Decision On Cost Reduction: A Holistic View

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ABSTRACT

The cost reduction is a critical and highly sensitive process. The required cost reduction that generates the required target profit level by ensuring optimal quality, delivery time and price level of new products, in other words; customer oriented cost reduction, is the core element of today's target costing. Obviously, overhead reduction is a sophisticated process when the difficulty in overhead measurement and assignment is considered. This study aims to exhibit how to determine cost reduction areas in accordance with customer requirements during manufacturing process by using Activity Based Costing, Analytical Hierarchical Process, Quality Function Deployment and Value Index using a holistic approach. The model presented in the study is flexible for all industries and the model may be used with other costing methods other than Activity Based Costing.

Keywords: *Target Costing, Cost Reduction, Quality Function Deployment, Value Index, Activity Based Costing.*

Jel Classification*: M40, D24.*

Maliyet Azaltım Kararı: Bütünsel Bir Yaklaşım

ÖZET

Maliyet azaltımı; kritik ve hassas bir süreçtir. En uygun kaliteyi, teslimat süresini ve fiyat seviyesini sağlayan diğer bir deyişle, müşteri tabanlı maliyet azaltımını sağlayan ve hedef karı gerçekleştiren gerekli maliyet azaltımının belirlenmesi; hedef maliyet sürecinin en önemli öğesidir. Açık olarak, genel üretim giderlerinin azaltılması; genel üretim giderlerinin ölçülmesi ve dağıtımındaki zorluklar göz önüne alındığında sofistike bir süreçtir. Bu çalışma, Faaliyet Tabanlı Maliyetleme, Analitik Hiyerarşi Prosesi, Kalite Fonksiyon Yayılımı ve Değer Endeksi temelli bütünsel bir yaklaşım kullanarak müşteri temelli maliyet azaltım alanlarının belirlenmesini amaçlamaktadır. Çalışmada sunulan model bütün endüstrilerde kullanılabilir ve model, Faaliyet Tabanlı Maliyetleme dışında diğer maliyet yöntemleri ile kullanılabilmektedir.

Anahtar Kelimeler: *Hedef Maliyetleme, Maliyet Azaltımı, Kalite Fonksiyon Yayılımı, Değer Endeksi, Faaliyet Tabanlı Maliyetleme.*

JEL Sınıflandırması: *M40, D24.*

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1. INTRODUCTION

Market price is one of the most important data for the industries characterized by intensive competition. In such industries, enterprises cannot sell their goods above this market price and simply cannot add a required profit margin to the cost of finished goods. During this process, the enterprises must strive to find an answer for the optimal cost of a product that achieves the required profit margin. These factors necessitate achieving the required cost reduction that generates the required target profit level by ensuring optimal quality, delivery time and price level of new products. This is the core process for today's global target costing[1] advocates (Monden, 1995; Ibusuki and Kaminski, 2007).

The cost reduction is a critical and highly sensitive process which needs meaningful cost information and clearly identified customer requirements. Thus, any significant deviation from the accurate cost information may misdirect areas for cost reduction which may deteriorate the survival zone[2] of the product. So, this study focuses on the cost reduction process of target costing.

Since Sakurai (1995) emphasized that the target costing can be used for indirect costs such as overhead and the study of Tani et al. (1994) reported 80.7% of Japanese firms used target costing for overhead and 83.3% of them used it for to the depreciation of new equipment, it is important to know how this process works. This study aims to show how to determine overhead reduction areas in accordance with customer requirements during manufacturing process.

In this context, the study exhibits the basis for a rational cost reduction in a manufacturer company (M) that produces an industrial vertical refrigerator (R product). The study preferred the M company as a case study for several reasons as following:

a) The primary customers of M company are four and five star hotels in the tourism sector in Antalya region of Turkey. There is an intensive competition in this industry. In competitive industries, the sales at market determined prices and gaining the maximum profit depends on the production of products that match the requirement of customers in respect of quality and functionality. This is is a typical target costing environment (Castellano and Young, 2003; Butscher and Laker, 2000).

b) M company assembles outsourced parts. The main parts of its product (metal sheet, electronic board, compressor and evaporator) are all outsourced. Since target costing is suitable for assembly industries (Kato, 1993; Fisher, 1995; Shank and Fisher, 1999; Kwah, 2004; Ansari et al., 2007; Afonso et al., 2008), M company fits this costing method

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[1] Identifying the cost at which the product must be manufactured to achieve its target profit margin when sold at its target selling price (Cooper and Slagmuler, 1997).

[2] The survival zone is the volume created by connecting the three minimum and maximum values of three dimensions which are cost/price, quality and functionality (Cooper and Slagmuler, 1997).

c) M company is a machinery manufacturer. Tani et al. (1994) shows target costing implementation levels are higher in machinery, electric-electronics and automotive industries in Japan. Kwah (2004) reports target costing implementation ratio was 57% in machinery and automotive industries in Sweden. Kocsoy et al. (2008, 95-96) show the usage of target costing in Turkish automotive industry was above 50%.

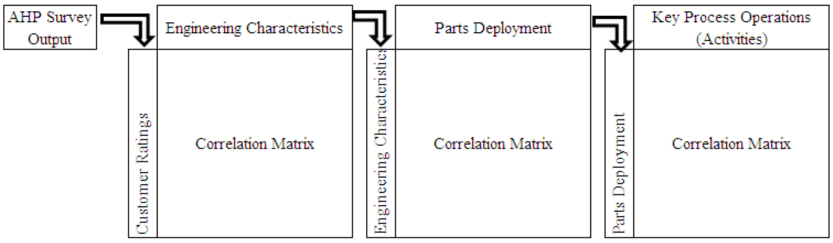
Figure 1 describes the stages of the study which aims to develop an integrated cost reduction model by the tools previously described in the cost reduction.

Stage I-Getting ABC information

a) Visits to the case company
b) Getting information about the activities for producing the sample product (R product)
c) Getting the indirect costs' information accumulated at the activities by ABC system
d) Getting the cost information of the components of the R product by ABC.

