strategy, core capabilities, and renovating product line (Wheelwright and Clark, 1992; Meyer and Utterback, 1993; Meyer and Lehnerd, 1997). A platform approach to product development helps to reduce

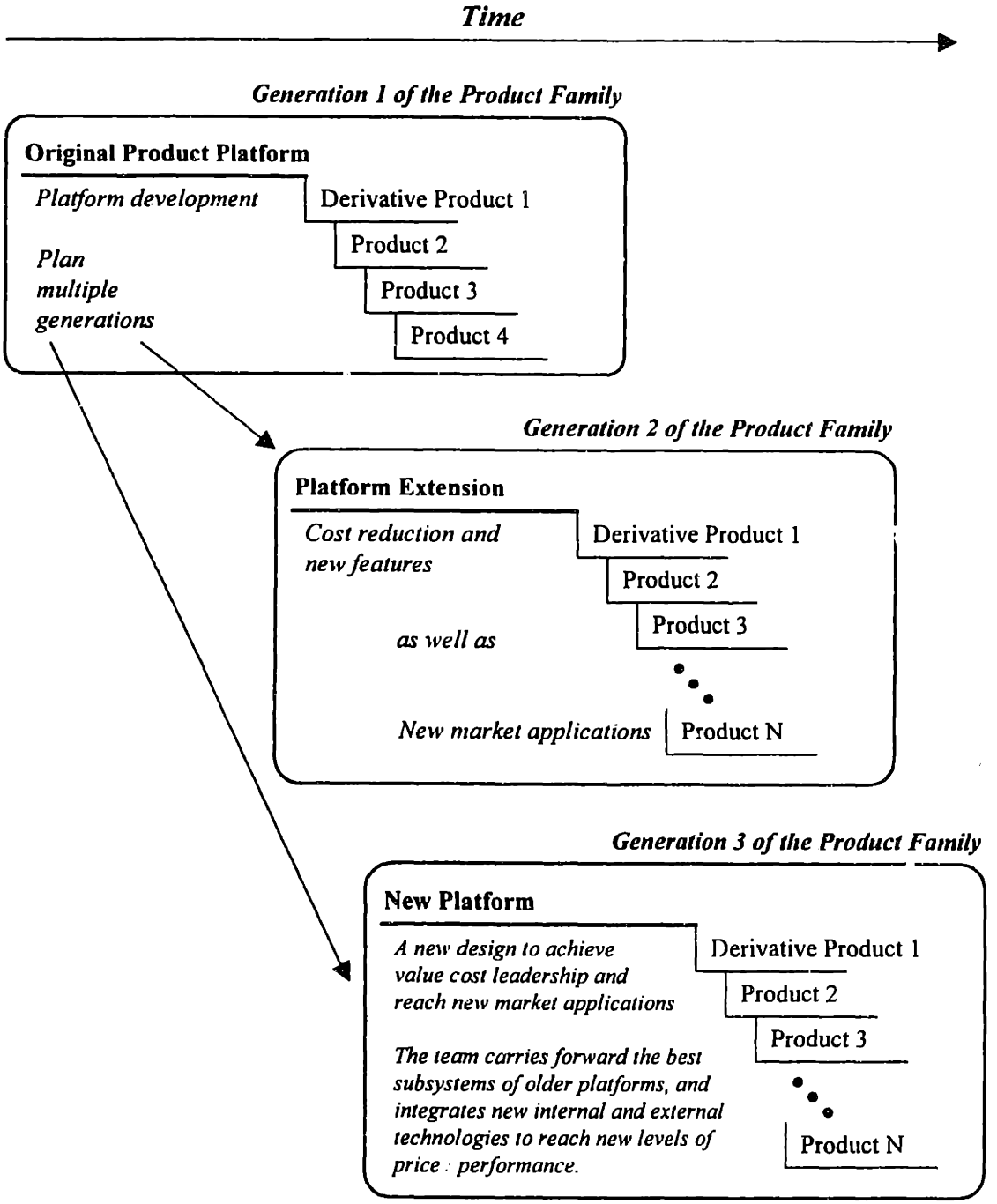
the development cycle time when a company introduces successive products. By sharing a common structure and components, platforms significantly save development resources, too. The product platform approach also addresses the issue of product variety. Modifying subsystems in the platform can efficiently create wide product variety. A carefully designed platform can also serve as a leverage to prevent cannibalization of products that often inevitably occurs with the rapid product introduction. A dramatic example of benefits of a product platform is often found in mature industries such as Black-Decker with its power tool product development (Lehnerd 1987).

Product Family and Product Family Map

A *product family* can be defined as a set of products that share common technology and address a related set of market applications (Meyer, et al. 1995). As a company builds its product line upon the basis of product platform, extension and derivative products, they form a stream of products and become a product family. HP DeskJet printer is an example of a well developed product family. Product families do not emerge at once. They are the results of a series of additions and replacements of products over a long period of time. The evolutionary model of the product family is shown in Figure 2-1.

Product family has long been considered useful as a basic unit of analysis. Recently, many studies have used the product family concept to measure core capabilities of a firm, product development performance, etc(Meyer and Utterback, 1993; Meyer, et al., 1995). Sanderson and Uzumeri (1996) show the usefulness of this concept in strategies for managing products.

Figure 2-1. Product Family Evolution



Source: Meyer and Lehnerd, *The Power of Product Platforms* (New York: Free Press, 1997)

2.2. Product Development Evaluation Metrics

Many attempts have been made to formulate rigorous R&D performance evaluation metrics. Reviewing previous R&D performance measurement methods, Meyer, et al. (1995) proposed new measures of R&D performance that are compatible with the management model of evolving product families. Platform efficiency and effectiveness are two measurements that utilize the product family concept. *Platform efficiency* is the degree to which a platform allows economical generation of products. *Platform effectiveness* is the degree to which the products, based on a product platform, produce revenue for the company relative to the cost of developing those products.

The merit of this metrics model is that it considers not only single products but product families. These metrics, when combined with product family maps, can help management understand the timing of platform renewal and the frequency of follow-on product generation from existing platforms (Meyer, et al., 1995; Wheelwright and Clark, 1992). Companies can also practice it more easily than traditional methods since most of the data can be managed easily though it was found that even leading companies are not managing them systematically.

2.2.1. Platform Efficiency

At the derivative product level, R&D leverage shall be defined as the development cost of a derivative product divided by the development cost of a platform from which the derivative products are generated. Individual product-level platform efficiency is defined as the following:

$$Platform\ Efficiency = \frac{Development\ Cost\ of\ Derivative\ product}{Development\ Cost\ of\ Platform}$$

Platform efficiency asks how much the product cost to develop in comparison to what it cost to develop the platform. Platform efficiency can be aggregated for initial platform or platform extension level. By grouping derivative products within their platforms, the platform efficiency asks how much it cost on the average to develop the derivative products relative to the development cost of the platform or platform extension. Average platform efficiency can be used to compare the platform efficiencies within a product family. The average platform efficiency is defined as:

$$Average\ Platform\ Efficiency = \frac{Average\ Development\ Cost\ of\ Derivative\ products}{Development\ Cost\ of\ Platform}$$

2.2.2. Platform Effectiveness

In calculating product development effectiveness, product sales revenues are used instead of profits proposed by Foster, et al. (1985). Profitability is much greater depending on other activities of a company apart from R&D and exposes weaknesses in reliability and accessibility.

At the individual product level, platform effectiveness is calculated comparing the product sales to product development costs. Platform effectiveness may be considered one of the commercial leverages by the development of new product. *Platform effectiveness* is defined as:

$$Platform\ Effectiveness = \frac{Sales\ revenue\ of\ Derivative\ product}{Development\ Cost\ of\ Derivative\ product}$$

Platform effectiveness can also be aggregated like platform efficiency. Average platform effectiveness is the sum of sales of products within a platform divided by the sum of

development costs for those products. Average platform effectiveness is a measure of the amount of commercial leverage a platform creates for its entire life including derivative products.

$$Average\ Platform\ Effectiveness = \frac{Sales\ revenue\ of\ products\ in\ Platform}{Development\ Cost\ of\ product\ in\ Platform}$$

3. Case Study

3.1. Research Method

This case study is based on the framework developed by Meyer, et al. (1995) described in the previous chapter. The product for the case study is a home washing machine of a large consumer electronics company in Korea. The product line is currently being sold and developed. The background of the company and the washing machine market is presented in the following section.

The first step of this study was to collect information about the product for the past 10 years. Engineering post-mortem reports were collected and supplemented by other related documents. Product family maps were formulated based on the collected data and product development performance was evaluated using development costs and sales data. Follow-up interviews with key engineering managers were held to gain insights about new approaches to the product development processes. Product family map, product development evaluation metrics and interviews were analyzed together and key findings were presented. Implications for managing product development are discussed as a conclusion.

3.2. Background of Company and Market

A profile of the company and a summary of washing machine industry are presented from the perspective of the market and industry as background for this case study.

3.2.1. LG Electronics Inc.

LG Electronics Inc.(LGE) was established in 1958 and started producing washing machines in 1969. It has played a pivotal role in shaping the Korean electronics industry.

LGE has maintained the strong product leadership in the Korean domestic market and is now one of the major players in the global consumer electronics market as well. It is currently a market leader in Korea and has strong presence in Asia, the Middle East, and Latin America.

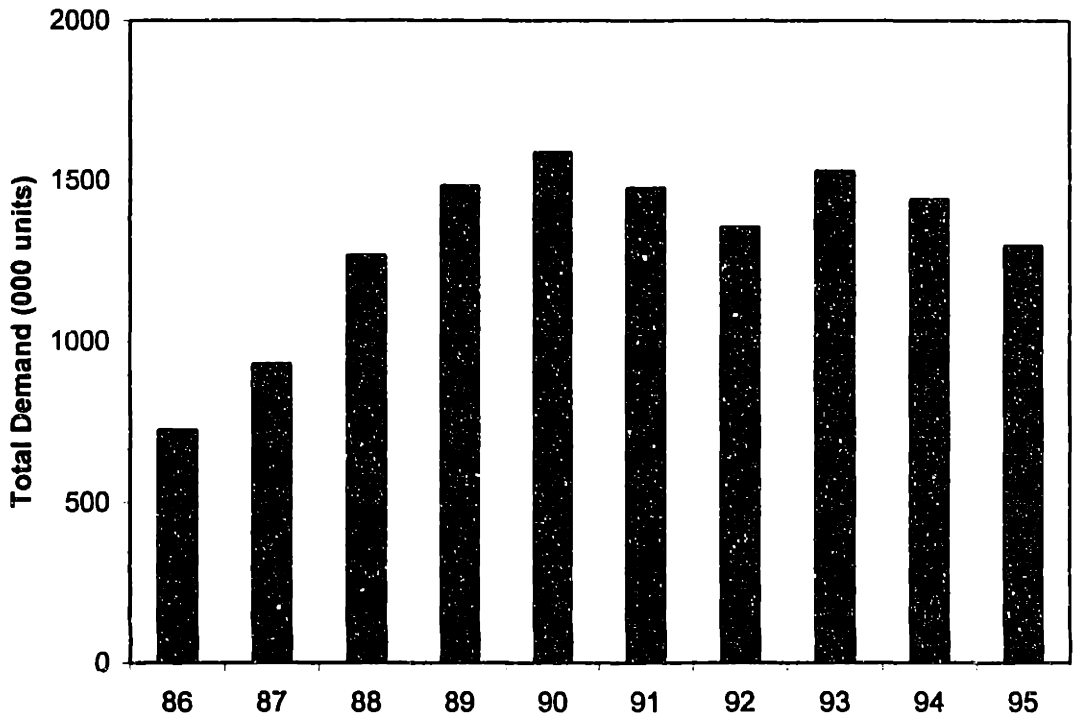
LGE produces three types of washing machines; a semi-automatic twin tub impeller, a fully-automatic single tub impeller and a tumbling type. LGE also offers a broad range of capacity in its washing machines: from 5kg to 12kg. Traditionally, LGE has focused on new product development as its major strategy. It has continuously developed new products every year which made obsolete its product line by itself. Over the years LGE has attracted customers looking for larger capacity and new functions. Other product strategy of LGE is to offer high-end products in the growing market segment. LGE has taken advantage of first mover to obtain high profit margins with high value-added products. As the low-end market segment became a greater factor with price competition, LGE recently modified its strategy to equally focus on both high-end and low-end products. As the market has become saturated and competition has become more intense, LGE has begun to evaluate its previous product strategy and has sought new product development strategies to efficiently deliver a variety of product and low cost designs.

