

Research on the Relationship between Product Architecture and Pricing: Take New Oriental Education & Technology Group as an Example

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Keywords: Product architecture, Module, Pricing, Relationship.

Abstract. Product architecture is the sum of the relationships among the modules of a product, which reflects the integration and decomposition capabilities among the modules. Based on the pricing theory and profit maximization principle, this paper constructs a mathematical model of the relationship between product architecture and pricing. By studying the course system of New Oriental Education & Technology Group, it is found that the stronger the relationship among the modules in product architecture, the stronger the influence on the pricing of product architecture, which expands the new direction of the research and development of product architecture.

Introduction

Product architecture mainly focuses on the study of product functions and the relationship among modules within the product architecture [Ulrich,1995]. The relationship among modules in the product architecture will have an impact on pricing. The relationship among modules in the product can be measured by coupling. The less the relationship among modules, the worse the coupling and the stronger their independence [Baldwin,2000].

Product architecture mainly studies product functions, product components and the relationship among modules in product architecture, and it cannot be regarded as the simple integration of modules [Jeffrey,2001]. The key of product architecture is that the interconnections among modules constitute a system as a whole, so that product functions can play their value, and product architecture ensures the systematic and functional integration of products [Baldwin,1997].

Krishnan [2011] deduced joint product architecture and pricing method through modeling and analysis, which solved the problem of inconsistent enterprise design and enabled innovative companies to launch modular and upgradable products in the best way and at the same time. These can also help researchers to understand the most suitable market and product types of modularity upgradability, and ensure the business efficiency of enterprises. Krishnan's research provides guidance for pricing and product design decisions for management sequential innovation.

Based on the relationship between product architecture and pricing, this paper has established a mathematical model based on pricing theory and profit maximization principle. Then, take New Oriental Education & Technology Group (NOETG) as an example, collect data through online and offline channels, verify the model, draw research findings, and propose suggestions for NOETG 's pricing decision. By comparing the architecture price with the accumulation of the module price under different architectural coupling, this paper discusses the influence of the coupling degree among modules on pricing, so as to draw the conclusion of the relationship between product architecture and pricing, and propose suggestions for the pricing decision of New Oriental Education & Technology Group.

Model of the Relationship between Product Architecture and Pricing

The numerous course systems of NOETG are multiple product architectures. Take the postgraduate entrance examination intensive training courses for example, the following courses: math, English, politics, etc., are multiple modules. The model is built based on the influence of each module on the pricing of the whole course system. Every company has multiple product architectures, each of which has different pricing strategies due to different attributes. There are

multiple modules within each produce architecture, and the relationship among the modules have an impact on the overall pricing of the product architecture.

Symbol Description

The variables and meanings used in this study are shown in table 1:

Table 1. Variable annotation table

Variable	Meaning
$\theta \in (0,1]$	coupling degree coefficient among modules When the value is 1, the relationship is the strongest. When the value is 0, the relationship is the weakest.
α	the relationship coefficient between the number of modules and the architecture price
β	the relationship coefficient between the architecture sales volume and the architecture price
a	the expected architecture sales volume when not affected by the price
b	the expected architecture price when not affected by the relationship among modules.
max rev	the biggest income
P_{j_i}	the product architecture price
Q_{j_i}	the product architecture quantity
P_{M_m}	the price of single module
Q_{M_m}	the module quantity

In this paper, the model is built on the basis of realizing the maximum revenue of the company, which depends on the price and quantity of the architecture. The unit price of the architecture is a variable that depends on the price of the module, while the unit price of the whole architecture is the accumulation of the module price.