Stage II-Making QFD work

a) Making a pilot survey to determine the customer requirements for R product
b) Preparing a survey in accordance with AHP
c) Conducting the survey to potential customers
d) Analyzing the survey results with Expert Choice software
e) Preparing the House of Quality by using customer ratings in accordance with the multi-phased OFD model presented by the American Suppliers Institute
f) Determining the relationship matrix between engineering characteristics and parts deployed for the manufacturing of the product
g) Determining the relationship matrix between parts and the activities (key process operations)



Stage III-Value Analysis

a) Comparing the costs and importance ratings of the components
b) Determining the areas for cost reduction of the components
c) Comparing the indirect costs accumulated at the activities and importance ratings of them
d) Determining the areas for cost reduction of the activities (Overhead Reduction)

Figure 1. The Framework of the research

This paper is organized as follows: Section 2 presents production and cost information of the case company. Section 3 gives brief information about the structure QFD. Section 4 exhibits QFD analysis in the case company. Section 5 presents the result of Value Index analysis with ABC cost information and QFD and discusses the potential cost reduction areas in the components and activities of the company. Section 6 summarizes the paper and makes suggestions for the companies to determine cost reduction areas. Section 7 concludes the paper.

2. PRODUCTION AND COST INFORMATION OF THE CASE COMPANY

M company produces industrial-type vertical double-door refrigerator (R product) and mostly sells it to five-star hotels in Antalya.

Since previous studies show ABC provides necessary information for the implementation the target costing (e.g., Lee, 1994; Koons 1994; Baker, 1995; Walker, 1999; Cokins, 2002; Davila and Wouters, 2004), ABC was implemented to M company.

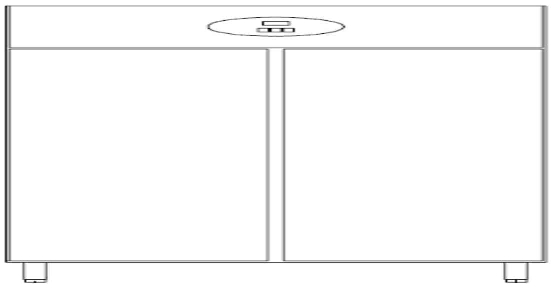


Figure 2. Industrial-Type Vertical Double-Door Refrigerator

Horvath et al. (1998) show that ABC supported target costing enables the most accurate way to calculate the target cost. While target costing ensures customer-driven objectives, ABC provides a more transparent process and determines the processes that the improvement should take place. In another example, at Siemens fiber optic products, ABC offered the manufacturer a valuable opportunity to compare the product features with their costs while monitoring the processing times and quality costs at each stage of the production process. (Bhimani and Neike, 1999).

Tani et al. (1994) reported 80.7% of Japanese firms used target costing for overhead and 83.3% of them used it for the depreciation of new equipment. Although previous studies explain the drawbacks of ABC because of its complex structure and the necessity for high initial investment (e.g. Innes and Mitchell 1991; Nicholls 1992; Drury and Tayles 1994; Banker *et al.* 2008), none of them mentioned it as erroneous. Thus, this elaborative focus of ABC leads to complex and expensive processes. Even contemporary time based activity based model suggested by Kaplan and Anderson (2004) as a successor of ABC claims to be less costly and easier than ABC but never more accurate.

M company produces R product by assembling seven main component groups in the form of a block. These parts are body group, evaporator group, compressor group, stainless steel door group, canopy group, a group of shelves and packing group. The main activities during the production process and the accumulated indirect costs are as shown in Table 1.

Table 1. Total Cost of Activities

Cost Centers	Activities	Indirect Costs	Total
Supplying	Purchasing	1.611,59 €	4.234,88 €
	Material and Parts Carrying	1.458,17 €	
	Storing	1.165,12 €	
Designing	AutoCad Drawing	595,36 €	595,36 €
Metallic Plants	Sheet Metal Control	472,27 €	7.130,49 €
	Sheet Metal Cutting	1.237,29 €	
	Sheet Metal Processing	2.274,06 €	
	Copal (Sheet Residual) Cleaning	440,98 €	
	Sheet Metal Bending	2.162,67 €	
	Argon Welding	543,22 €	
Assembly Plants	Polyurethane Compression	1.554,58 €	4.682,59 €
	Canopy (Front Forehead) Group Preparation	436,17 €	
	Door Group Preparation	442,16 €	
	Evaporator Group Preparation	432,15 €	
	Compressor Group Preparation	432,15 €	
	Group and Freezer Door Assembly	442,44 €	
	Canopy and Compressor Group Assembly	444,45 €	
	Gas Vacuum and Charging	498,50 €	
Quality Control	Electrical and Performance Testing	446,46 €	1.483,22 €
	Cabinet Cleaning and Packaging	604,60 €	
	Final Inspection	432,15 €	
Total			*18.126,54 €*

These indirect costs are assigned to the seven-component groups by cost drivers. After setting the direct materials (DM), direct labor (DL) and manufacturing overhead (MO) of the component groups, the unit cost of them may be calculated (Table 2).

Table 2. Distribution of Activity Costs to Components

No.	Component	Direct Materials	Direct Labor	Factory Overhead	Total
1	Body Group	228,23 €	25,40 €	41,77 €	295,40 €
2	Evaporator Group	138,58 €	8,41 €	6,74 €	153,73 €
3	Compressor Group	240,78 €	10,77 €	13,01 €	264,56 €
4	Stainless Steel Door Group	97,44 €	13,18 €	11,19 €	121,80 €
5	Canopy Group	89,61 €	5,77 €	11,01 €	106,39 €
6	Group Of Shelves	69,48 €	1,47 €	3,61 €	74,57 €
7	Packing Group	24,61 €	12,60 €	7,08 €	44,30 €
Total		***888,73 €***	***77,62 €***	***94,41 €***	***1.060,76 €***

3. QUALITY FUNCTION DEPLOYMENT

3.1. QFD Overview

Quality Function Deployment (QFD) is a key component for a successful total quality management.It is also an advanced management concept during manufacturing and quality management processes. This method ensures the integration of quality at the design stage of the new products or new versions of existing products by focusing on “voice of customers” (Shen et al., 2000). QFD is a process that helps to achieve a compromise between customer requests and the necessary steps to accomplish these requests (Han et al., 2001). QFD considers customer needs at every stage from research and development to engineering and from production to marketing / sales and distribution (Partovi, 1999).

QFDis advised to be used in the process of target costing. Because many case studies show QFD and target costing are useful for target costing process. For example, during the re-design of Caterpillar D9 tractor, QFD guided target costing team on the redesign of the necessary components of the tractor (Amara, 1998). In India, the success of target costing has been found to be connected to value engineering and QFD (Gandhinathan et al., 2004). In the automotive manufacturer operating in the Middle East, it was found that the use of QFD and target costing has increased customer satisfaction by 5.4% and reduced costs by 7.7% (Jariri and Zegordi, 2006). The first phase of the QFD is house of quality. Figure 3 shows the general structure of the house of quality.