3.2.2. Industry Characteristics, Market and Competition

The washing machine industry in Korea can be characterized as mature with little growth showing very high market saturation in recent years. Demand is mainly for home use with almost homogenous requirement. The market grew fast during the 1980s until its peak in 1990 with 1.6 million units. Following the peak, total demand has declined annually 3.8% until 1996. It is expected that the market will stabilize around 1.3 million

units per year after a couple of years adjustment. Figure 3-1 shows the growth and decline of total demand for the last 10 years.

Figure 3-1. Demand for Washing Machines in Korea



Three different types of washing machines are sold in Korea: the impeller popular in Asia, the agitator from America; and finally the tumbler from Europe. More than 95% of the market is the impeller type washing machine since most Korean manufacturers have their technology origins in Japan. LGE produces impeller type and tumble type washing machines. The capacity of the washing machine has been increased with the growth of market. Currently, the washing machine with a capacity of 8kg or larger represents over 65% of the market and10kg size machines represents 37% of total demand.

Two major competitors have provided very intense competition as is the case in most consumer electronics and appliances markets. Manufacturers have competed to meet the growing demand during growth periods and have tried to keep their market share during market declines. The major means of competition have been product capacity, performance, features, price and advertising. New product development, low cost and marketing implementation have been critical factors in the competition.

New Product Development

Rapid development of new products has been one of the most critical success factors in the industry. This was especially important in the 1980s when the market expanded rapidly with the large-capacity washing machine. LGE had to yield market share when one of the competitors introduced the 6kg washing machine earlier than LGE in 1987. It took six years for LGE regain the lead by introducing an 8.8kg washing machine in early 1992. From then on, LGE has maintained its leadership in capacity and market share by continually introducing new products.

Low Cost

As the market became saturated and showed little growth from early 1990s, price has become the most important driving factor. During early 1990s, the Korean domestic market had experienced three price cuts in only two years. LGE experienced a significant decline in profits when one of the competitors started with price competition in 1993 to increase its market share. Until then, competition had been mostly based on product performance and other features. In order to keep the market share, washing machine companies moved from a focus of new product development to low cost design and

production. Manufacturers have been required to renovate existing product lines in order to meet the competition.

Marketing

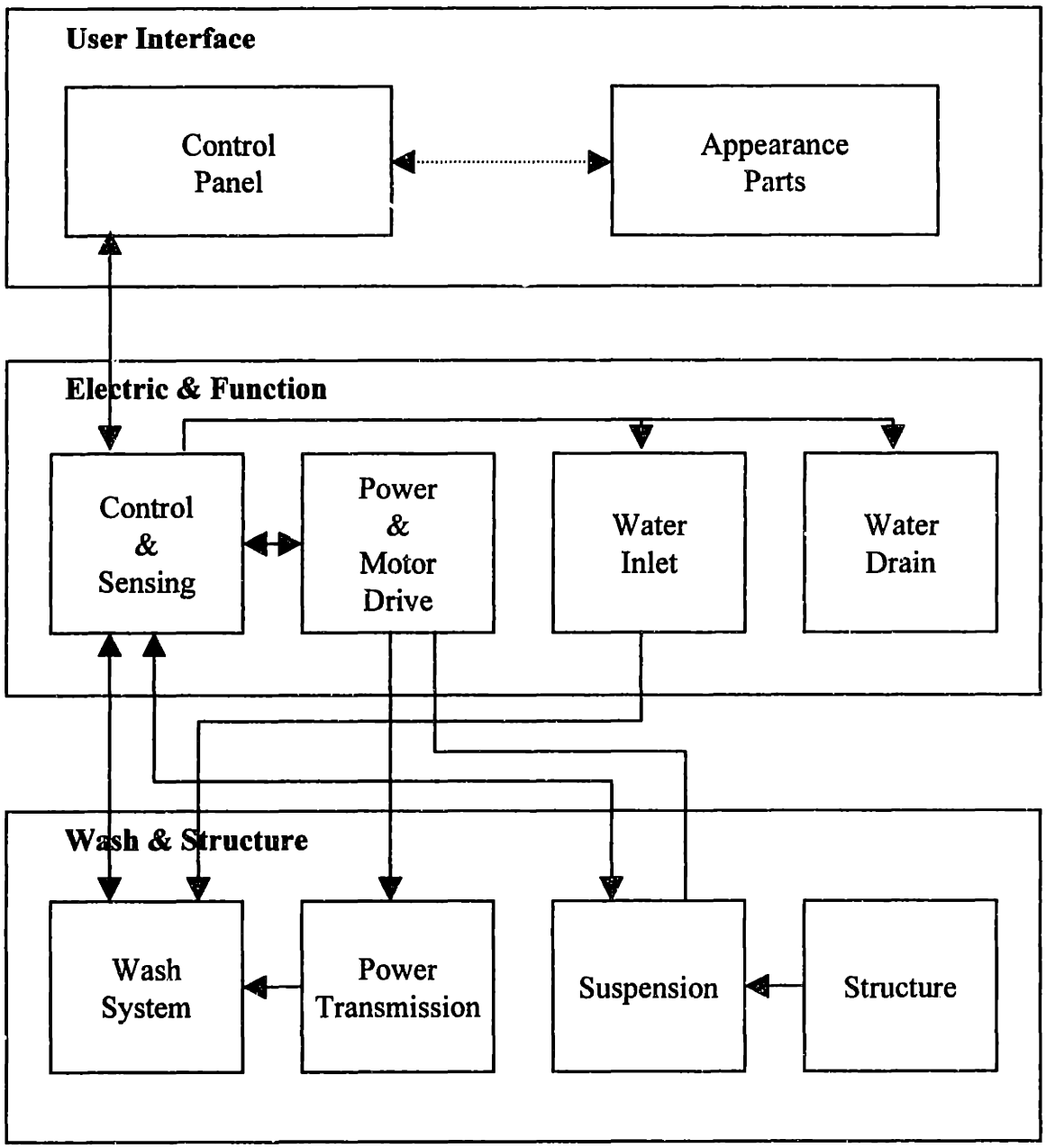
Marketing programs have also played a critical role in the competition. Traditional practice was that a company first introduced a single product with new features and used it as a flagship product. Looking closely at the customer responses, the company added new features to its product lines. However, the product variety and the simultaneous introduction of new products were required in order to maximize the marketing and sales effect. A single product could no longer boost sales and meet the customer demands efficiently.

3.3. Product Architecture of Washing Machine

Figures 3-2 and 3-3 show a high level schematic diagram and a cross-sectional view of a washing machine. Subsystems of this washing machine can be divided into three major groups: user interface, electric and functional, and wash system and structural.

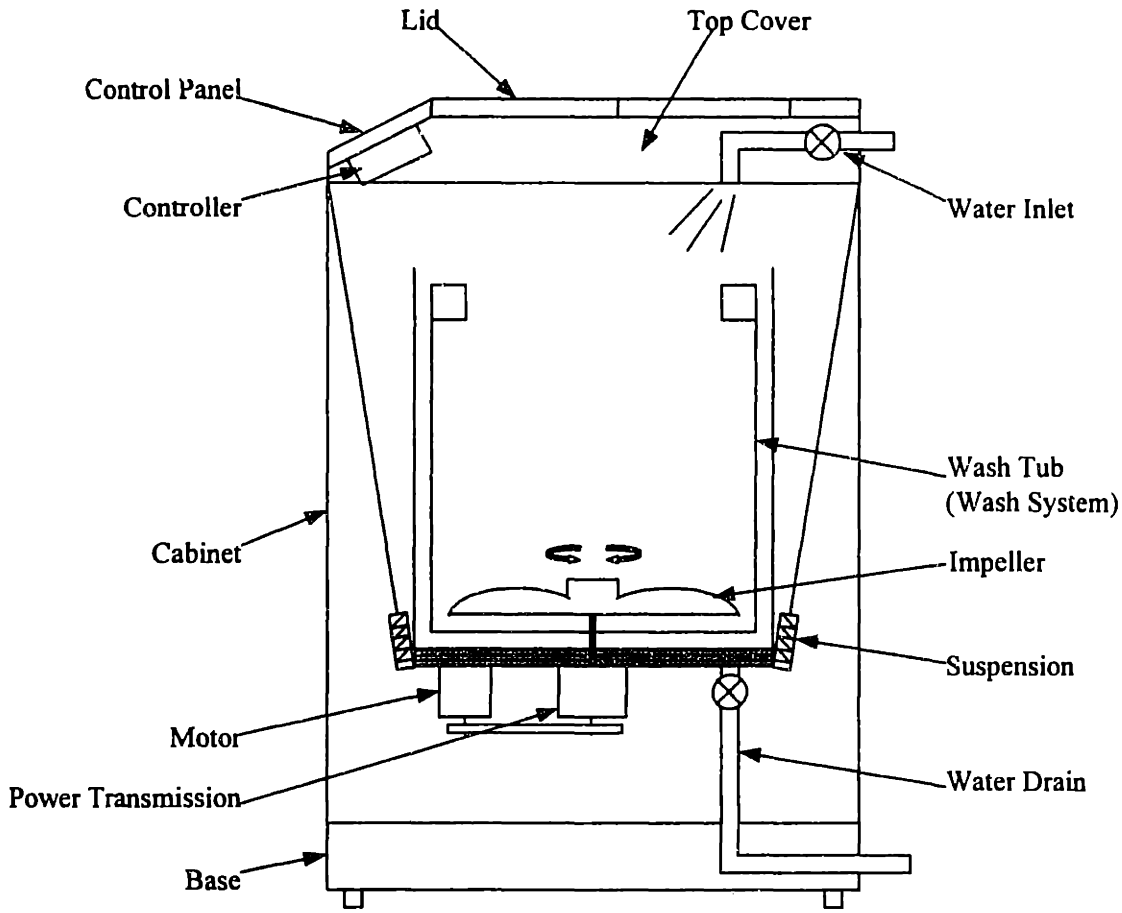
The Control Panel accepts control inputs from the user and displays the process status for the user. The Control Panel is directly connected to the control and sensing unit that controls all functional components and washing processes. Water comes into the washing machine through a water inlet system which consists of a hose, water valve and shower spray mechanism. After water has filled the tub, a signal is delivered through the sensor unit to the control unit which sends appropriate signals to the power and motor drive system while monitoring the processes in the wash system. Revolving power is generated from the motor and delivered through the Power Transmission system. Power

Figure 3-2. Schematic Diagram of Washing Machine



transmission reduces the speed of revolution and delivers the increased power to the impeller at the bottom of wash tub in the wash system. Completing the wash cycle, the water is drained naturally or by a pump through a drain system composed of a valve and

Figure 3-3. Sectional View of Washing Machine



hoses. The suspension system reduces the vibration and noise caused by high speed revolutions while the washing machine conducts spin extraction cycle. Structure system holds various components at appropriate positions inside the washing machine. The appearance parts form the outer shell of the washing machine and consist of a Cabinet with a Base, Top Cover, and Lid.

There are strong couplings among the control unit, power and motor drive system, power transmission, and wash system. These four subsystems comprise fundamental

architecture of the washing machine. The wash and structural system have physical couplings while the electric and functional system have informational couplings.

3.4. Development Types in LGE

LGE has traditionally classified its product development types by the amount of changes in the design and manufacturing. Figure 3-4 shows typical types of new product developments in the company. LGE's definition of new product development is based on the amount of effort required to develop new products. It also includes the characteristics of changes. However, it considers the changes mostly from an engineering perspective and lacks in product/market strategy perspective.

Figure 3-4. Development Types in LGE

	Development Efforts	Manufacturing Investment	Parts Changed
New Product	Large	Large	Whole system
New Tool	Large	Large	Tub + Top cover + Cabinet +...
Major Change	Medium	Medium	Top cover and/or Cabinet and/or other major subsystems
Minor Change	Small	Little	Small component
Cosmetic Change	Little	None	Electric rating Color

A product development is defined as New Product when the wash mechanism requires a new wash technology and new manufacturing investment. New Tool development usually means new capacity or a new design that requires building of major tools such as Wash Tub, Top Cover and Cabinet. A change is considered Major Change development

when Top Cover subsystem or other major functional subsystem is modified. A Minor Change is a small change in subsystem. A modification is considered a Cosmetic change when an electric rating or a color is changed that doesn't require much development effort or cost.

3.5. Product Family Evolution

The product family map (Figure 3-5 – 3-8) shows us how the company has managed its product developments. Specially, the platform evolution map shows how the company has developed its product family on a macro level while the product model evolution map shows how each platform has evolved with derivative products on a micro level. Figure 3-5 shows the evolution of platforms and their extensions. The following figures show detail evolutions of three different major families. The thickest line represents a *new platform*, the medium line delineates a *platform extension*, and the thinnest line a *derivative product*. The length of each line represents the life span of the product.

