Product Architecture Analysis of Projector and Strategy for Gaining the Competitive Advantage

Masahiro Togawa¹, Oke Oktavianty², Shigeyuki Haruyama³ and Yoshie Ishii⁴

¹,⁴ Graduate School of Science and Technology for Innovation, Yamaguchi University, Japan, 7550097
² Universitas Brawijaya, Indonesia
³ Graduate School of Innovation and Technology Management, Yamaguchi University, Japan, 7550097

¹ g503wc@yamaguchi-u.ac.jp
² okemn7@ub.ac.id
³ haruyama@yamaguchi-u.ac.jp
⁴ i001wc@yamaguchi-u.ac.jp

Abstract. The analysis of product and process architecture and how does it relate to the competitive advantage was studied. The integral degree of functional part was also investigated to determine the highly competitive part. The product flow strategy by product architecture’s type of three projector manufacturers was examined. The different architecture for each company’s product allows them to use product strategy for gaining the competitive advantage. The strategies are by conducting the vertical integration as the ultimate customization strategy, make standardization with the horizontal development while taking a thorough customization strategy for the lead company or standardize the external integral and change it to modular type of product architecture.

1. Introduction

The strategic decision making is important to strengthening the position of company in global competitiveness and increase the profitability. In product strategy, product architecture is one of the components that has a decisive role in developing and promoting integrated product strategy, technology, and operations [1]. In general, the product design is classified into functional design, structural design and process design, that is a system in which a plurality of constituent elements connected to each other. The interdependency of the linking of the plurality of the constituent elements so called as product architecture become a design philosophy. Product architecture is classified into two types, namely modular type and integral type [2]. It was stated from the previous research that the Japanese automobile manufacturers that choose an integral type of product architecture has a high global competitiveness [3]. Other study in the Japanese process industry clarified the relationship between process architecture and global competitiveness from an architecture-based approach. The process industry of two different product, Liquid Crystal Display (LCD) panel and flat glass from the same TFT-LCD industry was compared and the source of global competitiveness was identified [4].
In the architecture theory, it was argued that the architecture product and process which differentiated design of functional components are highly competitive products. This architecture-based approach has been used as an analysis tool for industry analysis [5]. There were few cases shown the methodology use a classification of functional parts as a standalone product or details of its usefulness [6]. It was stated from another study that evidence has showed that misleading can be occurred while adopting the modularity-integrality tradeoff [7]. In this research, we focus on display element parts for projectors that considered have highly competitive advantage based on market share of products. This study verified the usefulness of product architecture-based analysis in evaluating and classifying the functional parts of the product. Concurrently, we tried to investigate the competitive advantage of functional parts. Integral type of product architecture in the design philosophy is a product design philosophy in which the relationship between function groups and parts group is complicated. This type of product architecture is a design philosophy that suitable for optimum design. The optimum design is required for each product, but the development cost of an integral type of product is higher than modular type products. On the other hand, in the modular architecture with one-to-one part and function type of product architecture, there is no trade-off problem between the functions, and the necessity to develop each part is smaller than that of the integral type.

By considering the mutual relationship among multiple companies, there is another way of thinking with concepts of "open type" or "closed type" of architecture. The open architecture is a modular type product with the standardized interfaces between modules at the industry level. If we collect parts over the enterprise and combine it, we have the necessary functions and the products can be made without any friction. In closed architecture, the interface design rule between modules is basically closed by one company, and the "basic design" part which is interface design and functional design is accomplished by one company. The architecture classification is shown in Fig. 1. There are three types of architecture namely closed-integral type, closed-modular type, and open-modular type. [8], [9].

| Integral (fitting) | modular(combination) |
|-------------------|----------------------|
| design concept: conflicted functions and parts | each part is completed as a functional unit |
| relation between function and part is “one-on-one” | combination of parts is simple |
| fitting improves the perfection | gathered parts can be a product |

- **closed**
  - The design rule of inter-module interface is closed in one maker
- **closed-integral type**
  - Automotive, motor cycle
  - Small, light and thin application
  - Game software etc.
- **closed-modular type**
  - Mainframe computer
  - NC machine
  - LEGO® etc.
- **open (standard)**
  - The product that interfaces for modules are standardized
- **open-modular type**
  - Personal computer system
  - Body of personal computer
  - Internet product, bicycle