Determining customer requirements is a critical step for the right implementation of QFD (Franceschini, 2002). QFD matrix determines the relationship between customer requirements and design requirements with the help of certain averages (Sireli, 2003). Customer requirements can be determined by using customer information including customer surveys, customer interviews and focus groups (Cristiano et al., 2001).

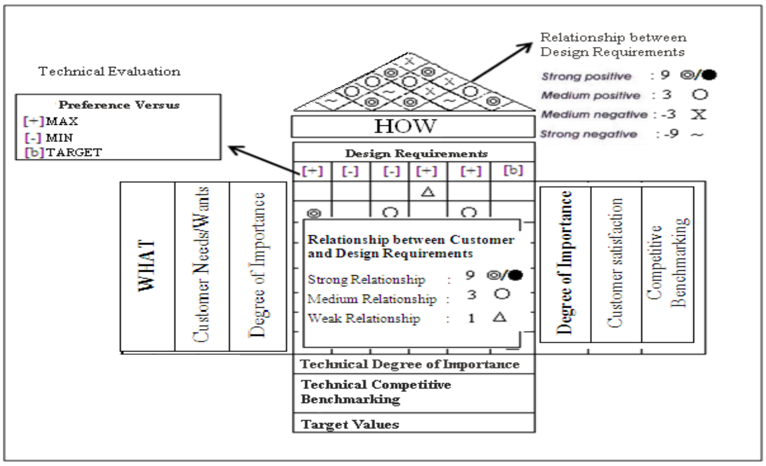


Figure 3. QFD-House of Quality (Akao 1990; Ho et al,, 1994; Adiano and Roth, 1994; Prasad, 1998; Omar, 1999; Sireli, 2003; Franceschini, 2002)

Design requirements and the effects of them to customer requirements may be provided by expert people working in industries that use QFD in their product development applications (Sireli, 2003). In order to minimize the risks during the development of new products and services, customer requirements should be handled as a multi-criteria decision-making problem. To this end, Analytical Hierarchy Process (AHP) is one of the most useful and most frequently used techniques. This technique can help decision makers on the measurement of consistency and reliability of their decisions (Ho et al., 2000; Lu et al., 1994). AHP is an advanced mathematical system in the evaluation of priorities which was described by Thomas L. Saaty (Cohen, 1995; Partovi, 1999). AHP is shown in Figure 4.

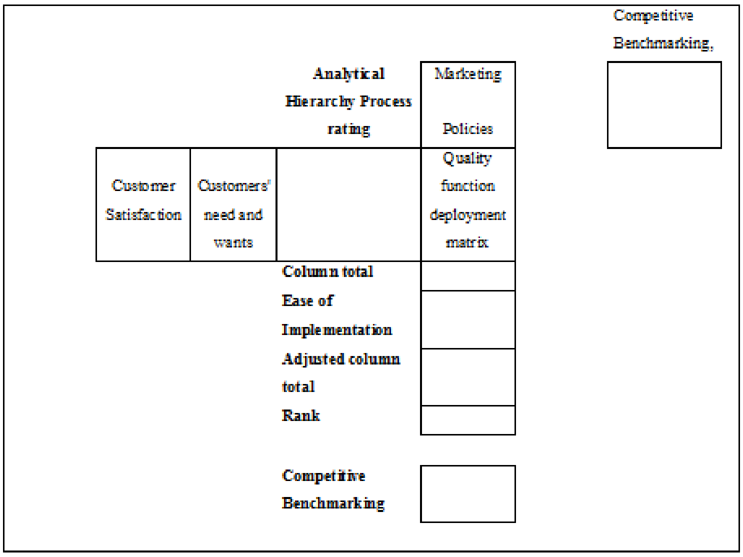


Figure 4. Integration QFD Matrix with AHP Rating and Benchmarking (Lu et al., 1994)

The technique of using AHP to determine customer priorities is shown by an example below. In the decision-making process with a sample of the four alternatives, these relations can be explained as given below (Cohen, 1995).

9 - Alternative A is extremely more important than Alternative B.

7 - Alternative A is a very strongly more important than Alternative B.

5 - Alternative A is strongly more important than Alternative B.

3 - Alternative A is moderately more important than Alternative B.

1 - Alternative A is of equal importance with Alternative B.

If the relationships are reversed (in other words, if it is converted as "Alternative B is more….than Alternative A"), 1/3, 1/5, 1/7, 1/9 fractions can be used as the inverse of these relations.

By using AHP, the drawbacks of using survey techniques like a 5 point likert scale are inhibited. Because although a respondent gives 5 point that shows high importance to some particular criteria, it may always not mean that those criteria have the same level importance. One criterion might have a high importance although its high importance level may differ from other high important criterion which is not possible to measure with a narrow scale like a likert scale. AHP gives opportunities of ranking the importance of criteria which is vital for determining the proper areas for a meaningful cost reduction based on the comparisons of the cost and importance levels like we did in our study.

3.2. QFD Calculations in The Decision-Making Model

Relationship matrix incorporates product features and customer requirements with the ordinal scale symbols in Figure 3. By using the information in the relationship matrix and focusing on the priorities assigned to customer requirements, a list of importance ratings assigned to product may be prepared. The conventional method (independent scoring method) consists of two steps to sort the product specifications. In the first step, the relationship between the customer requirements and product features are converted to the equivalent numeric values by using the symbols in Figure 3. In the second step, the importance rating of each technical attribute *wj* is determined. This value is calculated by summing the products of relative importance of each customer requirement multiplied by the quantified value of the relationship existing between *j*-th characteristic and each of the requirements related to it. The obtained equation will be as follows (Franceschini 2002; Sireli 2003):

$$w_j = \sum_{i=1}^{n} d_i * r_{i,j} \qquad (1)$$

d_i = degree of relative importance of i-th customer requisite, i=1,2,……,n

$r_{i,j}$ = the cardinal relationship between i-th customer requisite and the j–th product characteristic, j=1,2,…..,m

w_j= the technical importance rating of the j-th characteristic, j=1,2,…..,m

n = the number of customer requisites,

m = the number of product characteristics.

4. QFD ANALYSIS IN THE CASE COMPANY

After achieving product cost information based on ABC, the importance ratings of component groups and activities are compared with their cost levels by QFD analysis. The information obtained by this analysis will enable the comparison of the costs of component group with the importance ratings given by the customers with the help of value index analysis. QFD applications in the United States (U.S.) are carried out within the framework of the four-stage process developed by the American Suppliers Institute. Figure 5 shows set of matrices that contains the relationship between the outputs and inputs of QFD (Cristiano 2000). In this multi-stage analysis, the quality functions that answer "how is it done" questions may be converted to a shape that can answer “what should be done” questions in the further steps of house of quality (Ho et al., 1999; Sireli 2003).