The platform evolution map (Figure 3-5) is a simplified version of the product family map and shows the evolution of major products. For example, LGE developed a new platform with the capacity of 4.6 kg (A1) in the mid 1980s. This was the first generation of the 5 kg family. The first product had an electro-mechanical control system and a rear Control Panel. The next platform extension (A2) adopted a fully electronic control system with soft touch buttons, a first for LGE washing machines. This generation heralded the electronic age in the home laundry products. The electronic control gave the washing machine more versatile operations and improved the performance. The next generation platform (A3) was developed by modifying the Top Cover and control system, adding new functions and improving user interfaces.

Figure 3-5. Platform Evolution Map

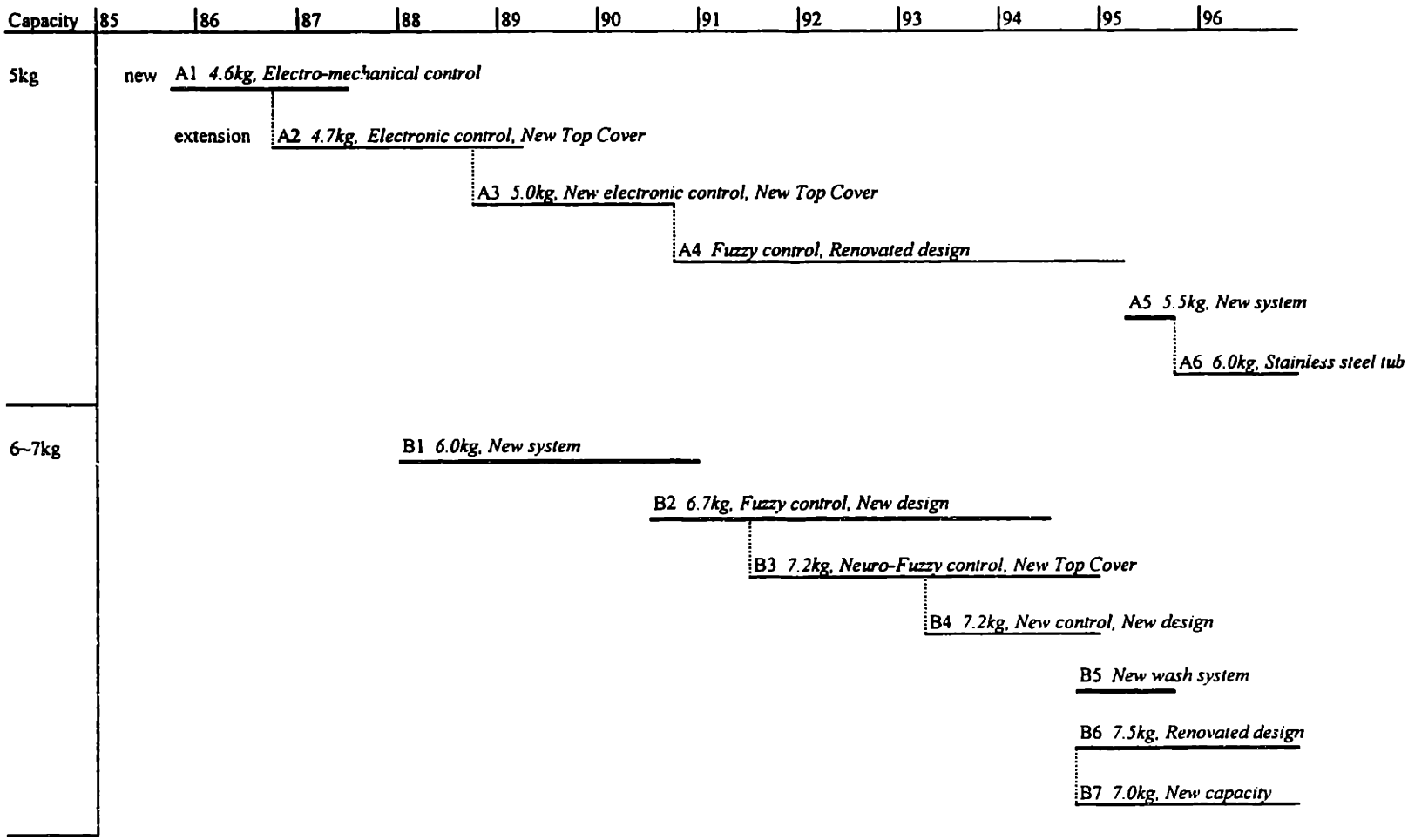


Figure 3-5. Platform Evolution Map

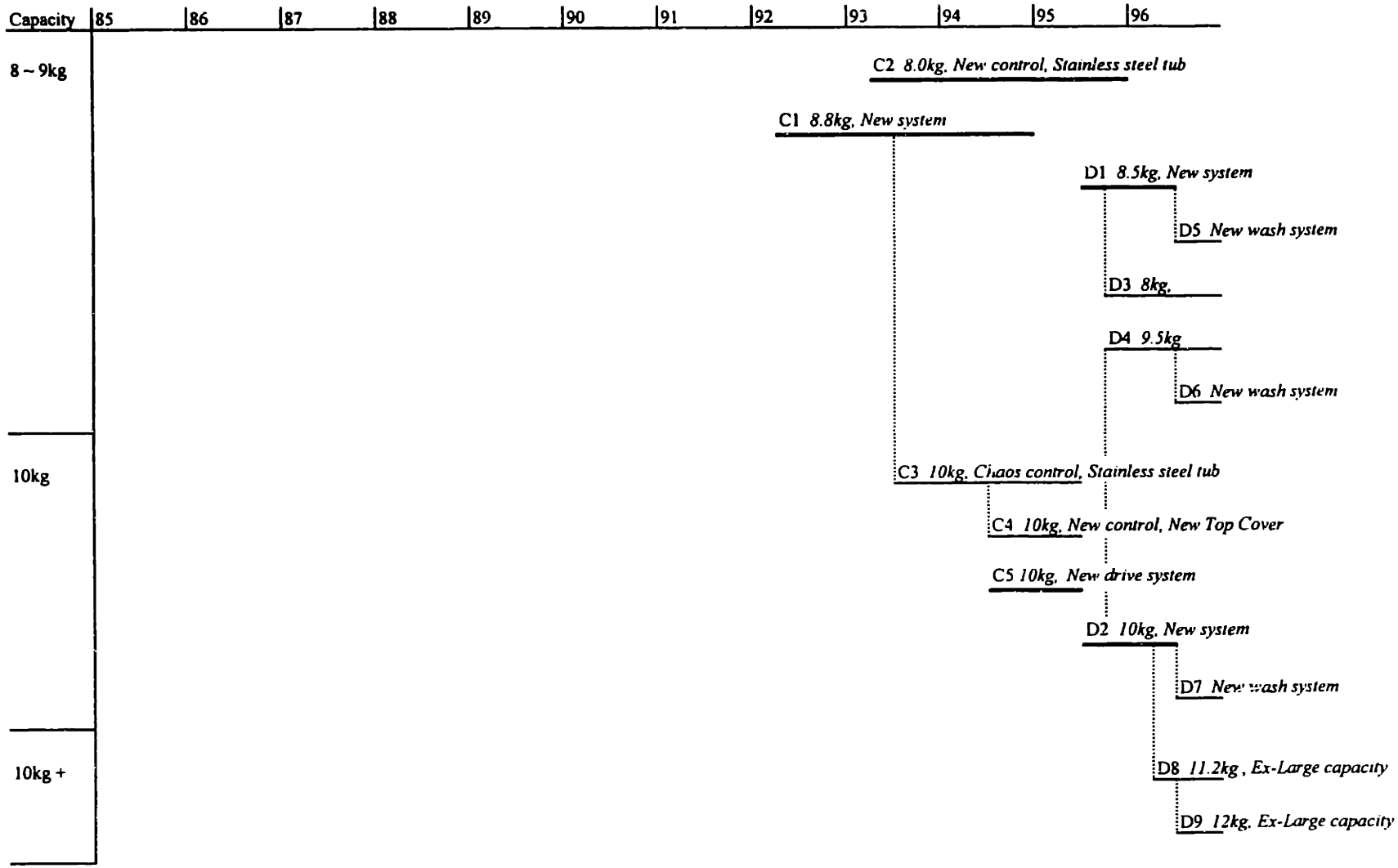


Figure 3-6. Product Model Evolution Map - Family A(5 kg)

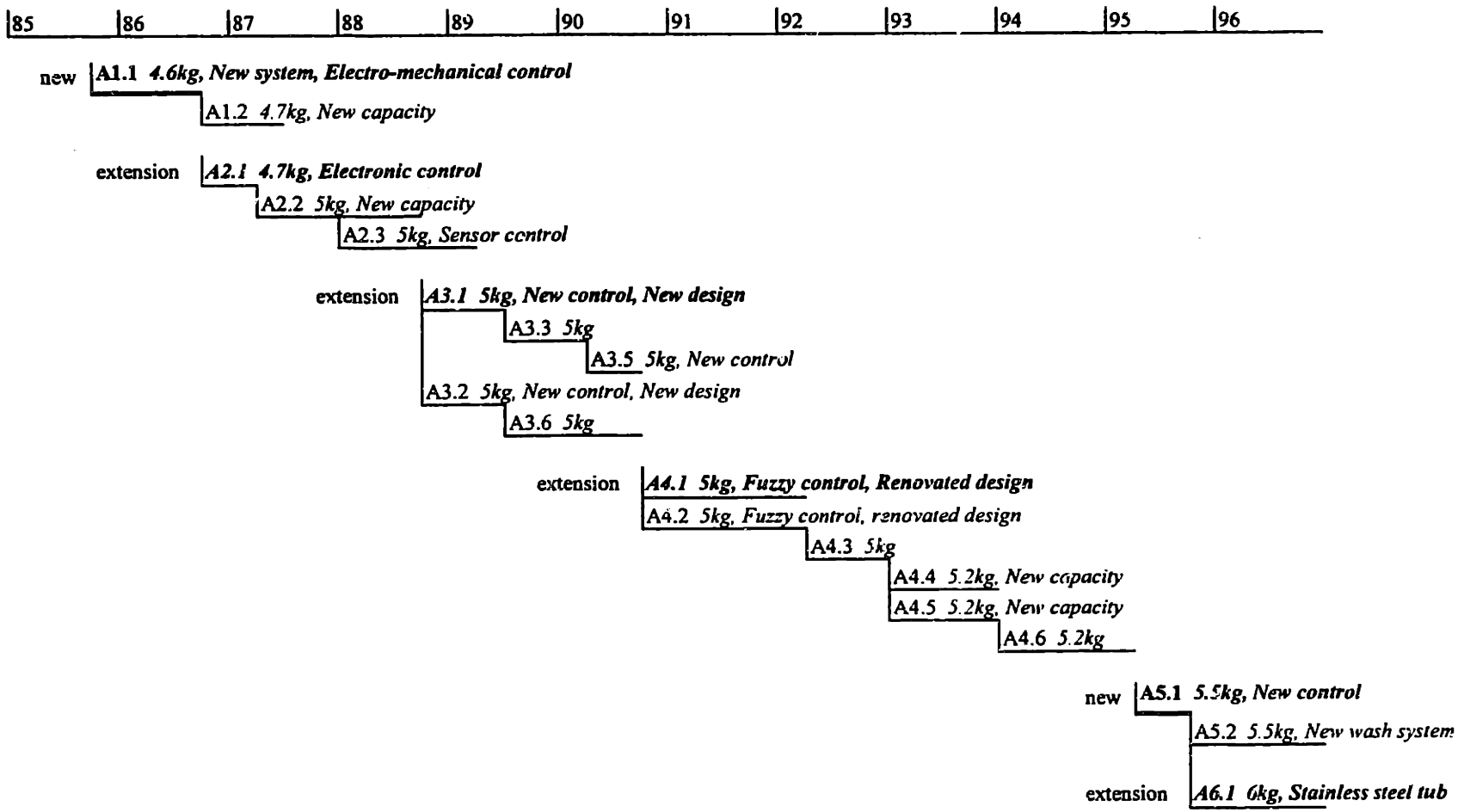


Figure 3-7. Product Model Evolution Map - Family B(6kg ,7kg)