Since the price of a single module is affected by the relationship among modules in the architecture, we introduce the relationship coefficient θ , $\theta \in (0,1]$. The coefficient α is used to indicate the relationship between the number of modules and the architecture price. The letter b is used to denote the expected architecture price when not affected by the relationship among modules. In this case, the formula of architecture price is:

$$P_{j_i} = b - \sum (1 - \theta) P_{M_m} + \alpha Q_{M_m}. \tag{1}$$

The sales volume of the architecture depends on the price of the architecture. The higher the price of the architecture, the lower the sales volume of the architecture, and the lower the price of the architecture, the higher the sales volume of the architecture. The coefficient β is used to indicate the relationship between architecture sales volume and architecture price. The letter a is used to denote the expected architecture sales volume when not affected by the price. So, the formula of the architecture sales volume is:

$$Q_{j_i} = a - \beta P_{j_i}. \tag{2}$$

Model Establishment

The objective function of this model is to maximize enterprise revenue, that is: the architecture price multiplied by the architecture sales volume. So,

$$\max \text{ rev} = P_{Jj} * Q_{Jj}. \quad (3)$$

$$\max \text{ rev} = P_{Jj} * Q_{Jj} = [b - \sum(1-\theta)P_{Mm} + \alpha \sum Q_{Mm}] * [a - \beta P_{Jj}]. \quad (4)$$

In this model, changes in related variables should be controlled to maximize the income. Make:

$$X = b - \sum(1-\theta)P_{Mm} + \alpha \sum Q_{Mm}, \text{ so,} \quad (5)$$

$$\begin{aligned} \max \text{ rev} &= X * (a - \beta X) \\ &= -\beta X^2 + aX \\ &= -\beta(X^2 - a/\beta X + a^2/4\beta^2 - a^2/4\beta^2) \\ &= -\beta(X - a/2\beta)^2 + a^2/4\beta. \end{aligned} \quad (6)$$

So the objective function is a downward opening parabola with vertices, and the function has a maximum. The model is established correctly. So,

$$\begin{aligned} \max \text{ rev} &= [b - \sum(1-\theta) P_{Mm} + \alpha \sum Q_{Mm}] * [a - \beta P_{Jj}] \\ &= -\beta [b - \sum(1-\theta) P_{Mm} + \alpha \sum Q_{Mm}]^2 + a [b - \sum(1-\theta) P_{Mm} + \alpha \sum Q_{Mm}], \text{ in which } a, b \text{ are fixed} \\ &\text{constants, and make } \alpha=0.3, \beta=0.6, \text{ so} \end{aligned}$$

$$\begin{aligned} \max \text{ rev} &= -0.6 [b - \sum(1-\theta) P + 0.3 \sum Q]^2 + a [b - \sum(1-\theta) P + 0.3 \sum Q] \\ &= -0.6 [(b + 0.3 \sum Q) - \sum P (1-\theta)]^2 + a [(b + 0.3 \sum Q) - \sum P (1-\theta)] \\ &= -0.6 [(b + 0.3 \sum Q - \sum P) + \sum P \theta]^2 + a [(b + 0.3 \sum Q - \sum P) + \sum P \theta]. \end{aligned} \quad (7)$$

Take the Partial derivative of θ :

$$\begin{aligned} \partial r / \partial \theta &= -0.6 \{ 2 * [(b + 0.3 \sum Q - \sum P) + \sum P \theta] * \sum P \} + a \sum P \\ &= -0.12 \sum P (b + 0.3 \sum Q - \sum P + \sum P \theta) + a \sum P \\ &= -0.12 (\sum P)^2 \theta + [a \sum P - 0.12 b \sum P - 0.036 \sum P \sum Q + 0.12 (\sum P)^2]. \end{aligned} \quad (8)$$

Make $\partial r / \partial \theta = 0$, so

$$\theta = [a \sum P - 0.12 b \sum P - 0.036 \sum P \sum Q + 0.12 (\sum P)^2] / 0.12 (\sum P)^2. \quad (9)$$

Revenue is greatest when and only when θ is taken for this value.

Case Verification--Take New Oriental Education & Technology Group as an Example

The case study method has been used by more and more researchers. This paper uses case study method to verify the rationality of the model by taking New Oriental Education & Technology

Group as an example on the basis of establishing the model of the relationship between product architecture and pricing.

The purpose of choosing the case study method is that the case study method can help us fully understand the complex issues, and help us understand the nature of the research problem more effectively by cross-examining the research question: the relationship between product architecture and pricing. Case studies do not require control over the research process and they are designed to address current issues.