**Figure 1** Architecture classification (integral modular, closed- open)

2. Evaluation method of architecture-based approach classification

The effectiveness of architecture-based approach analysis was discussed for similar liquid crystal display panels. In the same way, the examination is also carried out for image elements for projectors. In the past, the market for LCD televisions has taken high market share as a product of manufacturing in Japan. However, most of the current market share for liquid crystal televisions, the modularization, particularly for liquid crystal panels has been secured by overseas manufacturers [10]. The liquid crystal panel is an integral type product, but along with the development of the panel industry, the material procurement was facilitated by external sales and technical collaboration from Japanese companies. As a result, it has been shown that the interfaces between components have been widely standardized within the industry and the fact that the module type structure has become an essential factor. Similar with the
video system product, there is a projector that used liquid crystal in small panel as its main part. However, liquid crystal panels that used for personal computers and televisions is different. Therefore, even with the same liquid crystal panel, since the display elements in projector products having different functions with the final products, the competitiveness is still high. It was presumed that both product architectures and process architectures are integral type functional parts [10]. In this research, we verified that the image element for the projector is a functional part, by analyzing using the architecture classification. The other study described how to use architectural knowledge in a company for gaining advantage strategically [11]. In this study, we also conducted the comparison among three companies and examined their product flow strategy.

2.1 Architecture-Base Approach Analysis

The industries can be classified based on product-process design architecture [5]. An architectural way of thinking may provide the additional insights, that architecture matters may affect the company’s competitiveness and profitability. The different product or process architecture may affect the way of a company or the cluster of companies in developing, producing and selling the products. It will be affecting the strategies, competitiveness of companies, industrial structures, and the trade flows. In this study, we investigated the type of product and process architecture and the nature of mutual dependency among systems included in products.

2.1.1 Product architecture analysis

It is necessary to evaluate the degree of integral structure and the degree of openness and closeness for classifying the product architecture. The modular type has one-to-one relationship among the structure and function in product architecture. The value obtained by dividing the function / structure connection degree by the total number of functional elements and structural elements.

2.1.2 Process architecture analysis

There is similarity between product and process architecture. The process architecture is applied to the product which explicit and obvious relationship between structures and functions. The process architecture is defined in terms of relationship between the production process system and the product structure system. The functional requirement in product architecture is mapped to a processing flow. The type of architecture is decided according to the degree of connectivity that showing the relationship between the structure and the production process.

2.1.3 Customer product analysis (product architecture)

If our products are a part of the final product, the product architecture will greatly affect the properties of the final product. Therefore, the final product is divided into a basic functional component and each product architecture is analyzed. Architecture analysis and evaluation results on projector panel are shown in Figure 2. This figure shows that the market share of projector panel for three companies that secured the entire market. Therefore, we focused on the difference in panel technology in the analysis and evaluation.

3. Architecture analysis and evaluation results on projector panel

3.1 Architecture analysis

In this research, architectural analysis was evaluated by comparing the structural configuration and part with the requirement characteristics as “WHAT” characteristic needed by customer and “HOW” to fulfil the requirement characteristic in Quality Function Deployment (QFD) method by the product structure. Score “1” means that there is relationship between the characteristic and the structural configuration. The relationship between characteristic and structure-part configuration is shown in table 1.
Table 1 Product Architecture Analysis (QFD)

| Characteristic         | TFT  | Polarizer film | Optical design | Chilling technology | CF  | Projection | Total |
|------------------------|------|----------------|----------------|--------------------|-----|------------|-------|
| High definition        | 1    | 1              | 1              | 1                  | 1   | 1          | 4     |
| High quality image     | 1    | 1              | 1              | 1                  | 1   | 1          | 5     |
| High reliability       | 1    | 1              | 1              | 1                  | 1   | 1          | 5     |
| High contrast          | 1    | 1              | 1              | 1                  | 1   | 1          | 6     |
| High brightness        | 1    | 1              | 1              | 1                  | 1   | 1          | 4     |
| Low energy             | 1    | 1              | 1              | 1                  | 1   | 1          | 6     |
| Integral degree        | 6    | 4              | 6              | 3                  | 5   | 6          | 30    |

The relationship between required characteristics and the panel structure is depicted in figure 2. It shows the complicatedly intertwined connection. Therefore, it was determined that the product has high integral degree, and the panel is an integral type of the projector part. The functional element of projector was examined, and the analysis result is shown in table 2. The largest point of projector configuration is 42, but it was found that the score of the integral degree of projector is only 18. Therefore, it was concluded that the projector is not an integral type product. Although it is not a product with high degree of integral type, the panel of the unit configuration and the optical part are related to the important functions. The projector is a modular product, but the panel is an integral part. However, since the optical block is one the final product, it becomes an integral type of customer products. It is important to classify the product by unit even if the product is modular type, the relationship greatly changes with unit division method. By using this method, it was determined that the optical block is also the integral type.