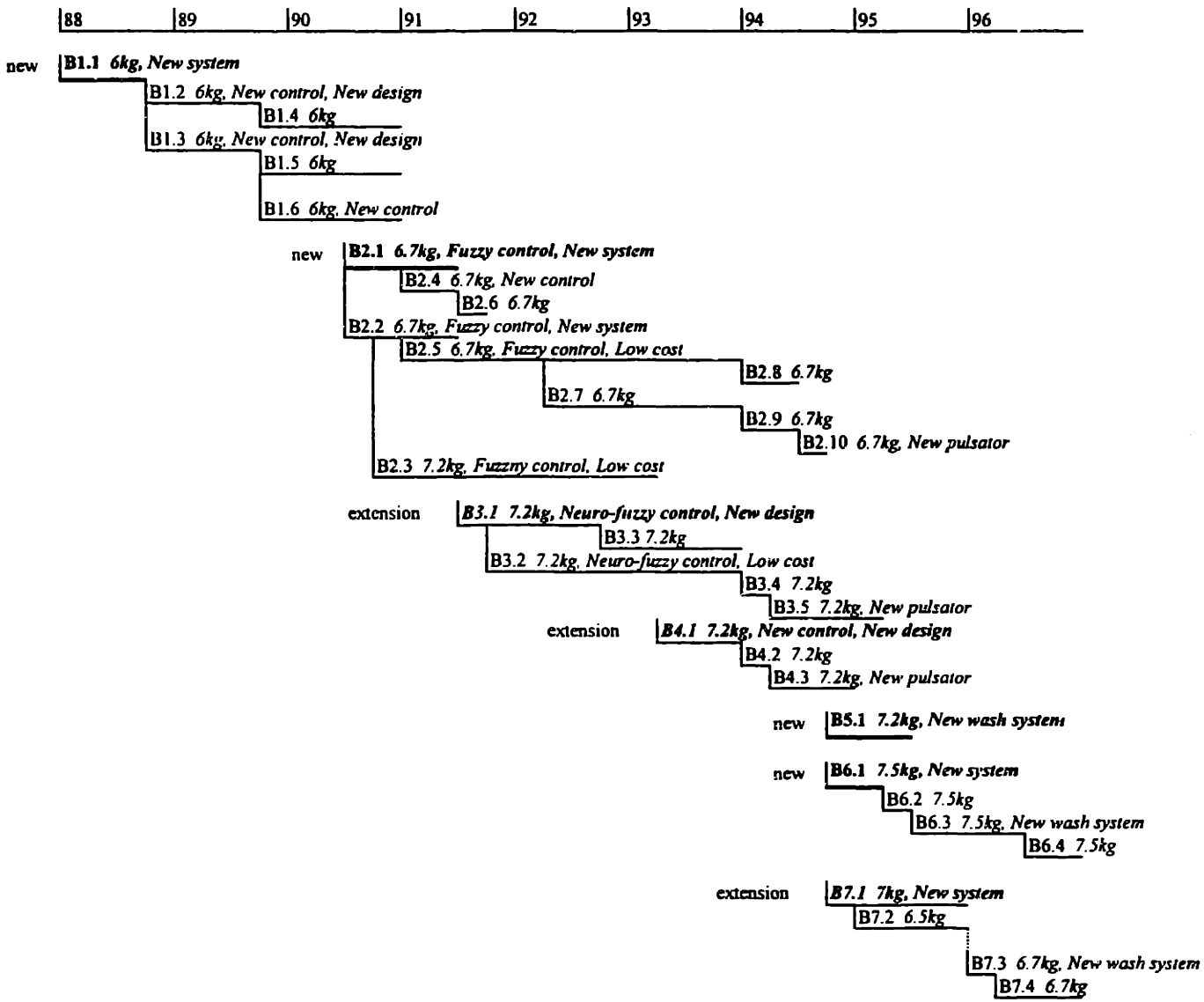
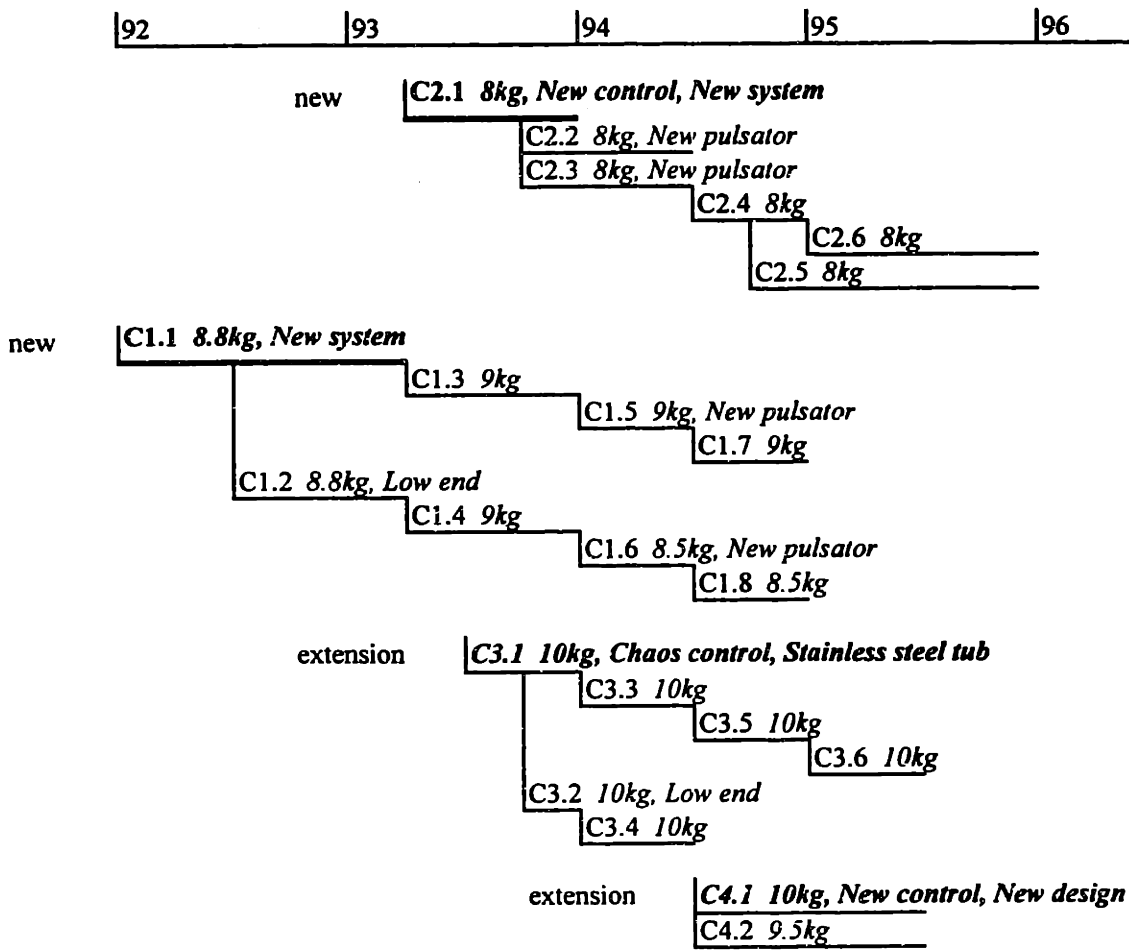


Figure 3-8. Product Model Evolution Map - Family C(8kg ~ 10kg)



The last generation (A4) in this platform was fully redesigned with only the wash subsystem unchanged. The Fuzzy Control system that was newly developed at that time was adopted and appearance design was totally changed to give customers newness of the product. Since this platform was very much improved compared to the previous generations, it lived for over five years. However, as the original platform and its extension architecture outlived its utility, the necessity of a new platform was raised in 1995. LGE developed new platform (A5) in the 5 kg family in 1995 which replaced a previous platform. It adopted a new wash system and control system that used in other product families.

The product model evolution map shows details of the product family evolution. Figure 3-7 shows the 6 kg and 7 kg product family evolution. The initial platform in the family was 6 kg B1 through LGE created five derivative products in two years. However, the platform lived only three years and one generation. As the initial platform was limited in creating platform extensions and derivative products, LGE developed a new platform (B2) in 1990. It incorporated new technologies and manufacturing processes to improve product performance and reduce costs. The Fuzzy Control system and quiet operation were major technological advances of the new platform. The Fuzzy Control system enabled the washing machine to run at optimal wash cycles and to sense the various wash processes. The new platform also incorporated a new assembly design and improved manufacturing productivity significantly. The second platform was so successful that it was followed by nine derivative products over the next five years. It also generated two platform extensions (B3, B4) with new control systems and appearance designs. The second platform was replaced by a new platform when it could no longer accommodate

new customer needs and design modifications efficiently. Two new platforms were developed simultaneously, however, one new platform was designed to incorporate specific market issues and failed to get wider market acceptance. The other new platform replaced the existing one with increased wash capacity of 7.5 kg. One particular aspect of this new platform was that the platform extension was developed together with a new platform. This was possible by developing two wash subsystems simultaneously.

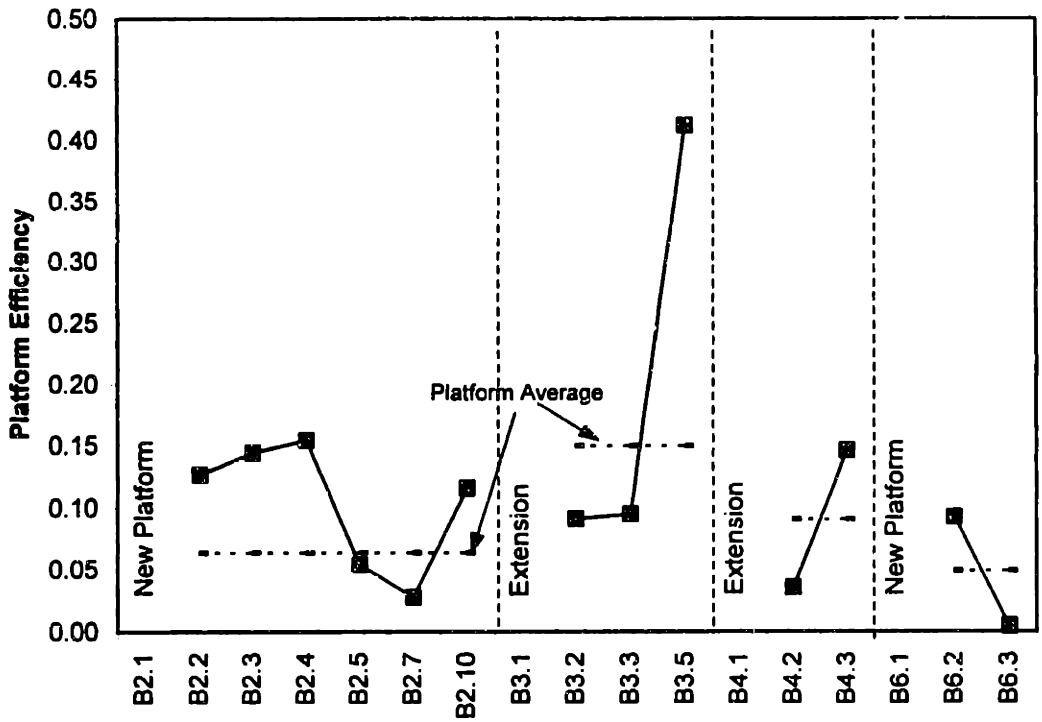
3.6. Product Development Performance

Representative product families were evaluated using the metrics discussed in Chapter Two. Design engineering costs were used to calculate the efficiency of derivative products since it was difficult to collect other engineering costs. Figures 3-9 through 3-12 show product development efficiency and effectiveness of product families B and C, respectively. Each chart shows how the efficiency and effectiveness had changed with the development of platform extension products and derivative products.