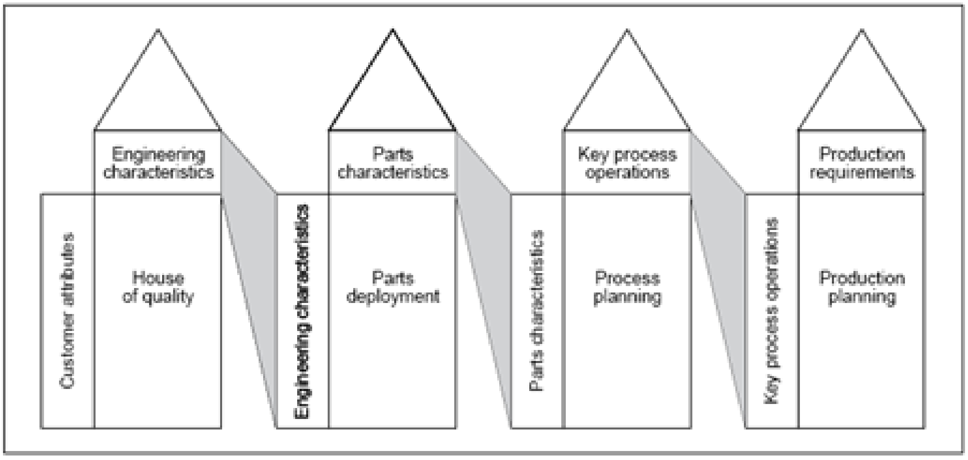


Figure 5. Four Phase Model of QFD (Adiano and Roth, 1994)

In the first phase also known as house of quality, customer attributes or requirements are correlated with engineering characteristics. This will give us the opportunity to translate the customer attributes to engineering characteristics. In the second phase, the engineering characteristics are correlated with the components of R product. The output is the importance of components in terms of engineering and customer requirements. In the third phase, the part (component) characteristics are correlated with the activities (*key process operations).* So, determining the cost reduction areas in respect of cost and importance by ABC and QFD is a proper element for a significant overhead reduction. The fourth phase for production planningis out of the scope of the study.

4.1. Determining customer requirements and placement of the matrix

M company sells R product especially to four-star and five-star hotels that produce food and beverage in relatively high-capacity. R product is often used by the hotel's kitchen and service staff. In order to determine customer requirements, a group of 15- cook and the chefs in ten five star Antalya city hotels were interviewed. This interview provided the determination of customer requirements related to the functions of the product. According to the findings, customer requirements were grouped under two main group factors including the physical and mechanical functions. The two main group factors were divided into the sub-group of factors for AHP analysis. Customer requirements for R product are shown in a hierarchical structure in Figure 6.

In order to determine importance ratings of each main and sub-criteria, a survey was conducted. SPSS 20.0 package program was used for statistical findings and AHP based Expert Choice 2000 package program was employed for determining the order of priorities. The survey was conducted to cooks and chefs working in four and five star hotels in Antalya.

In determining appropriate cooks and chefs for the survey, YIY-DER (Food and Beverage Association) member database was applied and the survey was sent to the 124 cooks and chefs that were in compliance with the criteria. 71 cooks and chefs responded the survey. The response rate was 57%. In the research, respondents were asked to evaluate the competiveness of the industry. Table 3 exhibits respondents' perception of competitiveness in the sector.

Table 3. The Perception of Competition among Respondents

The Competitiveness of the Industry	Rate of Respondents
No Competition At all	1,41%
Less Competition	5,63%
Moderate Competition	28,17%
High competition	40,85%
Extreme Competition	23,94%
Total	*100,00%*

It is clearly visible that 65% of respondents think there is significantly intense competition in the industry. Cooper (2002, 5) stated that the market-driven target costing process focuses on customers and customer needs, and uses this information for transferring the competitive pressure to product designers and suppliers. In an increasingly competitive market conditions, M company is likely going to face an intensive pressure transferred from hospitability enterprises. In this context, the implementation of cost reduction is expected to contribute to the business operations of the company.

In the following step, the priority levels of the main group factors between each other and the priority levels of the sub-group factors of each main factor is determined. The inconsistencies of the responds are also evaluated. As it is suggested by Saaty, an inconsistency ratio of 10% and less than it is an acceptable level of consistency in judgments (Kuruuzum and Atsan, 2002). Within the scope of the research, the inconsistency of each survey was calculated and the means of total inconsistencies are taken into consideration to reach a general inconsistency ratio. After analyzing the data, the priority levels of the main group factors and sub-group factors in Figure 6 were calculated by taking mean of every respond. Durability with 11.36% global priority is the primary criterion by customers for the decision making in purchasing the product. Security has the second place with the priority of 10.83%.

Expert Choice 2000 also accounts the global priorities of the physical and mechanical properties of R product. In order to calculate global priorities, the main factor's priority level was multiplied by each sub factor's priority level. For example, the global priority level of easy cleanabilitywas 0,44 * 0,17 = 0,07. Figure 7 shows the global priority levels of sub-group factors.

