

# A study on Logistics Cost Control in Product Design

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## Abstract

The aim of this study is to probe into achieving the balance between product design and logistics costs and to find the method of logistics cost control at the product design stage. The traditional product designers tend to focus only on aesthetics and functionality, with little regard to logistic cost. In fact, logistics factors should also be taken into consideration in the product design stage. Therefore, this research applying qualitative and quantitative analysis methods and referring to the ideas of product design and cost management, It explores the significance of cost control in product design. Based on the supply chain cost management method, cost control method in the product design stage is investigated. With the analysis of IKEA product design and development cases, the feasibility of the method is verified. This study proposes a logistics cost control method that uses a combination of activity-based costing, target costing, and value engineering to provide a reference for designers to control logistics costs during the product design stage.

Keyword: Product design, Logistics cost, supply chain cost management, IKEA

## 1. Introduction

The primary objective of this study is to examine that whether the method of logistics cost management suitable for product design stage. To achieve this, this study analyzes the relevant literature.

There are the following researches on logistics cost. Alan H. Stratford introduced the concept of overall cost analysis into logistics management for the first time in the book *The Role of Air Freight in Physical Distribution* written in 1957 [1].

There are the following researches on product design. In the book *World Class New Product Development* written by Dan Dimancescu and Kemp Dwenger, it is proposed to establish an effective cross functional team to detect errors in the early stage of development, so as to avoid those errors transferred to downstream operations and redesign [2]. Kajuter model [3] points out that cost management should be implemented at the design stage of the product, and the cost impact on the future product needs to be predicted. With the continuous application of IOCM, the relationship between

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enterprises and suppliers becomes closer and closer. They contribute cost information and cooperate in product research and development. Suppliers participate in the design of customer service and cost management of both parties [4].

This study focuses on how to reach a balance between product design and logistics costs to achieve the goal of benefit rationalization. By means of qualitative and quantitative analysis, the study provides a set of product logistics cost management methods that are applied in the design stage.

## **2. Research on Logistics Cost Management in Product Design Phase**

### **2.1 Impact of Product Design on Logistics Costs**

Product design is a comprehensive design of the product's shape, structure and function, in order to produce practical, economical and beautiful products that meet people's needs [5]. While contemporary designers attach great importance to the appearance and performance of products, they also attach great importance to the cost of products. However, the cost here often refers to the cost of materials and manufacturing costs, and logistics costs are rarely considered.

Although the logistics costs incurred during the product design phase are small, it determines most of the costs of logistics activities. In [Table 1], the complete product design process is mainly divided into five stages: demand analysis, scheme design, structural design, detailed design and design solution. The product characteristics determined at different design stages are different [6].

In summary, the parts of product design that have an impact on logistics costs include product raw material, product parts, product form and volume, and the packaging.

[Table 1] Product characteristics identified during the product design phase

| <b>Product Design Phase</b> | Determination of product characteristics                 |
|-----------------------------|----------------------------------------------------------|
| <b>Demand Analysis</b>      | Product flow                                             |
| <b>Program Design</b>       | The general shape of the product, product design program |
| <b>Structural Design</b>    | Volume, shape, weight, structure                         |
| <b>Detailed Design</b>      | Shape, volume, weight, structural combination            |
| <b>Design Solution</b>      | Raw material, component, shape, volume, packaging        |

#### **2.1.1 Impact of the Design of Raw Materials and Components on Product Logistics Cost**

A large part of logistics costs is the procurement costs of raw materials. The company standardize Parts as much as possible to reduce the parts categories on inventory, to increase the compatibility

among different parts, and finally to reduce inventory cost. At the same time, we use the postponement strategy to produce the products of right quantity and quality at the right time in strict accordance with the order. For example, Dell the computer company cooperates with suppliers to use standard parts, reduce parts category and inventory cost. When Dell receives customer orders, they just combine different products parts on basis of function and packing differently according to clients'request [7].

### **2.1.2 Impact of Product Design Form and Volume on Logistics Cost**

Diversification of product forms should be considered in product design. Folding and disassembly can effectively reduce the space occupation during transportation, for reducing transportation costs [8].

To miniaturize the product volume should be considered when the product is designed. And try to increase the actual load factor of the transportation means [9].

### **2.1.3 Impact of Product Packaging Design on Logistics Costs**

Packaging can collect items into units that are convenient for tally, and reasonable packaging units can reduce the cost of tallying and handling in storage and transportation [10]. The company should consider when packaging unitization the coordination of the transportation, loading and unloading of pallets, containers, and also the quantity units that consumers expect to purchase.