Efficiency

Figure 3-9 shows platform efficiency of product family B (6 and 7kg). The chart shows efficiency of each derivative product as well as the average platform efficiency of each generation. For product family B, individual platform efficiency shows wide fluctuations. Of particular interest in the chart is that while the first two derivative products (B3.2 and B3.3) of the second generation platform show stable high efficiency, the third derivative product (B3.5) shows relatively low efficiency (high number). This derivative product was developed during the last stage of the platform life. It needed more engineering effort

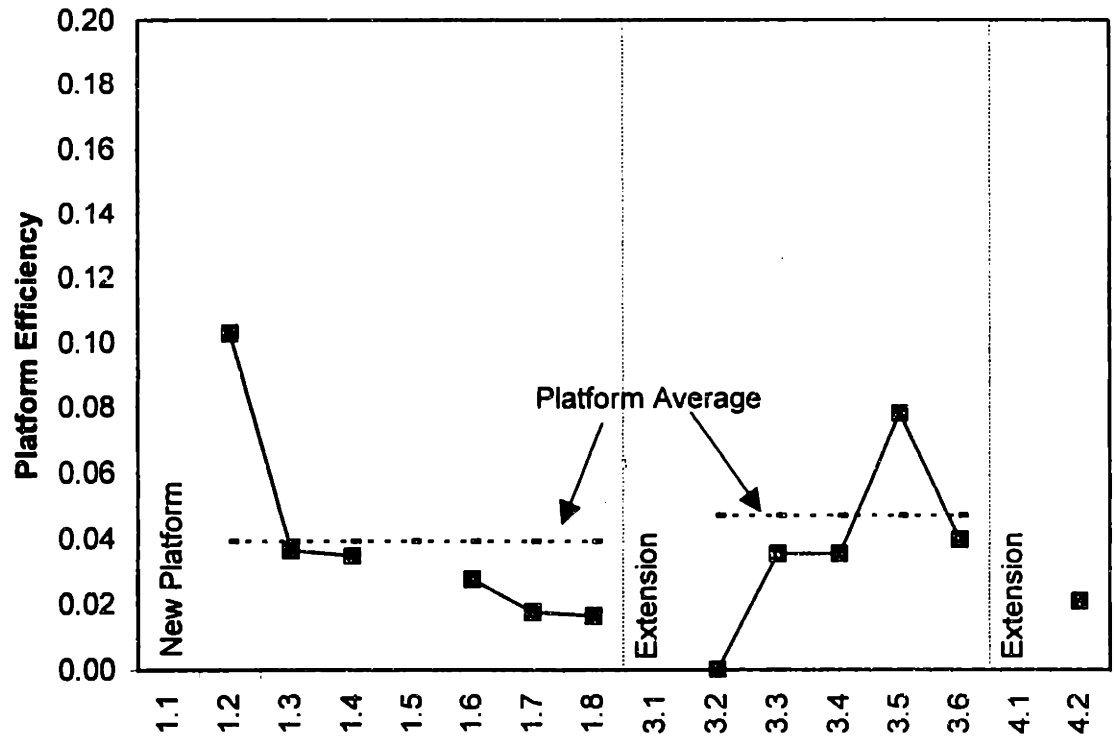
Figure 3-9. Platform Efficiency - Family B(6, 7 kg)



to meet the new market demand using old platform while other product families were newly developed to meet the new customer needs.

The platform efficiency can be evaluated to assess the overall platform generation development efficiency. The dotted lines in the same chart (Figure 3-9) show the average efficiency of each generation of platform and platform extension. Compared to individual derivative products, average platform efficiency is at stable level. Average platform efficiency shows that the two platform extensions have less leverage than the first generation. This means that developing derivative products cost more over time. It also implies that derivative products developed in the later stage of the platform life might

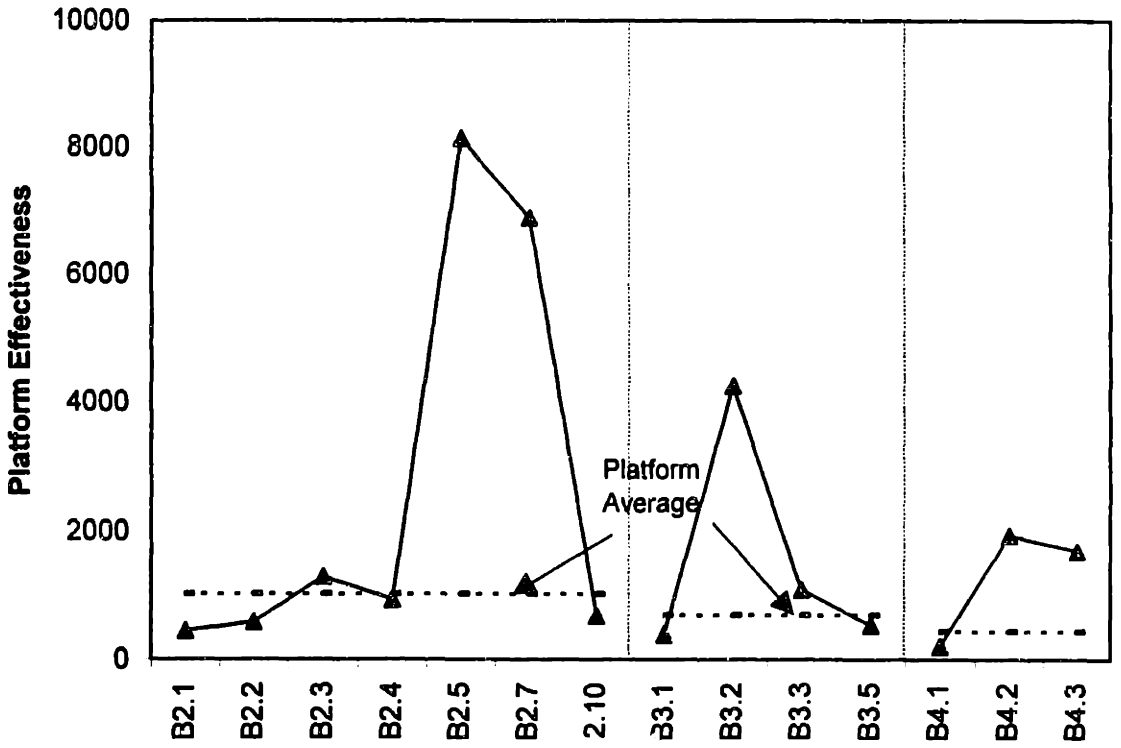
Figure 3-10. Platform Efficiency - Family C(8~10kg)



have been more costly because the customer needs and technology changes were difficult to accommodate in the old platform.

Platform efficiency can be compared across product families. Product family C (8 kg to 10 kg) shows higher efficiency leverage than product family B (6 and 7 kg) in developing derivative products. For example, most derivative products in product family C were developed with less than 5% of the R&D cost of the initial platform product while derivative products in family B costed 5% to 15%. It seems that the company was building robust platforms that enabled efficient development of derivative products over time.

Figure 3-11. Platform Effectiveness - Family B(6, 7 kg)



Effectiveness

Another metrics for evaluating product development performance is *platform effectiveness.* Platform effectiveness is a simple commercial leverage that compares the sales revenue with development costs. Development costs include engineering costs, manufacturing engineering costs, market development costs and expenditure for plants and equipment. However, it was difficult to collect these costs except engineering cost. Although initial tooling costs and equipment costs were available, they were not product specific. In this analysis, design engineering cost was used to measure effectiveness.

Figure 3-12. Platform Effectiveness - Family C(8 ~10 kg)

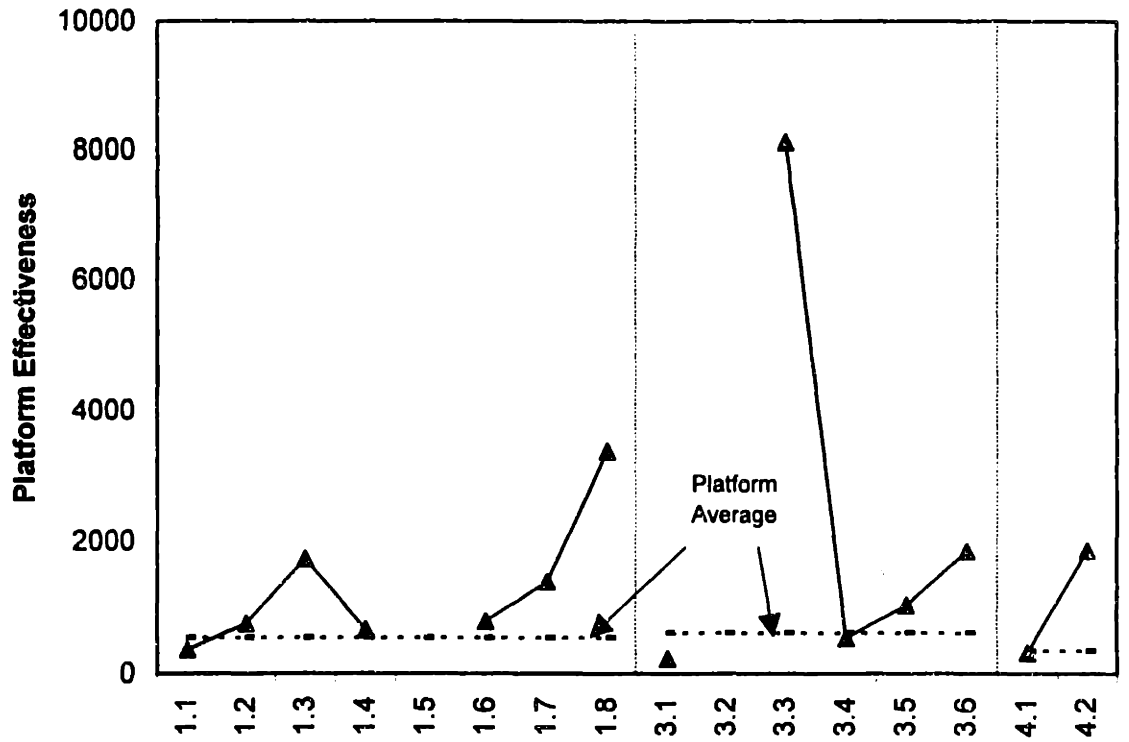
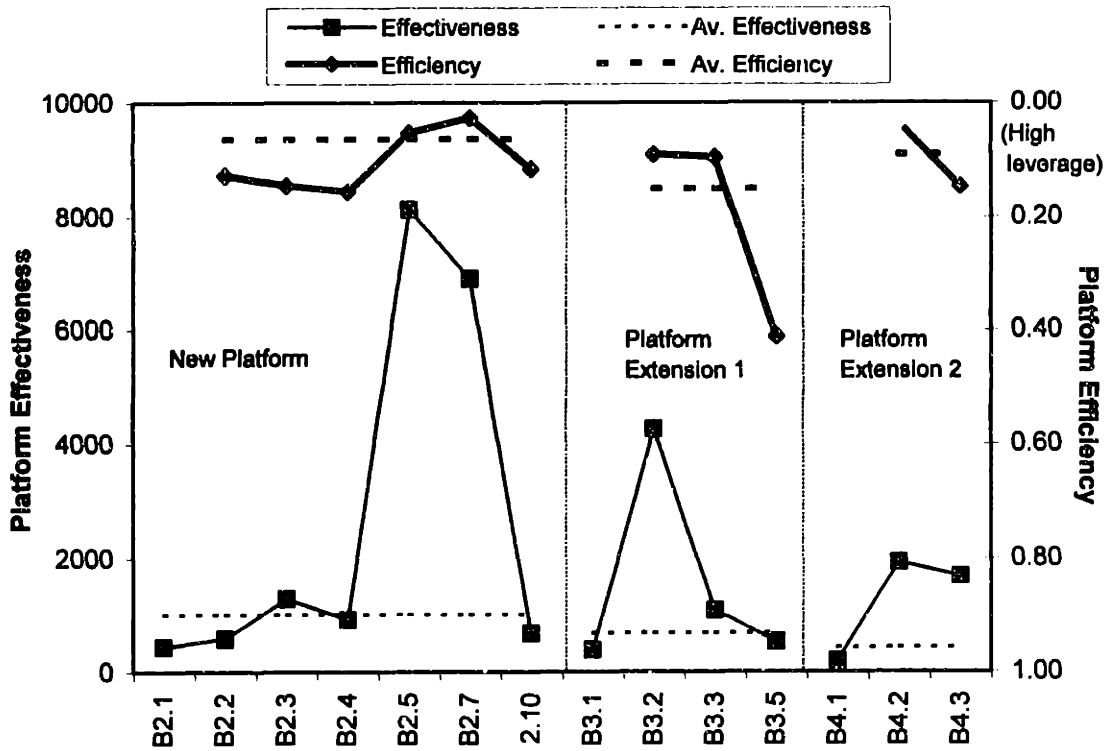


Figure 3-11 shows product development effectiveness for product family B. The same as with efficiency, effectiveness shows wide fluctuations in individual derivative products. While most derivative products show average effectiveness, a few products show high effectiveness. For example, products B2.5, B2.7 and B3.2 showed four to eight times higher effectiveness than other products. The product family map explains part of the answers. One of the reasons why these products showed high effectiveness was their long product life. They lived two to three years while others lived one year on the average in the same product family.

While individual derivative products shows fluctuations, platform average effectiveness shows a stable trend. For example, product family B shows declining platform average

Figure 3-13. Platform Efficiency and Effectiveness - Family B(6, 7kg)



effectiveness over generations. This declining platform average effectiveness can be explained in the combined efficiency and effectiveness chart.

Combined Efficiency and Effectiveness Chart

The platform effectiveness chart can be combined with the platform efficiency chart. Comparing effectiveness with efficiency shows how the platform has performed over time. Figure 3-13 shows the platform effectiveness and efficiency. For the sake of comparison, platform efficiency is in reverse order to show that the leverage level is same as the effectiveness level.