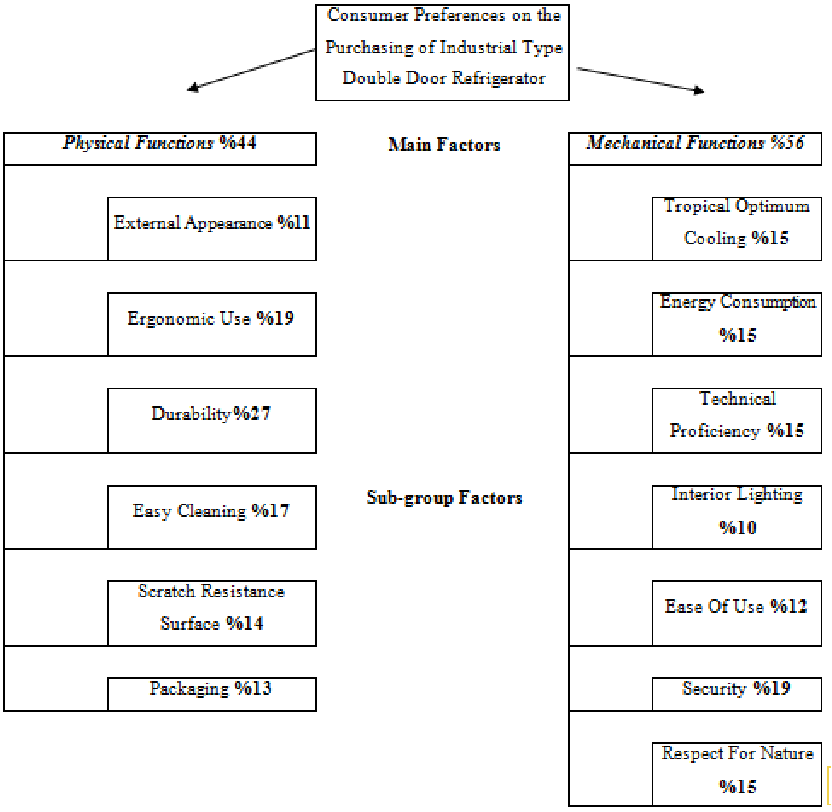


Figure 6. Priority Levels Between Main Factors and Sub-group Factors

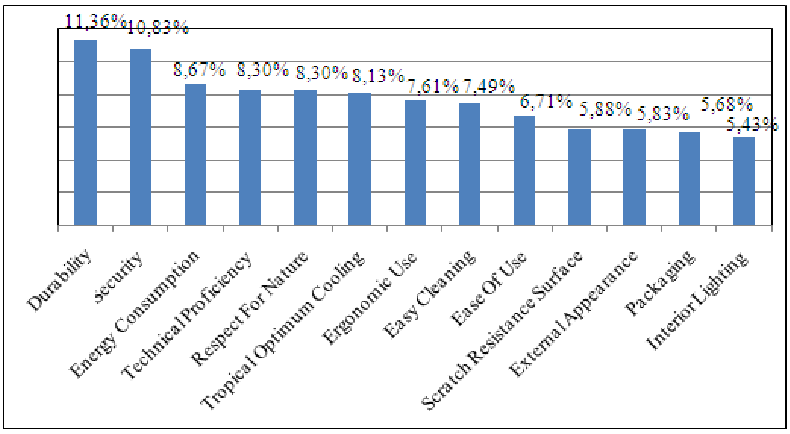


Figure 7. Global Priority Levels of Sub-group Factors

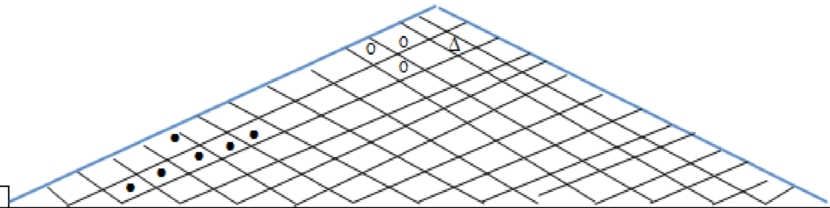
4.2. Determining Engineering Characteristics (Design Requirements) And Correlation Between Relationship Matrix And Technical Requirements

After determining the customer requirements, the priorities needed to fulfill the engineering characteristics (design requirements) were determined. For this process, the views of mechanical engineer, production manager, foreman and designer that were the members of cost reduction team have been the primary reference for the research and the results obtained in Figure 8.

After customer requirements and design requirements were determined, the relationships between the two groups have been determined by the help of discussions with the experts; the production manager and foreman. While establishing the relationship, the extent that the realization of that the design requirement will contribute to that customer requirement has been taken into account. At the roof of the house of quality, the relationship between the design requirements are shown. Again the expert opinion is the primary reference for this process. Figure 8 shows the matrix of the relationship of house of quality.

The technical importance of each design requirement as shown in Figure 9 is the sum of the relationship score in the each line of its own column multiplied by the AHP score of the customer requirement in that line. For example, the design requirement of sheet metal work is 1.524 (0.0583 * 9 + 0.0749 * 9 + 0.1083 * 3), and the relative degree of importance will be % 8 (1.524 / 19.69).

Legend
Relationship Matrix
•:Strong Relationship = 9 Points
O: Medium Relationship = 3 Points
Δ : Weak Relationship = 1 Points



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Customer Requirements	Analytic Hierarchy Process Rating	Engineering Characteristics (Design Requirements): Quality of Metal Sheet Work	Quality of Assembly Work	Quality of Evaporator	Quality of Compressor	Type of Illumination	Polyurethane Work	Characteristic of Body Design	Control Panel	Option of Shelve Height	Compliance with Gastronomic Sizes	Magnetic Door Seal	Gas Type	Folding Carton	Residual Current Circuit Breaker	**RELATIVE WEIGHT**
External Appearance	0,0583	•	•				O	•	O							**4,26%**
Ergonomic Use	0,0761					O		•	O	O	•	O				**6,59%**
Stability	0,1136		O	O	•		•	•	O			Δ				**13,75**
Easy Cleaning	0,0749	•						O								**6,69%**
Scratch Resistance Surface	0,0588		O				O									**4,43%**
Packaging	0,0568													•		**4,42%**
Tropical Optimum Cooling	0,0813			•	•		O	O	O			O				**10,13**
Energy Consumption	0,0876			O	O	O			O			O				**10,36**
Technical Proficiency	0,0830								•		O					**9,33%**
Interior Lighting	0,0543					•										**4,39%**
Ease Of Use	0,0671								•	O	O					**6,48%**
Security	0,1083	O	O					O	O						•	**12,62**
Respect For Nature	0,0830												•	O		**6,55%**
Total	1,00														Total	**100%**
Technical Importance		1,524	1,367	1,335	2,017	0,980	1,618	3,026	2,926	0,430	1,135	0,849	0,747	0,760	0,975	19,69
Relative Importance		8%	7%	7%	10%	5%	8%	15%	15%	2%	6%	4%	4%	4%	5%	%100
Absolute Weight		**1,364**	**1,308**	**0,723**	**1,548**	**0,904**	**1,498**	**2,794**	**2,850**	**0,392**	**1,068**	**0,646**	**0,590**	**0,197**	**1,136**	17,02
Relative Weight		**8,016 %**	**7,684 %**	**4,250 %**	**9,098 %**	**5,312 %**	**8,804 %**	**16,417 %**	**16,749 %**	**2,305 %**	**6,274 %**	**3,796 %**	**3,465 %**	**1,155 %**	**6,676 %**	

Figure 8. House of Quality of Product R

4.3. Competitive Benchmarking

To compare the perceived quality of the R product in the market, the respondents were asked to indicate the brand of their industrial type refrigerators and evaluate its performance based on previously identified sub-group factors on 5-point Likert scale (1 - not satisfactory, 5 - very satisfactory). This section was answered by 61 participants and the survey results were analyzed using SPSS 20.0 program. Brands were divided into two categories; domestic brands and international brands. M company considers itself advantageous when compared to the local brands in terms of quality, functionality and price (see Cooper and Slagmulder, 1997). But it is clear that foreign brands which high international sales share in the market are more advantageous in terms of quality and functionality. However, M company wants to compete with foreign brands by minimizing operating costs and offering the appropriate quality and functionality at the lowest rates in the domestic market.