## **2.2 Method of Logistics Cost Management in Product Design Phase**

### **2.2.1 Supply Chain Cost Management Methods**

Stefan Seuring believes that supply chain cost management is the method and concept of analyzing and controlling all costs in the supply chain [11]. Therefore, the research on supply chain cost management must involve the research of supply chain cost management methods.

Target Costing(TC) is a method that attempts to reduce the cost of a target product during the R&D and design stages. It is conducive to improve the level of cost management [12].

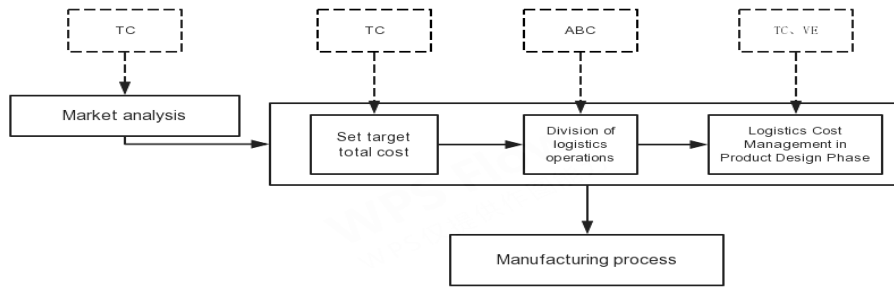
The cost calculation program under Activity Based Costing(ABC) is to integrate various resource libraries. The cost is allocated to each activity, and then the cost of each activity cost library is allocated to the final product or service [13].

Value Engineering(VE) is a method of creating schemes and optimizing schemes. It studies how products can achieve the functions required by users at the lowest life cycle cost [14].

### **2.2.2 Application of Supply Chain Cost Management Method in Logistics Cost Management**

When controlling the logistics cost in the product design stage, the combination of target cost method and value engineering is an effective management method. However, the combination of the TC and VE can only reduce the overall target cost. To further control the logistics cost, we must use the ABC to decompose the logistics operation process, determine the different costs of each operation, and feedback to Product design and development stage, then strive to improve and reduce costs.

The application steps of the supply chain cost management method in the logistics cost management of the product design stage can be roughly divided into [Fig. 1]:



[Fig. 1] Frame model

(1) Use the Target costing to set the target cost for product design

The following study uses a function model to specifically discuss how to set the target cost. First, analyze the influencing factors of the product design target cost (C), mainly: product function (F)(functional parameters, model parameters, service life, performance), user demand (D)(personalized needs, comfort requirements, safety requirements), and resources on the supply chain (R)(various enterprise personnel at supply chain nodes, supply chain management, technology, funds and other resources), User-acceptable prices (P) and profit requirements (E).

$$C=f(F, D, R, P, E) \quad (1)$$

The minimum cost to achieve a certain level of function under a certain resource is expressed by  $C_{FR}$ , which constitutes the lower limit constraint of the target cost of the product:

$$C_{FR} \leq C \quad (2)$$

The price (P) requirement of the product by the enterprise user and the profit (E) requirement of the enterprise together constitute the upper limit constraint of the target cost:

$$C \leq P - E \quad (3)$$

In this way, the upper and lower limit constraints are a reasonable interval for cost design. If the cost exceeds this range, it means that the product function must be re-planned, the resource or profit goals in the supply chain must be adjusted, and a design solution that meets users' needs and achieves the optimal configuration of functions and costs must be sought.

(2) *Use Activity Based Costing to perform a number of activities for logistics activities*

It is necessary to use the activity cost method to divide the logistics operations, to accurately distinguish the logistics costs. It is necessary to eliminate those worthless operation processes, and to choose a lower cost operation chain among many logistics operation chains.

(3) *Comprehensively use the target cost method and value engineering method to control the logistics cost in the product design stage*

The purpose of value engineering is to not only achieve the necessary functions of the product, but also reduce logistics costs and pursue the best benefits for the enterprise. Therefore, suppose that the number of product design elements of the product be  $n$ , and the number of experts be  $N$ . And  $V=F/C$ ,  $V$  is value,  $F$  is function,  $C$  is cost. In this study, suppose  $V$  represents the value,  $F$  represents the function evaluation value of the product, and  $C$  represents the evaluation value of the impact of the product on logistics costs.