Product family B showed wide fluctuations in platform efficiency; however average platform effectiveness had declined over generations of platforms. In the beginning stage of the platform life, the platform showed high leverage and it accommodated modifications efficiently. However, in later generations, the changes that the platform accommodated could not meet the customer needs though its efficiency still showed high leverage. The derivative products during the last stage of the platform did not sell well and their average effectiveness was lower than the previous platform generation. This implies that the product platform lived longer than its capacity to accommodate changing customer needs. It was able to accommodate easy modifications in terms of development cost, however, the features and functions that it offered with modifications could not meet customer demands very well.

3.7. Findings

3.7.1. Patterns of Product Evolution

The product family evolution map and performance evaluation chart show valuable information of how the company has developed and managed its products over the platform life. First of all, *different patterns of platform evolution* are identified from the product platform evolution map. This can be characterized by "*generational change vs. diverse pattern*" of platform evolution. The platform has evolved generation by generation from 1986 until 1993. The platform evolution chart shows an increase in the number of platforms in 1994 and shows that several platform and extension products were introduced simultaneously and characterized by a diverse pattern of evolution.

Secondly, the platform evolution map shows that the company has developed new platforms and platform extensions and has moved its focus to large capacities. The

company introduced large capacity washing machines more rapidly after 1992. This *capacity-platform evolution* can be viewed with the development of market demand and competition.

Generational Change vs. Diverse Evolution of New Platforms and Platform Extensions

The platform evolution map from 1986 until 1993 shows the introduction of new platform and platform extensions, generation by generation. The old platform and platform extension products were usually replaced by new ones. For instance, product family A of the 5 kg washing machine shows typical generational change. One year after the introduction of a new platform (A1) in 1985, the first platform extension (A2) with an electronic control and new Top Cover was introduced. Over the next four years, two more platform extensions (A3, A4) were introduced replacing the old platform extensions. Then, as the new platform (A5) was introduced in 1995, the old platform was dropped.

Beginning in 1993, the new platforms overlapped more with old platforms. Product family B (6, 7kg) made a transition from generational change to diverse pattern. For instance, the first platform (B1) in family B had a small overlap with the new platform (B2) while the new platform and its extensions (B3, B4) showed a longer overlap with existing platforms and extensions.

Recently, the platform evolution displayed a diverse pattern. Several platforms and platform extensions were developed simultaneously. This diverse pattern of evolution is particularly noticeable in the range of larger capacities (8.5 kg ~ 10 kg). This diverse pattern developed because the capacity range has become a major market segment. As

Figure 3-14 . Characteristics of Platform Evolution

Characteristics	Generational change	Diverse pattern
Period	~ 92	93 ~
Number of platforms running	2 – 3 / year	7 – 11 / year
Number of platforms developed	1 – 2 / year	3 – 6 / year
Market demand	• Growing market • Growth segment changing • Capacity changing • Can identify major capacity and platform	• Stable market • Low growth • Capacity segmentation fixed • Less clear major capacity and platform
Development pattern	• Develop platform product initially • Develop platform extension products later	• Develop platform product and platform extension products simultaneously
Architecture and Subsystem change	• Each platform has own architecture • Several subsystems developed simultaneously	• Commonality and modularity critical • Key subsystem development focused
Platform efficiency	• Medium leverage	• High leverage
Platform effectiveness	• High	• High

product family C (8 kg to 10 kg) is experiencing major market demand, the company is introducing many derivative products. It has narrowed its capacity differentiation to 0.5 kg in this segment by introducing new platforms and extensions.

One of the factors that distinguishes the generational change and diverse evolution is the development pattern. In generational change evolution, platform extension products were

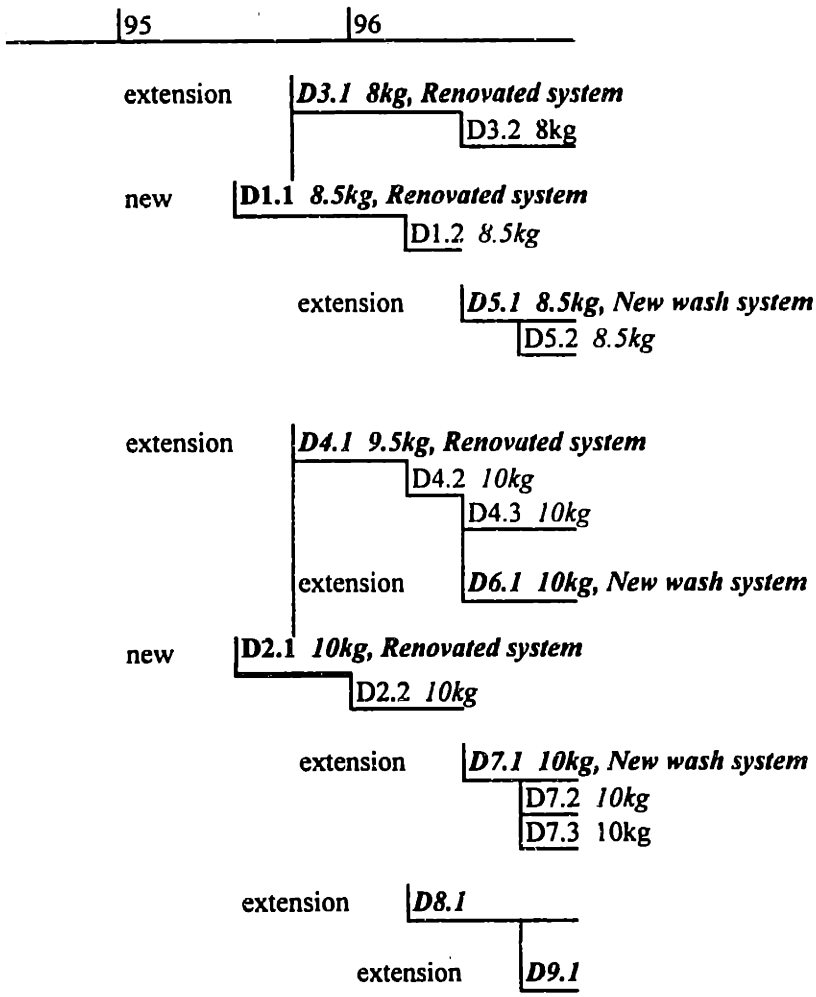
developed after some interval along with new platform products. In a diverse evolution, platform extension products were developed simultaneously or followed new platforms in very short intervals. Figure 3-14 summarizes the characteristics of generational change vs. diverse evolution of platforms.

Change-intensive vs. Variety-intensive Evolution of Derivative Products

While platforms and platform extensions showed a transition from generational change to diverse pattern, derivative products continued to show a *change-intensive* evolution until recently. Product families A, B and C all show this change-intensive pattern characterized by generational change. Typically, most old derivative products were replaced by new ones. The force behind this change-intensive pattern is competitive market pressure. It forced the company to develop new derivative products more frequently. New derivative products were used to show newness and innovativeness of products without incurring much development cost and manufacturing investment.

The evolution of derivative products evolution have shown a generational-change-intensive pattern before recently showing a variety pattern. For instance, product family C shows an increasing variety of derivative products. Figure 3-15 shows a recent variety pattern in a new product family D (over 8 kg). With stable demand, capacity segmentation became fixed and customer needs became relatively stable. At the same time, customers are more price and feature sensitive. These factors drive the company to more varieties of derivative products within a platform.

Figure 3-15 Product Model Evolution Map - Family D(over 8 kg)



Transition from Capacity-platform Evolution to Derivative Evolution

Product evolution shifts from platform evolution to derivative product evolution as the market becomes stable. This is analogous to what Sanderson and Uzumeri (1996) called "*transition from product family evolution to product model evolution.*" When the market was growing with changing capacity segmentation, product family evolution focused on capacity-platform development. LGE tried to develop new capacity-platforms and extensions targeting the growing segment. During this rapid capacity-platform evolution period, customers wanted the largest capacity and latest products. Competitors also tried to render existing capacity-platforms obsolete by offering new capacities. Even when market growth became flat, LGE tried to increase the demand by introducing larger capacities. However, when it became clear that the market could not grow any more and the capacity-platform evolution hit the limit in 1995, the capacity-platform evolution shifted to a derivative products evolution. This was clearly illustrated by the proliferation of derivative products over 8 kg in product families C and D in 1995.

3.7.2. Market Forces of Product Family Evolution

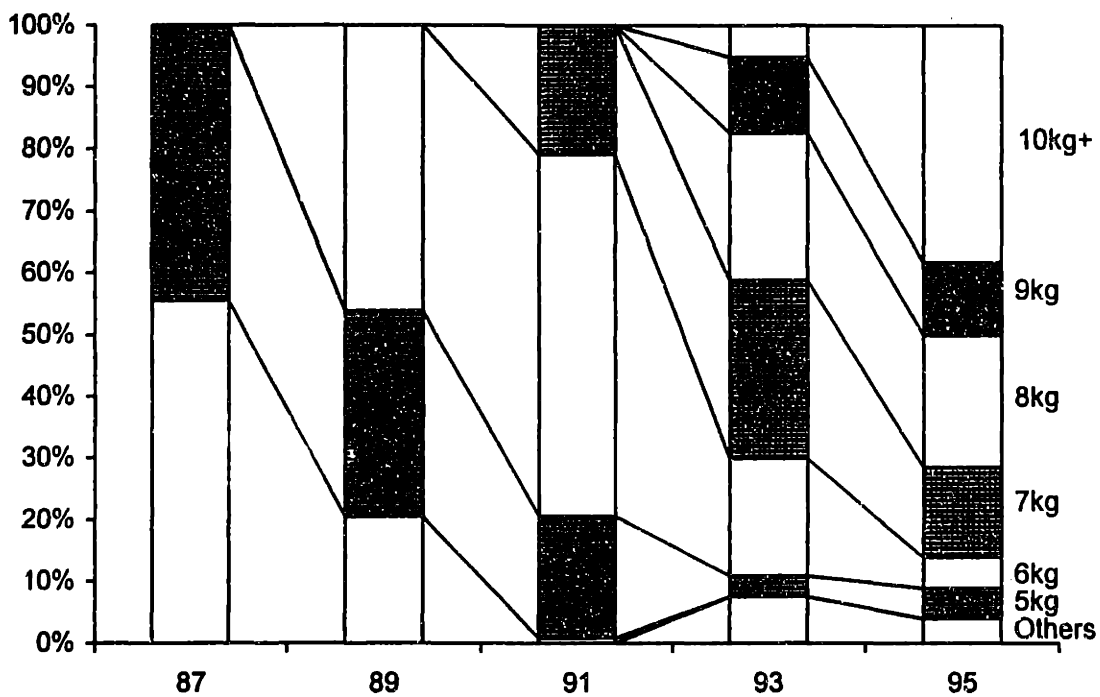
What drives product family evolution? Sanderson and Uzumeri (1996) argued that not only market forces but also technological forces influence the patterns of product family and model evolution. In the case of LGE washing machines during the 1990s, market forces have mostly shaped the patterns of product family evolution. Technologies embedded in washing machines have been conventional and changed little and slowly. Most technologies required to meet the market demand were readily available or easily developed. Market forces, however, have been changing dramatically for the last ten

years as is shown in market demand (Figure 3-1) and capacity segmentation (Figure 3-16).

Capacity

Capacity, which has been found the most important factor that characterized the market demand, has driven the product family evolution in the washing machine case. The capacity trend in Figure 3-16 shows how market segmentation has changed over time. The platform evolution map (Figure 3-5) shows that LGE has developed new platforms and platform extensions following the capacity trend. Until 1987, the largest capacity product that LGE's produced was 5 kg. LGE has now washing machines ranging in size from 5kg- to 12kg- capacities. The company has continued to introduce new

Figure 3-16. Capacity Segmentation Trend



capacity-platforms and extensions. For example, after the introduction of the 6.7kg washing machine (B2.1) in 1990, LGE produced 7.2kg, 8.8kg and 10kg capacity washing machines within the next three years. LGE developed not only new platforms and platform extensions but also derivative products targeting growing capacity segments. While capacity 6 kg had been a major segment from 1989 to 1991, LGE developed as many as seven derivative products in this 6 kg segment. Product families B and C show the shift of target segment from 6 kg to 8kg and 10 kg capacities.

The shift of capacity can be seen in the declining product development effectiveness, too. Figure 3-11 shows that platform average effectiveness declined with platform extensions in product family B. When 6 kg was the fastest growing segment, the platform effectiveness was high. However, as the capacity moved to 8 kg, later generations of platform extensions (B3, B4) showed declining platform average effectiveness.

Price-performance Tier and Product Longevity

Price-performance tier had also influenced product family evolutions. Especially, the price-performance tier played a significant role in the derivative products evolution based on the competitive pressure. This influence can be explained by the product longevity. For example, even during generational change-intensive period, there were a few derivative products that lived long. Product family B (6 kg and 7 kg) had three long lived derivative products (B2.3, B2.5, B3.2) which had sold for about three years while other derivative products lasted less than one and half years. These derivative products also recorded very high effectiveness showing far better commercial leverage than other derivative products. The reason why these products lasted long and showed high

effectiveness was that they successfully targeted the low-end tier of the growing segment. They were all developed to provide low-end product variety after high-end platform product or platform extension products were initially introduced.