According to the survey, 31% of participants use foreign brands, 25% expressed their preferences for domestic brands. The 44% of participants use R product of M company.

The results of the competition evaluation analysis are placed on the matrix as shown in Figure 9. In this section, the mean of the respondents' assessments about the R product and other brands were taken into account. Targets for the new model were based on the highest performance score required by the customer. For example, the durability score of R product is 3.815 while the mean score of foreign products is 4,263.

Customer Requirements	B: Benchmarking on the Basis of Perceived Quality: Present Model	Foreign Manufacturers	Domestic Manufacturers	C: Quality Planning: Targets for the new model	D: Improvement Ratio	E: Strength (Sales Point)	F: ABSOLUTE WEIGHT	G: RELATIVE WEIGHT
External Appearance	3,741	3,789	2,933	3,78	1,0	1,00	0,0	4,26
Ergonomic Use	3,667	3,632	3,333	3,66	1,0	1,20	0,0	6,59
Durability	3,815	4,263	3,267	4,26	1,1	1,50	0,1	13,7
Easy Cleaning	3,778	3,895	3,400	3,89	1,0	1,20	0,0	6,69
Scratch Resistance Surface	3,481	3,632	3,333	3,63	1,0	1,00	0,0	4,43
Packaging	3,222	3,474	3,267	3,47	1,0	1,00	0,0	4,42
Tropical Optimum Cooling	3,704	4,263	3,400	4,26	1,1	1,50	0,1	10,1
Energy Consumption	3,519	3,842	2,800	3,84	1,0	1,50	0,1	10,3
Technical Proficiency	3,852	4,000	3,267	4,00	1,0	1,50	0,1	9,33
Interior Lighting	3,333	3,737	2,800	3,73	1,1	1,00	0,0	4,39
Ease Of Use	3,963	4,421	3,467	4,42	1,1	1,20	0,0	6,48
Security	3,815	4,105	3,867	4,10	1,0	1,50	0,1	12,6
Respect For Nature	3,704	4,053	3,333	4,05	1,0	1,00	0,0	6,55
Total						Total	1,3 85	100 %

Figure 9. Competitive Benchmarking of the Product

Thus, the robustness target for the new model is determined as 4,263. The improvement ratio for the new model was calculated by dividing the targets for the new model by R product's performance score.

The current satisfactory performance for the present model (Column B) and targets for the new model (Column C) are combined arithmetically to create a value called "improvement ratio". Improvement ratio (Column E) is a multiplier coefficient that effectively scales the importance rating of the customer and therefore, rearranges the customer requirements. The most common method of determining the improvement ratio is dividing the targets for the new model by the current performance ratio of present model (Cohen, 1995). For example, the improvement ratio for appearance is 1.013 (3.741 / 3.789). A sales point (Column E) is the sales impact in the event of realization of that customer requirement. Traditionally, 1.5 point is used for the requirements whose satisfaction gives a very important strength in the related column. The requirements whose satisfaction provides a possible strength may be graded as 1.2 points and the requirements whose satisfaction creates no strength will simply have 1.0 points as a weight value (Cohen, 1995; Franceschini, 2002). For our research, the marketing member of the target costing team determined the sales points.

With a current perspective, this analysis may be used for helping strategic decision-making and business policy about the new product. All of these two elements (voice of the customer and business policy) are taken into account by calculation "the absolute weight" (Column F) of the requirement. The calculation is as follows:

Absolute Weight = Level of Importance (AHP points)* Improvement Ratio * Strength (Sales Point).

Figure 8 also includes the relative weights of the customer requirements calculated in Figure 9. Thus, the absolute weights of each design requirement can be calculated. For example, the absolute weight of the quality of sheet metal work is 1.364 (0.0426 * 9 +0.0669 * 9 +0.1262 * 3) and the relative weight will be 8.016% (1.364 / 17.02).

4.4. Building Part Characteristics Matrix and Key Process Operations Matrix

The importance ratings output of design requirements in the house of quality matrix act as an input for parts (components) deployment matrix. The correlation scores of part characteristics and design requirements were determined by production manager and foreman in the target costing team. The calculation of the absolute and relative weights of parts (groups of components) was similar to the calculation of the relationship matrix in the house of quality as previously explained. Therefore, the relative weights of groups of components and their degrees of importance would be calculated and used in the value index analysis where degrees of importance and cost levels were compared. The final outcome is parts (components) deployment matrix.

In the second stage, the relative weights for parts (component) characteristics taken from the parts deployment matrix used as an input for the key process operations matrix. The correlation scores between key process operations and parts characteristics were determined by the expert members in the cost reduction team. Key process operations were defined as activities used in the activity-based costing system. The calculation of relative weights of main activities was also considered as the degrees of importance of activities. This provided comparison of the accumulated indirect costs in these activities with the degrees of importance by value index analysis. This constituted the key process operations matrix. The analysis was meaningful for the cost reduction team because it is a rational guidance for determining the areas of cost reduction in the activities. Finally, the importance of parts (components) and activates were calculated as given in Table 4 & 5 (Section 5).

5. VALUE INDEX ANALYSIS IN THE CASE COMPANY

For each component part, the Value Index (VI) is calculated by using degrees of importance and percentages of components' costs. Therefore, VI = Importance Ratings / Cost Percentage. At this stage, the VI implication consists of two stages for the study.

- At the first stage, degrees of importance of components obtained from QFD system were divided by the costs obtained from ABC. Thus, areas of cost reduction were examined based on component groups.
- At the second stage, the degrees of importance of the main activities obtained from the QFD system were divided by the accumulated indirect costs at the cost pools due to the fact that Sakurai (1995, 25) emphasized target costing can be used for indirect costs such as overhead and Tani et al. (1994) reported 80,7% of Japanese firms used target costing for overhead and 83,3% of them used it for the depreciation of new equipment.

For component parts, the most appropriate value of the index value should be close to 1.0. For example, if "*x*" is defined as a variable that equals the percentage value of the degree of importance of a component group or main activity and "*y*" is defined as a variable that equals the percentage value of target cost of the same component group or the same activity then the value index can be expressed as x/y. If $x/y = 1$, then it is expressed as $x=y$. In other words, the target cost should be distributed in exact compliance with the degrees of importance of the group of component or degrees of importance of the main activity (Tanaka, 1989).