Firstly, compare the functions of each element in pairs. Suppose  $f_{ij}^k$  be the score of the  $k$ -th expert's one-to-one score on the  $i$ -th element and the  $j$ -th element.  $F_{ik}$  is the cumulative score of the  $k$ -th expert on the  $i$ -th element.  $Sum_i$  represents the cumulative score for all experts scoring the  $i$  element.  $Sum$  represents the total score of all elements.  $F_i$  represents the functional evaluation coefficient of the  $i$  element. Secondly, the impact of each element on the logistics cost is evaluated: Suppose  $C_{ik}$  be the score of the  $k$ -th expert on the  $i$ -th product design factor.  $C_i$  means the score of all experts on the  $i$ -th product design factor.  $C_i'$  means the use of the  $i$ -th product Coefficient of design element impact on logistics cost. Then the following relationship holds:

$$F_{ik} = \sum_{j=1}^n f_{ij}^k \quad (4)$$

$$Sum_i = \sum_{k=1}^N F_{ik}, 1 \leq i \leq n \quad (5)$$

$$Sum = \sum_{i=1}^n Sum_i, 1 \leq i \leq n \quad (6)$$

$$F_i = \frac{Sum_i}{Sum} \quad (7)$$

And  $\sum_{i=1}^n F_i = 1$  holds

$$C_i = \sum_{k=1}^N C_{ik} \quad (8)$$

$$C'_i = \frac{C_i}{\sum_{i=1}^n C_i} \quad (9)$$

And  $\sum_{i=1}^n C'_i = 1$  holds

Implemented with MATLAB software: Generate evaluation function matrix

$$[F_{ik}]_{n \times N} = \begin{bmatrix} F_{11} & F_{12} & \dots & F_{1N} \\ \dots & & & \dots \\ \dots & & & \dots \\ F_{n1} & F_{n2} & \dots & F_{nN} \end{bmatrix}$$

Generate a functional score matrix for expert k

$$[F_{ik}] = [F_{1k} F_{2k} \dots F_{nk}]$$

among them,  $F_{ik} = \sum_{j=1}^n f_{ij}^k (1 \leq j \leq n, 1 \leq k \leq N)$

Summary function score matrix

$$[F_{ik}]_{n \times N} = \begin{bmatrix} F_{11} & F_{12} & \dots & F_{1N} \\ \dots & & & \dots \\ \dots & & & \dots \\ F_{n1} & F_{n2} & \dots & F_{nN} \end{bmatrix} \quad [C_{ik}]_{n \times N} = \begin{bmatrix} C_{11} & C_{12} & \dots & C_{1N} \\ \dots & & & \dots \\ \dots & & & \dots \\ C_{n1} & C_{n2} & \dots & C_{nN} \end{bmatrix}$$

And calculate the function evaluation coefficient, output matrix M

$$M = \begin{bmatrix} F_1 & C_1' & V_1 & C_1 \\ F_2 & C_2' & V_2 & C_2 \\ \dots & \dots & \dots & \dots \\ F_n & C_n' & V_n & C_n \end{bmatrix}$$

Each column is expressed as follows: function evaluation coefficient, product design factors on logistics cost impact evaluation coefficient, value coefficient and product design factors on logistics costs.

From the perspective of value engineering, if the value factor of a product design element is 1, it means that the element has the same effect on the product's function and logistics cost, and can be appropriately modified; if the value coefficient of a product design element is low, it indicates that this product design element has a small impact on the function of the product. The impact on logistics costs is relatively large, so this product design element is the main point of logistics cost control (matrix M).

Through cost analysis, we can find out the key design factors that need to be controlled, and make decisions on logistics cost management within the target cost range:

If  $V_1$  (value coefficient of raw materials and components in product design) is low, it means that raw materials and components have a small impact on the function of the product and a large impact on logistics costs. At this time, the raw materials and components must be controlled. The work of selecting raw materials like the design work, it is a multiple iterative process, that is, perfecting while designing, and gradually narrowing down the selection range until the last material is selected.

If  $V_i$  (design of product shape, volume and weight in product design; product packaging design value coefficient) is low, it means that product shape, volume and weight design and product packaging design have a greater impact on logistics costs. On the premise of meeting product function requirements, minimize logistics costs, and also meet the individual needs of some customers.

### 3. Discussion and Research Findings : IKEA as an example

The value engineering theory is used to analyze the logistics cost of the product design stage. Take the design of the Ogra chair as an example:  $V = F / C$ . Among them, V represents the value, F represents the function evaluation value of the product, and C represents the evaluation value of the impact of the product on logistics costs.

[Table 2] make a pairwise comparison and evaluation of the functions of each element. Suppose  $f_{ij}^k$  be the score of the k-th expert's one-to-one score on the i-th element and the j-th element.  $F_{ik}$  is the cumulative score of the k-th expert on the i-th element.  $F_i$  represents the functional evaluation coefficient

of the  $i$  element, and summarize the scores.