LGE had traditionally focused on high-end products based on its technological leadership. High-end products were usually introduced first followed by low-end products. This strategy helped to increase sales revenue and profit. LGE had concentrated its marketing efforts on high-end products as flagship products. Low-end products were introduced to create product variety. However, the longevity and high effectiveness of low-end products requires the company to review its product development strategy to exploit the sweet spot of the market. During the growing period, high-end products can catch customer attention easily as customers want the best and latest products. However, after the market saturated, it needs to further exploit the growing low-end segments.

3.7.3. Patterns of Product Development

Another point that needs close examination is the pattern of platform extension and derivative product development with the evolution of subsystems. Though it is not shown on the map in detail, it is found that platform extension and derivative product have their own development patterns. Most platform extension products were developed by changing capacity or the control system while derivative products were developed by small topological changes or functional changes. This pattern of platform extension and derivative products development shows major subsystem evolutions and their impact on the product change and variety.

Subsystem and Pattern of Product Development

The control and wash subsystems were the two most important subsystems for platform extension products. Platform extensions were generally developed by improving major benefits to the customers. In the washing machine, wash performance is the most important benefit and the wash subsystem, together with the control subsystem, addresses this performance. The wash subsystem determines the capacity and the control subsystem controls the wash processes in the wash subsystem. The wash subsystem has changed from a small plastic tub to a semi-stainless steel tub to a full-size stainless steel tub. The stainless steel tub enabled the increase of capacity of over 10 kg that was difficult with the plastic tub. The control system has been one of the most changed subsystems in the washing machine because with the development of electronics and software technology, the control subsystem in the washing machine has also evolved continuously. The electronic control system has evolved from a simple touch button control to a fuzzy logic control to a chaos logic control more recently. The continuous evolution of the control subsystem provided an advanced technology image to the washing machine that had been considered one of the most conventional appliances.

The appearance subsystem was the most frequently changed part of the platform extension and derivative products. The design changes of appearance parts such as Top Cover, Lid and Control Panel were the most visible changes. Other minor changes also were done with cosmetic variations such as color and graphic decoration changes. The appearance subsystem changed mostly because it was the most efficient way to present newness to customers without incurring large development costs.

4. Implications for Managing Product Development

Analyzing product family evolution and performance metrics provides valuable insights for managing product development. A company should recognize the patterns of evolution for its product lines and the key drivers of the evolution. It should also know how efficiently its products have been developed and how effectively its new products have contributed to the business performance. Most of all, it should know how to plan for the future product development based on its knowledge of past product family evolution and performance metrics.

During the generational change period, LGE developed one or two new platforms and platform extensions every year while, for the diverse evolution period, it developed three to six new platforms and platform extensions. The development pattern for generational change showed that derivative products were developed later with some time interval after the platform products. In a diverse pattern of product family evolution, derivative products were developed simultaneously or with a short interval between platform products. Different patterns of product family evolution require managing product development differently.

The company should change its development system accordingly. LGE had developed different architectures and subsystems for each platform in the generational change period. It recently started to develop a common architecture and subsystems through several platforms. The developmental focus has moved from individual platform performance to product family performance based on commonality and modularity. LGE has also started to develop key subsystems that can be applied to several platforms.

In this section, major implications for managing product developments will be discussed and examples of future product development approaches will be presented.

4.1. Types of Product Development

The traditional definition of product development (Figure 3-4) didn't view product development from a product family evolution perspective and lacked a long-term horizon. It was mostly based on the amount of resources needed, especially a tool-building requirement. An analysis of product family evolution provides insight about the pattern of product development in the company. This pattern of product development helps the company to redefine the types of product development. The extent of changes in the subsystems and the pattern of development are useful factors in developing new types of product development for washing machines. Figure 4-1 shows new types of product development from a product family evolution perspective.

Defining types of product development is one of the primary elements of product development strategy. Explicit definition helps functional organizations to understand and communicate product development clearly from a product family evolution perspective. Once types of product development are classified, a company can use it strategically to plan long-term product family development and technology development. It also allows the company to plan resource and capability development accordingly since different types of product development require different levels of resources and capabilities. A company can also plan the evolution of key subsystems that relate to each type of product development. Key subsystem changes that are incorporated in new platform or platform extension developments should be prepared in advance.

Figure 4-1. Types of Product Development

Type	Extent of Changes	Development pattern
New product	• New wash mechanism	• New technology
New platform	• Two or more major subsystem changes including: – Wash system – Control system – Appearance parts – New Drive system • New manufacturing process	• Capacity change with new wash system • Overall system redesign for cost reduction • Overall product system performance improvement
Platform extension	• Major subsystem changes of the following: – Wash system – Control system – Appearance parts (Top Cover)	• Overall appearance change • Major appearance(Top Cover) change with other minor subsystem changes • Major subsystem redesign for cost reduction • Major product performance improvement • Major function and feature improvement
Derivative	• Minor subsystem change – Component level – Electrical rating • Capacity change by software • Minor wash software change • Minor appearance change – Lid, Control Panel – Color / Graphic	• Market newness • Adding or deleting function or features

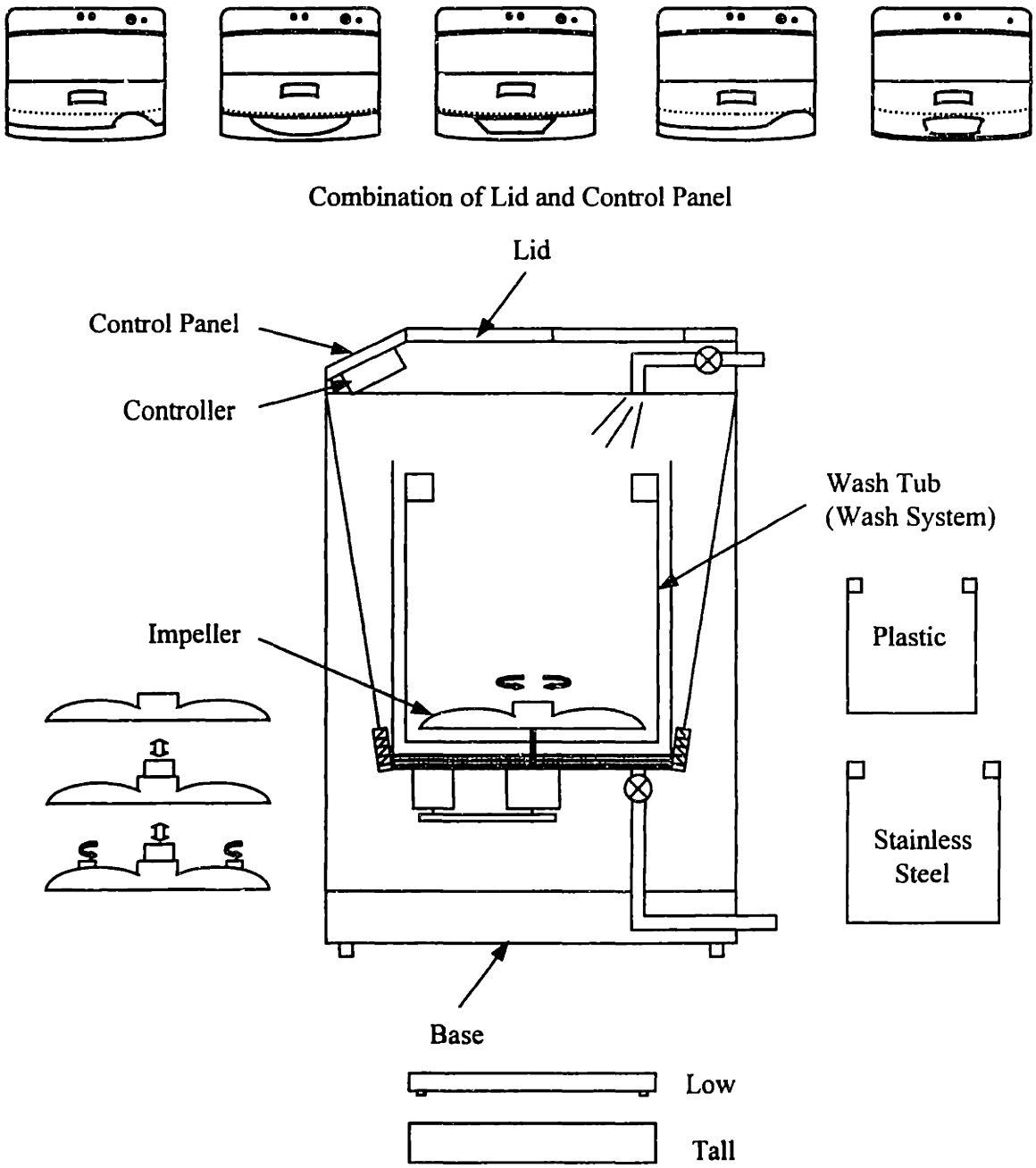
4.2. Product Architecture, Modularity and Commonality

The patterns of product family and subsystem evolutions show the importance of architecture in product platform. Product platforms that had well-designed architecture lived long and created many derivative products efficiently. Recent product example highlights the efficiency of creating multiple derivative products from a well-designed architecture with commonality and modularity.

P-Project is a 5kg to 6kg capacity washing machine. The company developed the P-Project initially targeting the overseas markets as well as the domestic market. Historically, the company first developed products for the domestic market and then modified them for the overseas markets. Taking these various target markets into account, the development team considered different market needs around the world and the evolution of products for long-term. The development team analyzed the patterns of customer needs and evolutions of past product families in the target markets.

When the capacity range was determined 5.2 kg to 6 kg other potential development areas were determined. Different capacities would be supported by two different wash systems – one by a plastic tub and the other by a stainless steel tub. The wash tubs were developed with common base geometry to accommodate three different impellers. Two control systems were adopted sharing mostly common components and several variations of control systems were offered with optional functions. Most changing market demands fell into the appearance differentiation as was found from past derivative product evolutions. The team planned modular appearance parts developing four Lids and five Control Panels. The other subsystems and components were all designed as common

Figure 4-2. Modularity of P-Project



parts. With the combination of the above subsystems, the company could develop eight basic derivative products with six engineers in 18 months and make numerous variations thereafter. If the products had been developed in the past, it would take more than 3 years

and require twice as many engineers. Later, a platform extension was developed using the same methodology creating another eight derivative products in nine months.

As is described in the above example, product architecture is important in manufacturing companies for managing product change, product variety, component standardization, product performance, and product development management (Ulrich 1995). Product architecture especially determines how efficiently the product can be changed and how broad an array of products can be offered. The efficiency of product change is becoming more critical as the competition becomes more intense. With a robust architecture, a company can meet the market demands quickly and efficiently without losing windows of opportunity. For example, when there is a price competition, a company can quickly create the low-end product stripping down high-end modules.

The architecture of a product is the scheme by which the functional elements of the product are arranged into physical chunks and by which the chunks interact (Ulrich and Eppinger 1995). The architecture serves as a basis for the product platform. A product architecture can become a product platform architecture if it is designed and then used as the basis for creating several derivative products (Meyer and Lehnerd 1997). Commonality and modularity are the two most important characteristics of a product's architecture. Design strategies based on commonality and modularity have the major advantage of reducing cost without significantly reducing product variety. However, it requires managing complexity and integration efforts (Tung 1991).

Product architecture, commonality and modularity should be explicitly defined and shared among functional organizations in the company. A clear and explicit definition of

them helps organizations to identify the role of platforms and plan the evolution of the product family strategically. For example, it would help to plan how to meet different customer needs in different marketplaces and how to add or delete product functions and features to create derivative products.

4.3. Long Term Product Development

With an explicit and clear definition of type of product development and a robust product platform, a company can create a long-term product development plan. The timing of product platforms and derivative products, and intervals among them become critical elements in planning long-term product family evolution. Market requirements and product strategies are the most critical factors that determine the timing and interval of product developments.

As shown in the evolution of the capacity-platform of washing machine, when the capacity had been major driving force in the late 1980s and early 1990s, LGE focused its efforts on the development of platforms and platform extensions in the growing capacity segments. Once platforms were developed, its focus moved to derivative products that followed platforms. LGE's product development exhibited *'steady stream'* strategy (Wheelwright and Clark, 1992). LGE introduced derivative products in steady intervals until the capacity-platform reached the limit of growth. Then, a new capacity-platform or platform extension was developed to address changing market demands and another groups of derivative products followed.