This paper takes New Oriental Education & Technology Group as an example to verify the model, so as to study the relationship between product architecture and pricing. This paper strictly follows the standard requirements of *Case Study Research: Design and Methods* [Yin, 2003], so as to ensure the reliability and accuracy of data information and the reliability and validity of case study, and to ensure the rigor of the study.

There are two course systems of New Oriental Education & Technology Group. The relationship among courses in each course system is different. Through comparison, research results can be obtained.

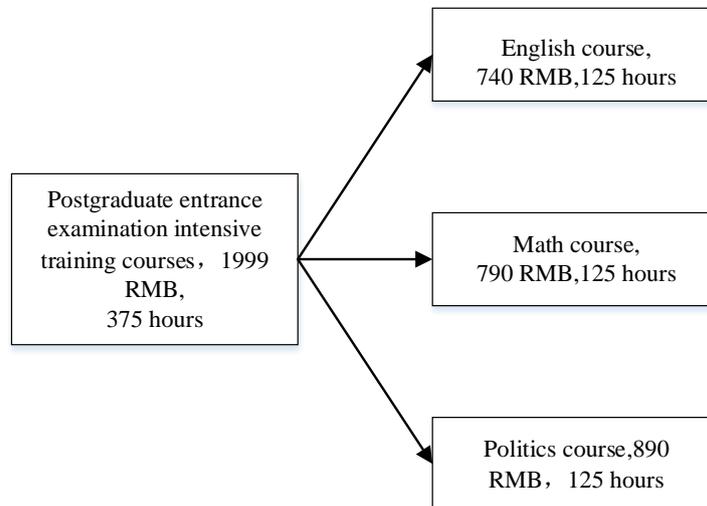


Fig. 1 The postgraduate entrance examination intensive training courses system of NOETG

Figure 1 shows the postgraduate entrance examination intensive training courses system of NOETG. There are three modules of course in the whole course system, namely English course, math course and politics course. All of courses are 125 hours, and the price are: 740 RMB, 790 RMB and 890RMB respectively. The price is 1999 yuan for the whole course system, 375 hours. The correlation among these courses cannot be determined at present, so we can calculate based on existing data.

Firstly, we should calculate the correlation coefficient among the three courses according to the model. Secondly, we have to judge the size of correlation coefficient. The closer it is to 1, the stronger the relationship will be; otherwise, the weaker it will be. Finally, the price of the whole course system and the cumulative price of courses are compared to determine the influence of the relationship between modules on the architecture pricing.

$$\text{Apply the formula: } P_{Jj} = b - \sum(1-\theta) P_{Mm} + \alpha Q_{Mm} \tag{1}$$

According to the data, $P_{J1}=1999$, $P_{M1}=740$, $P_{M2}=790$, $P_{M3}=890$

$$\theta = [a \sum P - 0.12b \sum P - 0.036 \sum P \sum Q + 0.12(\sum P)^2] / 0.12(\sum P)^2 \tag{9}$$

Put in $\alpha=0.3$, $\beta=0.6$, $a=100$, and $b=740+790+890=2420$.

After calculation, it is obtained that: $\theta \approx 0.34$,

The correlation coefficient is 0.34, and there is a weak correlation among courses under the course system, so the price of the whole course system will not be much cheaper than the accumulated price of courses. Therefore, the relationship among the modules in the product architecture is weak, and the influence on the pricing of the product architecture is not strong.

Besides, there is another course system for elementary minority languages.