[Table 2] Score the function of each element by 6 experts

| Product Design Elements | Expert Evaluation Results |   |   |   |   |   |
|-------------------------|---------------------------|---|---|---|---|---|
|                         | A                         | B | C | D | E | F |
| Material                | 6                         | 6 | 8 | 5 | 4 | 7 |
| Volume                  | 3                         | 2 | 2 | 1 | 5 | 3 |
| Weight                  | 3                         | 3 | 1 | 2 | 2 | 4 |
| Package                 | 5                         | 3 | 1 | 2 | 1 | 2 |
| Shape                   | 7                         | 6 | 8 | 7 | 8 | 6 |

[Table 3] is evaluate the impact of each factor on logistics costs.  $C_{ik}$  means the score of the  $k$ -th expert on the  $i$ -th product design factor.  $C_i$  means the score of all experts on the  $i$ -th product design factor.  $C_i'$  means the use of the  $i$ -th product Coefficient of element impact on logistics cost, and summarize the scores.

[Table 3] Score the function of each element by 6 experts

| Product Design Elements | Expert Evaluation Results |   |   |   |   |   |
|-------------------------|---------------------------|---|---|---|---|---|
|                         | A                         | B | C | D | E | F |
| Material                | 7                         | 6 | 8 | 8 | 5 | 6 |
| Volume                  | 8                         | 6 | 5 | 6 | 4 | 6 |
| Weight                  | 1                         | 2 | 1 | 2 | 3 | 4 |
| Package                 | 5                         | 6 | 7 | 8 | 5 | 5 |
| Shape                   | 3                         | 2 | 5 | 4 | 6 | 8 |

The resulting matrix is:

$$M = \begin{bmatrix} 0.292683 & 0.263158 & 1.112195 & 40 \\ 0.130081 & 0.230263 & 0.564925 & 35 \\ 0.121951 & 0.085526 & 1.425891 & 13 \\ 0.113821 & 0.236842 & 0.480578 & 36 \\ 0.341463 & 0.184211 & 1.853659 & 28 \end{bmatrix}$$

As follows: function evaluation coefficient, product design factors on logistics cost impact evaluation coefficient, value coefficient, and product design factors on logistics costs.

The IKEA design team found that in the design of the Ogra chair, volume and packaging are the focus of control, and raw materials can also be adjusted appropriately. In the aspect of packaging, the design team of ogira chair has realized flat packaging, which greatly reduces the logistics cost [15]. When flat packaging did not meet the low cost requirements, the design team began to work hard on the raw materials. IKEA introduced a new technology to the furniture industry. This new technology

saves material and weight by injecting gas into composite plastics, and is able to produce products faster [16]. In this way, it not only meets the needs of customers for product functions, but also reduces logistics costs. IKEA found in subsequent research that furniture products are generally similar to the logistics cost control of Ogra chairs. Therefore, before IKEA's furniture design plan is determined, the focus of control is on materials, volume and packaging in order to better control logistics costs.

IKEA provides a good direction for other similar companies, that is, the control of logistics costs is very important during the product design stage.

#### **4. Conclusion**

This study explores how to effectively manage logistics cost during the product design stage:

(1) This study systematically analyze the influencing factors of logistics costs, and focus on the impact of product design on logistics costs.

(2) A detailed analysis of the application of supply chain cost management methods (target cost method, value engineering, activity cost method) in logistics cost management at the product design stage. First, the target cost method is used to set the target cost for product design. Then, the activity cost method is used to divide the logistics activities into several operations, and the operation process is improved. Finally, the target cost method and value engineering method are comprehensively used to control the logistics cost at the product design stage.

(3) Taking IKEA as an example, this paper analyzes the application of supply chain cost management method in enterprises, and proves the effectiveness of this method, which can be used for reference by other similar enterprises.

There are two issues that need to be addressed in future research:

(1) To carry out fine logistics cost control, it is necessary to build complex models. For an enterprise, the accounting of logistics costs is a complicated process in itself, and it is necessary to analyze the causes caused by changes in logistics costs, which requires a large cost to implement.

(2) Product design is a complex process, including product performance, product safety, product pleasantness, product aesthetics, product manufacturing, management, and logistics costs. This study only weighs performance and logistics costs, whether all these goals can be weighed, whether it is necessary to do so, and whether the results of the research are suitable for promotion and implementation to enterprises are issues that need to be studied in the future.

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