Recent changes in the timing and interval of product development in LGE require a different strategy. As the capacity-platform segmentation was stabilized, the competition

has changed to product variety and price competition. The volatile market required companies to quickly develop derivative products meeting different customer needs and low-price efficiently. LGE needed to shift to simultaneous and initially-concentrated development of platform and derivative products and to bring both high-end and low-end products together from the beginning. This strategy helped the company to efficiently develop derivative products with limited resources in a short time period.

While there is a range of choices regarding when to introduce platforms and derivative products, above two examples show representative strategies in formulating long-term product development planning. The 'steady stream' strategy helps a company to efficiently catch the sweet spots of the market as market demand moves from one segment to another. A 'simultaneous development' strategy addresses intense competition. A 'simultaneous development' strategy can also maximize market effects such as advertising and launching a promotion. A company should consider the market development and resource requirement as well in planning for the long-term. It also needs to plan product architecture carefully taking platform efficiency and effectiveness into account. A subsystem evolution should be planned parallel to product development plan ensuring commonality and modularity.

4.4. Platform Strategy

Identifying platform strategy based on market segment and the price-performance tier shows how the company has leveraged its product platforms to develop product families. LGE had leveraged its platform to address a range of price-performance tiers in each capacity segment. LGE traditionally developed high-end platform products initially. Then it expanded its platforms to low-end derivative products stripping down some functions

and features. When one market segment was dominant, LGE was able to expand its product offerings from the high-end to low-end tier.

LGE also experienced platform leverages across several market segments. When it developed new functions or components that had critical benefits for customers, it usually applied them to the platforms in all market segments. For example, when LGE developed new impeller system, it was adopted by platforms in all capacity segments. Another example is the application of fuzzy control technology. Fuzzy control technology was developed for 6.7kg platform washing machines initially and later incorporated into control subsystems across all market segments.

These examples show two different generic platform strategies: vertical leverage and horizontal leverage. Vertical platform strategy can be employed in two ways. One strategy is to strip down product offerings from the high-end to low-end tier and the other is to scale up low-end products to the high-end. Vertical platform leverage can be employed when the market grows moving from one segment to another. The benefit of vertical leverage is that it enables a company to develop products efficiently. A company can exploit the sweet spot and increase revenues as it can quickly develop new products targeting growing segments. Horizontal platform leverage occurs when the market is stable and several market segments coexist. A company could introduce streams of new platforms across market segments by leveraging one platform. Horizontal leverage improves the commonality and standardization and reduces cost by increasing the scale economies of subsystems and their components.

The choice of platform leverage is a strategic decision based on market and product strategies. For example, Meyer and Lehnerd (1997) argue that building platforms that can profitably serve the low-end tier first is better. The growth in markets invariably shifts downward over time. Thus, the fact that companies make money in the lower price-performance tier enables easy scaling upward and ensure better overall profitability in a selected market segment. A company should assess its market environment and future development to formulate an appropriate platform strategy. It should also know what the current platforms are and how efficiently derivative products are developed from them.

4.5. Concurrent Multiple Product Development

In this section, new approaches to product development suitable to LG Electronics will be described as an example of managing product development based on the lessons from the analysis of product family evolutions and platform performance evaluations.

With an intense price competition during the past couple of years, LGE has lost market opportunity due to late product development. As the product platforms were planned and developed individually targeting each capacity segment, many problems were discovered. First of all, late sequential application of improved features and functions to derivative products caused the company to lose revenue and cost reduction opportunities. Though, new subsystems or components were developed to improve the product value, it took some time for the company to take advantage of new subsystems or components. New cost reduction ideas could not applied to all segments, either. Secondly, as the individual products were developed separately without considering the cross-segment platform leverage, subsystems and their components proliferated which created difficulty and

inefficiency in developing new products. The proliferation of subsystems and components also added costs and complexity of management.

Reviewing and benchmarking the product family evolution and product development process, LGE found that front-end product planning did not take the product architecture, commonality and modularity into consideration. Consequently, the number of subsystems and components were increased. It was also found that the platform leverage was not properly planned and typically minor subsystems or components were leveraged within the single-capacity segment. As a result, LGE lost the full benefit of platform leverage. Specifically, horizontal platform leverage was rarely planned and developed. The sequential development and introduction of different capacity platforms and derivative products obstructed full horizontal platform leverage.

In order to address these issues, new approach to product development were needed. The company decided to focus on the modularity across capacity platforms. New approach also addresses the issue of sequential derivative product developments by implementing concurrent development of multiple platforms and derivative products. New approach emphasizes front-end planning of product architecture, commonality and modularity to enable rapid product development and to increase the scale economy of subsystems and components to reduce cost.

New Process

The first step in LGE's new approach to product development is the Quality Function Deployment process which identifies customer needs and competitiveness. The second step is spec simulation which defines modules matching the customer needs. By grouping

Figure 4-3. Spec Simulation

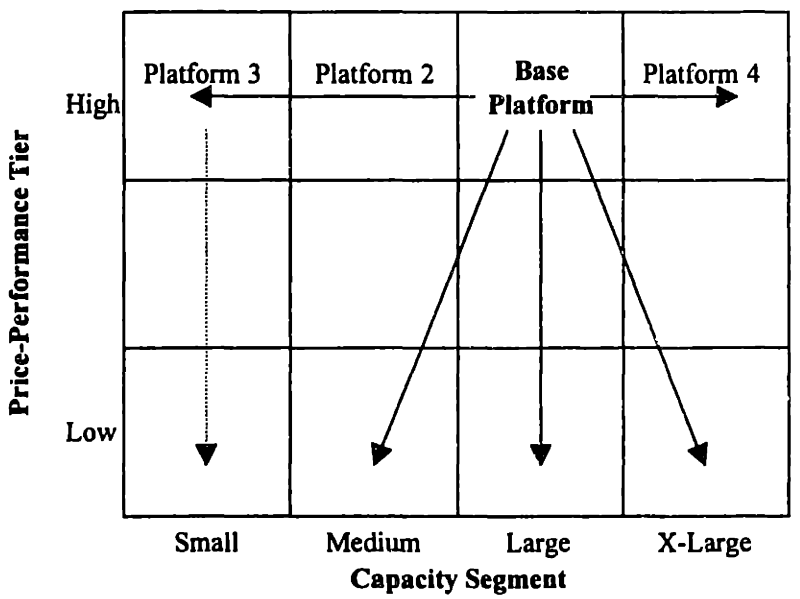
Subsystem Module	A		B		C		D	
Spec	a	b	c	d	e	f	G	H
Group 1	O	X	O	X	O	X	X	X
Group 2	O	X	O	X	X	O	X	X
Group 3	O	X	X	O	O	X	X	X
. . .	"a" standardization		"c" and "d" standardization		"e" and "f" standardization		Delete "D" module	

Subsystem Module	A		B		C		D		Competitiveness	Cost	Platform
Spec	a	b	c	d	e	f	g	h			
Group 1	O	X	O	X	O	X	X	X			Base
Group 2	O	X	O	X	X	O	X	X			
Group 3	O	X	X	O	O	X	X	X			Low tier
. . .	. . .		. . .		. . .		. . .		. . .	. . .	. . .

specs that can be accommodated into products, the company can simulate potential specs of subsystems. A module is an interchangeable subsystem or component (1) that enables differentiation and impacts sales or (2) that is common across several platforms or

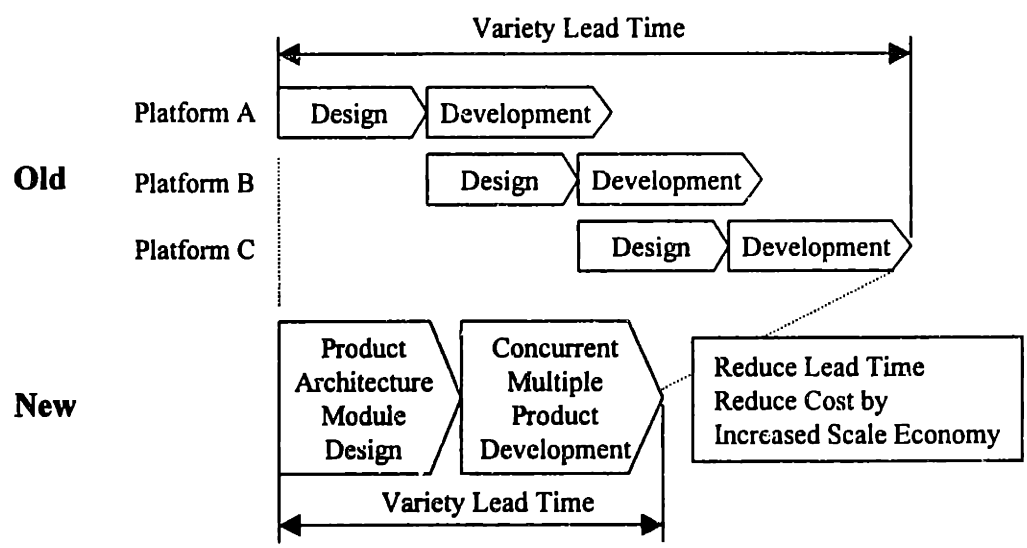
derivative products. Though a module should possess interchangeable structure and characteristics, a spec-module simulation is based on customer benefits and competitiveness. Figure 4-3 shows an example of spec module simulation. Grouping spec modules based on target customer segment leads to the creation of product platforms. The platform that targets a major segment serves as a base platform. The platform strategy must be considered in selecting a base platform. The last step is to leverage this base platform and its modules across several capacity-platforms to maximize scale economies of subsystems and components. Figure 4-4 shows the leverages from the high-end base platform. Base platform can be modified to platform extensions to serve different price-performance tiers in the same segment or nearby segments. When deciding commonality, a company should consider the trade-off between savings from scale economy, and investment and cost difference from different module.

Figure 4-4. Base Platform and Leverage



Managing the development organization of this new approach is also different from the past. In the initial stage of development when front-end planning occurs, the development team is organized as an architectural design team and consists of subsystem teams and functional teams to support them. An architectural team defines platform architecture. It also identifies and plans platform leverages. Once the modular platform architecture is defined and leveraged across several capacity platforms, each capacity platform is developed by a dedicated project team. At the same time, derivative products in each segment and price-performance tier are also developed simultaneously. Figure 4-5 shows the difference between the old process and the new approach in concurrent multiple product development processes.

Figure 4-5. Concurrent Multiple Product Development Process



It is possible to have *concurrent multiple product development* by building robust platform architecture based on commonality and modularity. Its major benefits are (1) reduced lead time to leverage one platform to another and to increase product variety, and (2) cost reduction from horizontal leverage across several market segments with increased scale economy of subsystems and components. It also has high efficiency in creating derivative products within a platform. Predefined spec modules enable the platform scale upward or downward easily. Past research on product development have focused on excellence in single product development. However, with a robust platform, concurrent multiple product development is more efficient than a series of sequential product development.

5. Conclusion

The objectives of this paper were to assess the product development strategy and identify implications for managing product development in the case study company. The study was based on the frameworks of product family evolution and product development performance metrics developed by Meyer, et al. (1995). The case study identified a few implications for managing product development.

It was found that different market environments required different platform strategies. When market was growing from one segment to another, the company needed to develop platform products more rapidly to exploit the growing segment. A vertical platform leverage was more important in the growing period. A platform should be developed to enable more efficient creation of derivative products within a platform. As the market became saturated, intense competition required the company to bring broader product variety to the marketplace. Today, the pattern of product evolution has changed to variety driven competition. The company should shift its platform strategy to leverage horizontally across segments developing multiple platforms and derivatives efficiently. Key subsystems and components should be shared among multiple platforms to increase scale economies and to reduce costs.

It was also found important that a company should identify and define patterns of product development in relation to product architectures. New patterns of product development were identified and presented for the case study product. Identifying types of product development helps the company to formulate platform strategy and long-term product development plans. In order to address the need for product variety and simultaneous

development of multiple products, a company should design robust product architectures based on the patterns of product development that guide the speed and variety of product change.

A few low-end products were found to have lived longer than high end products. Though the company has traditionally focused its product development on high-end products, as the market becomes saturated and mature, the fastest growing segment moves into the low-end tier. This low-end product longevity urges the company to review its product and platform strategy. One possible solution would be to develop a base platform in low-end tier and leverage it to other price-performance tiers and market segments.

Because this paper is limited to a single case study of one company, it is difficult to generalize the implications to other products or companies. However, close examination of the market environment and product evolution will show analogies of the findings from this paper. Further case studies of multiple companies within an industry would give more insights. One of the alternatives would be a series of case studies for multiple products in a company. They will lead to a more comprehensive understanding of product evolution, platform performance and platform strategies in the company.

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