Figure 2 Product Architecture Analysis
Table 2 Integral Degree Analysis in Projector

| Characteristic  | Panel | Optical block | Drive circuit | Outer Chill unit | Projection unit | Total |
|-----------------|-------|---------------|---------------|------------------|-----------------|-------|
| High definition | 1     | 1             | 1             | 1                | 1               | 2     |
| High quality image | 1     | 1             | 1             | 1                | 4               | 4     |
| High reliability | 1     | 1             | 1             | 1                | 2               | 5     |
| High contrast   | 1     | 1             | 1             | 1                | 3               | 6     |
| High brightness | 1     | 1             |               | 2                | 2               | 6     |
| Quietness       |       | 1             | 1             | 1                | 1               | 4     |
| Integral degree | 6     | 5             | 2             | 1                | 2               | 18    |

3.2 Process Architecture

The process architecture can be specified by applying the architecture concept to the production process. It was defined with respect to a correspondence relationship between production process system and product structure system. Therefore, when the process architecture relies on the structure and production process of the system, the type of architecture is determined based on the degree of connectivity showing the correspondence between the structure and the production process.

Table 3 Process architecture analysis (QFD)

| Structure                  | BP Depositio n | Repeat | Liquid crystal | Mountin g | Total |
|----------------------------|----------------|--------|----------------|-----------|-------|
| Digital BP                 | 1              | 1      | 1              | 1         | 4     |
| Tight GAP                  | 1              | 1      | 1              | 1         | 5     |
| Inorganic alignment film   | 1              | 1      | 1              | 1         | 4     |
| High reflectance           | 1              | 1      | 1              | 1         | 5     |
| Liquid crystal cell        | 1              | 1      | 1              | 1         | 5     |
| Integral degree            | 5              | 5      | 4              | 5         | 23    |

Table 3 shows the relationship between product structure and production process. The high score 23 of 25 or 92% from total score indicating that the process architecture is the integral type. It was found that the image element for the projector is an integral type for both product architecture and process architecture, and the element is a functional part.

3.3 Evaluation of Architecture Benefit

The market share of the projector display device biz is shown in figure 3. The market share is monopolized by three manufacturers from 2012 to 2017. The image elements of each company are products with high entry barriers and each company has a high market share and considered to be a highly competitive product. However, because there is a difference in occupancy rate, even though the product architecture is the same, further investigation is necessary concerning the factors that contribute to the difference in share of each company.
4. The product flow strategy by product architecture’s type

The value chain in manufacturing process of the projector is shown in figure 5. The panel manufacturer supplies the panel, and the projector manufacturer uses other parts to manufacture. From the analysis in the previous section, the image element and the optical block section are the main constituent elements of the projector, which is a component with high functionality.

![Figure 5: Projector component parts and elements plan](attachment:image.png)

The classification and properties of the product architecture is depicted in figure 3. The positioning strategy diagram for each classification and properties of the product architecture is shown in figure 6. According to the analysis results in Section 3.4, the effectiveness of customization strategy is discussed for the table elements of the projector. It was stated in section 3.3 that market share is monopolized by
three companies (TI DLP, EPSON HTPS and SONY HTPS). The strategy differs among the three competitors (three companies) even in the middle integral.

4.1 Texas Instrument (TI): Digital Light Processing (DLP)

The product flow strategy of this company is shown in figure 7. The value chain is made in the form of selling the panel to the projector manufacturer by hand with the optical division manufacturer, and standardization is being carried out.