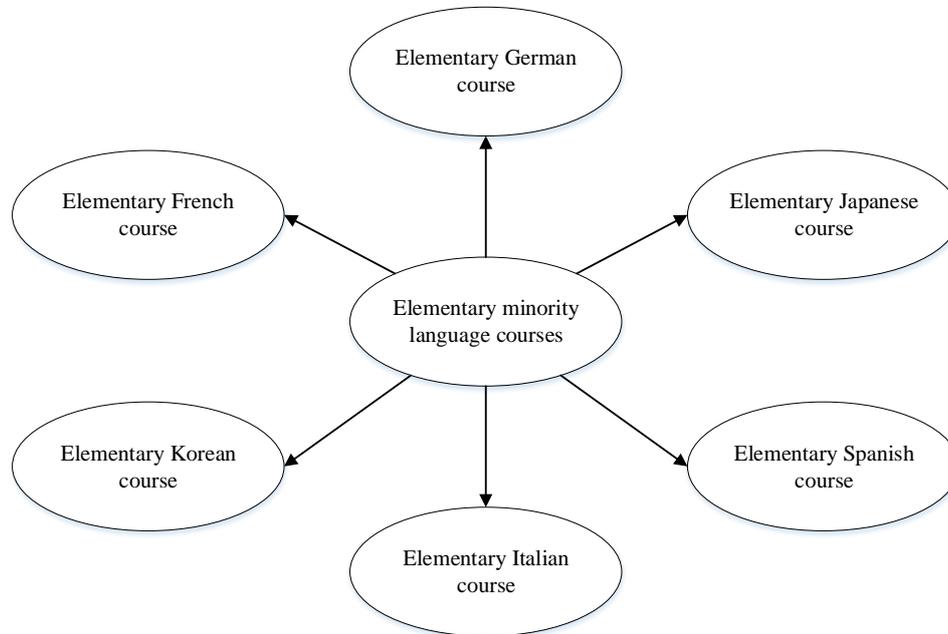


Fig. 2 The elementary minority language courses system of NOETG

Figure 2 shows the elementary minority language course system of NOETG. In this course system, there are six courses: elementary French course, elementary German course, elementary Japanese course, elementary Korean course, elementary Italian course and elementary Spanish course. According to the data survey, the cost of the six elementary classes are: 2200 RMB, 3900 RMB, 1380 RMB, 1080 RMB, 2800 RMB, and 5480 RMB respectively. The price of the whole course system is 14999 yuan. We can calculate and verify it in the same way.

Apply the formula:

$$PJ_j = b - \sum (1 - \theta) P_{Mm} + \alpha Q_{Mm} \tag{1}$$

According to the data, $P_{J2} = 14999$, $P_{M1} = 2200$, $P_{M2} = 3900$, $P_{M3} = 1380$, $P_{M4} = 1080$, $P_{M5} = 2800$, $P_{M6} = 5480$.

$$\theta = [a \sum P - 0.12b \sum P - 0.036 \sum P \sum Q + 0.12(\sum P)^2] / 0.12(\sum P)^2 \tag{9}$$

Put in $\alpha = 0.3$, $\beta = 0.6$, $a = 1000$, and $b = \sum P = 16840$

After calculation, it is obtained that: $\theta \approx 0.49$

The correlation coefficient is 0.49, and there is a high correlation among courses under the course system. The price of the whole course system is much cheaper than the accumulated price of courses. Therefore, the relationship among the modules in the product architecture is strong, and the influence on the pricing of the product architecture is strong.

Conclusion

This paper established a model of the relationship between product architecture and pricing. Through data collection, we collected two major course systems of NOETG and the price of each course to verify the model. The result shows that the objective function is established correctly. Through the verification of the model, it is known that the stronger the relationship among courses in the course system, the stronger the influence on the product architecture pricing. And the weaker the relationship among courses in the course system, the weaker the influence on the product architecture pricing. We also found that the overall revenue of the enterprise is affected not only by the correlation among modules in the product architecture, but also by the expected sales volume of the architecture when it is not affected by the price, the expected price of the architecture when it is not affected by the relationship among modules, the relationship coefficient between the number of modules and the architecture price, and the relationship coefficient between the sales volume and the price of the architecture. Finally, it is also found that there is a certain relationship among all the modules in the product architecture in the general situation, and the modules that have no relationship basically do not appear in a product architecture.

This research enriches the content framework of product architecture and extends the depth of product architecture. However, the model in this paper gave little consideration to other factors affecting pricing, such as cost and market, and the assignment of some variables is not scientific enough, which may have an impact on the research results. In the future research, various factors should be considered comprehensively to enhance the adaptability and complexity of the model.

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