Table 4 exhibits value index calculations in accordance with information collected from QFD and ABC models and Table 5 shows the value index for the main activities.

Table 4. Value Index for Component Groups

No.	Part (Component)	Relative Weight of Component Cost (y)	Relative Weight of Component (x)	Value Index (x/y)
1	Body Group	27,85%	30,38%	1,09
2	Evaporator Group	14,49%	13,98%	0,96
3	Compressor Group	24,94%	13,23%	0,53
4	Stainless Steel Door Group	11,48%	14,77%	1,29
5	Canopy Group	10,03%	23,03%	2,30

6	Group Of Shelves	7,03%	3,65%	0,52
7	Packing Group	4,18%	0,96%	0,23
Total		***100,00%***	***100,00%***	

Table 5. Value Index for Main Activities

Activities	**Relative Weight of Activity Cost (y)**	**Relative Weight of Activity (x)**	**Value Index (x/y)**
Purchasing	8,89%	4,59%	0,52
Material and Parts Carrying	8,04%	5,41%	0,67
Storing	6,43%	2,30%	0,36
AutoCad Drawing	3,28%	6,23%	1,90
Sheet Metal Control	2,61%	8,17%	3,13
Sheet Metal Cutting	6,83%	9,28%	1,36
Sheet Metal Processing	12,55%	13,32%	1,06
Copal (Sheet Residual) Cleaning	2,43%	3,01%	1,24
Sheet Metal Bending	11,93%	15,46%	1,30
Argon Welding	3,00%	2,20%	0,73
Polyurethane Compression	8,58%	9,80%	1,14
Canopy (Front Forehead) Group Preparation	2,41%	1,67%	0,69
Door Group Preparation	2,44%	1,07%	0,44
Evaporator Group Preparation	2,38%	3,03%	1,27
Compressor Group Preparation	2,38%	2,87%	1,20
Group and Freezer Door Assembly	2,44%	2,08%	0,85
Canopy and Compressor Group Assembly	2,45%	2,62%	1,07
Gas Vacuum and Charging	2,75%	3,88%	1,41
Electrical and Performance Testing	2,46%	0,96%	0,39
Cabinet Cleaning and Packaging	3,34%	1,00%	0,30
Final Inspection	2,38%	1,03%	0,43
Total	**100,00%**	**100,00%**	

However, in practice, Tanaka (1989) considered that distributing the target cost in exact compliance with the functional areas of the product would be too rigid. Therefore, he suggested expressing the optimal value of the index value as optimal range or zone or value. A value control chart has important applications for this purpose. For example, if the value index of the component group falls in the north west of the optimal value zone, then the cost-reduction efforts should aim to bring the value index of component groups into the optimal value zone. If the value index falls in the south east area, cost increases may be required to ensure that the product performs its functions in a satisfactory manner (Tanaka, 1989).

The below equations determine the target cost as range of allowable values based on deviations from the degrees of importance of the functional area of the product in the value control chart that offers the optimal value zone. The optimal value zone is represented by the area between the two curves defined in the following equations:

$Y_1 : y = (x^2 - q_1^2)^{1/2}$ (lower boundary target cost value) (2)

$Y_2 : y = (x^2 + q_2^2)^{1/2}$ (upper boundary target cost value) (3)

In the equations above, Y_1 and Y_2 represent lower and upper bounds of target cost values, respectively and *qi* (i = 1,2) indicates the allowable deviations from x (degrees of importance of the functional area). *qi* values are the decision-making parameters determined by the management. Empirical studies show that *qi* is a value lower than 20 (*qi* <20). (Tanaka, 1989). Tanaka (1989) determined the value of *qi* = 16 in his case study. Therefore, it is reasonable to use the same value for *qi* in the research. For each component group, Figure 10 shows areas between those above equations with the assumption that qi = 16.

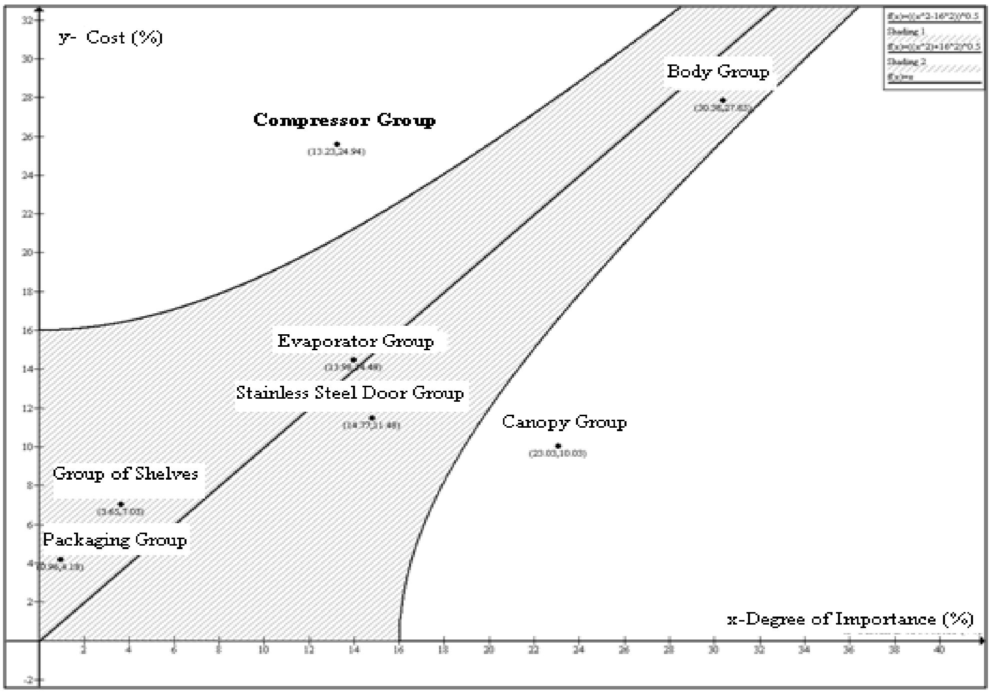

Figure 10. Value Control Chart for Component Groups

As Figure 10 exhibits, the compressor group falls to the north-west of optimal value zone. Thus, the compressor group's cost seems excessive when its degree of importance is considered. As the compressor is externally supplied, M company should work with the foreign external supplier to provide some cost reductions that will enable the compressor group's cost fall in the optimal value zone. For example, the compressor group which has 13,23% (x) the degree of importance and 24,94% (y) of cost level has a total cost of 138,58 €. When "x" is replaced with 13,23 on upper boundary of the value control chart which is Y_2: $y = (x^2 + q_2^2)^{1/2}$ and for q_i=16, "y" value will be equal to 20,76. A compressor with a 20,76 percentage of cost will be exactly at the top of the upper boundary curve.