Figure 6 Positioning strategy diagram by architecture

The product flow strategy of three companies by product architecture’s type is as follows:

- **Texas Instrument (TI): Digital Light Processing (DLP)**
4.2 EPSON: High-Temperature Polysilicon (HTPS) LCD Panel

The product flow of EPSON HTPS is shown in figure 8. In the case of this company, the optical block was changed to the final set of projectors. Vertical integration type was altered. Vertical integration was conducted thoroughly designing to meet the target, and the target in the set more than the customization strategy. By creating more value-added products and product groups, it is possible to make the total product as a final product and increase profits.

![Figure 8 Product flow of EPSON HTPS](image)

4.3 SONY High-Temperature Polysilicon (HTPS) LCD Panel

This company aims to standardize panel specifications with product flow is shown in figure 9. Rather than promote new development with each company but to dealing with lead company for its own products. The products for others are standardized by promoting lateral development. This is a close strategy of products development.

![Figure 9 Product flow of SONY HTPS](image)

The panel which is the main part of the projector product is an integral type product. The latter optical block has the structure of the middle integral and the outer integral. Table 4 shows different strategies of three panel manufacturers. Basically, each company has different strategies depending on the response policy of the post-process.
Table 4. Strategies of three panel manufacturers

|   | TI                        | EPSON                                         | SONY                                        |
|---|---------------------------|-----------------------------------------------|---------------------------------------------|
| **Strategy** | standardized external modularization of the post process | Overall optimization by vertical integration from panel to projector | Intensive customizing and standardization |
| **Contents** | By introducing a new panel using Digital Light Processing (DLP), the system can be easily introducing the optical block without the deflection element that is the main factor of the optical characteristics like the liquid crystal. Therefore, optical manufacturers can also advance market expansion and development into new markets by entering by emerging manufacturers and securing a large market. | This company deals with selling projectors, withdraws the panel sales business, strengthens its response to the needs, and coordinates its own core technologies by vertically integrating from panel to projector, focusing on its own projector products. As a result, it contributed to many advantages such as cost reduction in response to in-house products, improvement in total projector performance, leading the industry as lead company. | When developing a new panel for the first customer to introduce a new panel. The panel development will be deployed to other customers with slight modifications, and standardization will be made with no major change. It is a standardization strategy for the customization strategy to the lead company and the panel manufacturer. |

For strategy of TI, several manufacturers handling only the optical parts of the post-process. By standardizing the optical parts, it is possible to make the final product of projector as a modular architecture type of product. Therefore, it also become potential to increase the number of end users as compared with the barriers to entry in the post-process. In the case of EPSON’s strategy, they originally sold projectors, but on the other hand they were supplying parts to other projector manufacturers. However, the requirement from each projector manufacturer was vary then it cannot be standardized. Hereby, EPSON’s company can develop and produce the projector in a short time through vertical integration.

SONY’s company has both a panel and a projector, but the panel is not a vertical integration. The panel is panel, and the projector is projector and each of them is profitable. Thus, the panel takes the form of an outer integral. Basically, the development will proceed in alignment with customers but as specifications, we will use the same panel as much as possible. For example, even if a customer requests the high resolution, when the panel reaches production, we will proceed to have the supply from other companies. In this way, we are developing with lead company. Keep supplying to the standard panels and developing other companies. However, the development speed is significantly inferior than vertical integration with EPSON’s company.

The unique architecture for each company is different by considering the connection between the projector and the image element. The policy was made by using the product architectural. Accordingly, we will able to gain more profit by the following methods:

1. Conduct the vertical integration as the ultimate customization strategy.
2. Make standardization as the horizontal development while taking a thorough customization strategy for the lead company.
3. Standardize the external integral and change it to modular.

5. Conclusion

From the architectural analysis, the image elements of the projector are integrated into the product architecture and the process architecture. The structure and function of the product are complicated, then the functional part of the product is an integral type. It was found that the barrier to entry the other companies are high. In addition, the functional part is a highly competitive part because there is no change in market share in the last few years and there is no entry from other companies.

For securing the market share, it becomes apparent from the architecture analysis that the complementary strategies are necessary. As architecture analysis result of the image element of this projector, it was shown that the product and process architecture functional component is an integral type of product, and it is determined as a highly competitive product.

However, there are parts that cannot be discussed by merely the product and process architecture. The complementary methods can be examined by architectural analysis of the final product since each share is different in a competitive environment. The strategic part of the whole product including the architecture classification of the final product is considered to be useful and become a future challenge.

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