On the other hand, the canopy group which is one of the critical parts of industrial type double-door refrigerators and contains the evaporator, compressor, residual current circuit breaker, interior lighting, security lock and digital control, falls to the eastern section of the value control chart. When at the lower boundary of the control chart equation [Y1 : $y = (x^2 - q_1^2)^{1/2}$], "x" is replaced with the degree of importance of canopy group which is 23,03, the cost percentage (y) will be 16,56. At the same time, when at the upper boundary of the control chart equation [Y2 : $y = (x^2 – q_2^2)^{1/2}$], "x" is again replaced with the degree of importance of canopy group which is 23.03, the cost percentage (y) will be 28,04. Therefore, in theory, the cost of canopy group (10,03%) may be increased to a value between 16,56% and 28,04% by adding new functionalities. In other words, ensuring that the product performs its functions satisfactorily, cost increases may be considered necessary. But members of the cost reduction team (production manager, designer and foreman) think canopy group has an optimal level of quality. The spot used for interior lighting is non-diffusing, the customized digital control part is manufactured in Italy for M company and the canopy is built with metal sheet that is at approved thickness and quality standards. In addition, the security lock and residual current circuit breaker are offered as standard to customers. Thus, in this situation, we've come to a conclusion that M company produces the product that has a higher degree of importance at a lower cost.

Figure 11 shows the main activities in the value control chart. The indirect costs accumulated in cost pools (see Table 1 and 2) are in compliance with their degrees of importance and all of them are in the optimal value zone. Accordingly, it may be said that the firm performs its activities effectively and efficiently and the company may perform no cost reduction processes according to this value of q_i.

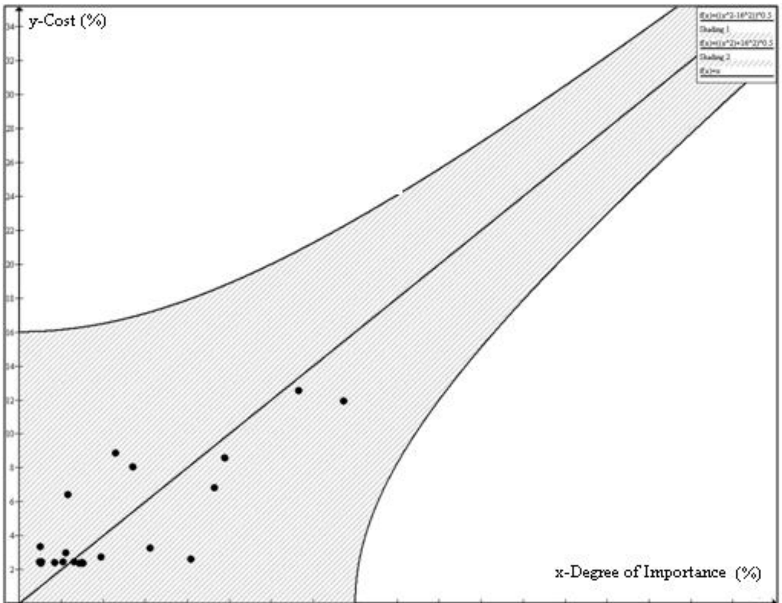

Figure 11. Value Control Chart for Main Activities

6. RESULTS AND DISCUSSION

This study exhibits the cost reduction process of R product in a company operating in an intense competitive machinery industry. In order to provide guidance to the similar manufacturers in the design of customer-focused new products during cost reduction process, the customer requirements were defined and cost reduction areas were identified based on the actual production costs of the present model. The results of the study exhibit that ABC information provided significant contributions to the cost reduction process when combined with QFD analysis.

The study used Value Index analysis (VI) for the comparison of the degrees of importance and cost levels of the component groups and, production activities to check if these were in exact compliance. Theoretically, the ratio of degrees of importance of an item to its cost must be 1. However, due to the impossibility of such a practice in real life situations, the study used the percentage of deviation value as Tanaka (1989) used in his case study to analysis the data. The findings are summarized as follows:

a) In M company, the compressor group has excessive cost when it is compared to its degree of importance.

b) The canopy group has less cost when it is compared to its degree of importance. We have concluded that the company produces an item that has a higher degree of importance with a less cost by efficient operations.

c) In the first stage, a 21% of cost reduction is suggested for the compressor group. With this cost reduction, the product falls onto the boundary of optimal value zone.

d) All of the activities of the M company are in the optimal value zone. So, we have concluded that the firm performs its activities effectively and efficiently. This supports the finding in (b).

e) Obviously, however, a significant cost reduction does not seem possible in the first stage. Due to the fact that M Company is a new established company and lacks of cost reduction culture, significant cost reductions may not be possible by designing a single next-generation product. Cooper (2002) suggested multi-generation business strategies for such companies and M company should establish more aggressive targets for each generation. As significant cost reductions take palace, the effectiveness of the target costing process increases accordingly.

7. CONCLUSION

A review of the cost reduction processes in manufacturing companies reveals a limited amount of previous studies based on various tools combined. To this end, the study collects cost data from Activity Based Costing and prioritizes the customer preferences with Analytic

Hierarchy Process and translates these preferences to engineering characteristics by Quality Function Deployment. The Value Index compares cost and importance and thereby guides for areas for cost reduction. Although the study uses a producer firm, the holistic model may be applied to all of the industries (service industries as well) with same order of techniques and survey method.

The ABC model in this study highlights some important factors. The model is essentially suitable for the producers that produce different types of products of which overhead information is critical. The firms may see the implementation of ABC and other tools like QFD as another cost generators but it is the firm that will decide the optimal deployment layout of these tools that yields the highest price-benefit ratio. For instance, JIT and lean advocates, who see the detailed overhead information as a waste and avoid using ABC, may use overhead information collected from the value streams and compare them through value analysis. That may still be meaningful but the measure of overhead would be rougher due to the nature of subjective overhead assignment of lean-value stream costing.

Obviously, it is a fact that ABC yields elaborative overhead information and assists greatly for *the most diagnostically accurate cost reduction method.*

AHP is another critical element for cost reduction process in the model. A traditional likert scale is deficient because it does not give any opportunities to rank the importance of criteria between each other. AHP provides useful information for the decision maker to properly rank the degrees of importance of the criteria between each other. So, the levels of cost can match the degrees of importance more objectively. That appears a critical step for holistic cost reduction process.

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