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Kano's Model and Decision Making Trial and Evaluation Laboratory Applied to Order Winners and Qualifiers Improvement: A Study of the Computer Industry

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Abstract: This study puts forward a new decision analysis method that exploits Kano's model to know the quality attributes and nonlinear effects of order winners and qualifiers. The proposed method adopts a decision making trial and evaluation laboratory (DEMATEL) to identify the causality of order winners and qualifiers and the extent to which they interact. This method can know who the core order winners and qualifiers are. Based on a specific industrial computer manufacturer in Taiwan, this study looks into the quality attributes and causation of order winners and qualifiers using the Kano questionnaire survey analysis and Delphi method. This study case shows that Kano's model and DEMATEL together can accurately assess the quality attributes of order-winners and qualifiers. The proposed method helps managers solve complicated problems by showing the causality. In a word, this new model can effectively and correctly provide information for making marketing and manufacturing strategies.

Key words: Decision making trial and evaluation laboratory, Kano's model, order-winners and qualifiers

INTRODUCTION

The study of manufacturing strategies has recently achieved prominence in academia and onsite management operations. Voss (1995) defines manufacturing strategy as industry-based strategy attempts to select the right production technologies and production control for each industry. Karras *et al.* (1999) held that a manufacturing strategy should be designed in line with customer needs, company strategies and internal needs, including productivity, product improvement and production design. Hill (2000) devised a framework for manufacturing strategies to make strategies for existing and future markets. However, other scholars produced a capability-based model. Stalk (1988) proposed a time-based competition theory that looked at time as future competitiveness. Recently the Flexible Manufacturing System (FMS) became a significant operation management subject. In the research by Slack (1994), flexibility's role in manufacturing is discussed; Oke (2005) addressed a new category and framework for analyzing how flexible a manufacturing company could actually be.

Vickery (1991) suggested that manufacturing capacity be used to analyze to what extent a company's manufacturing system could support its strategies. Meanwhile, another manufacturing strategy, order-winning criteria, was developed. However, only a few scholars analyzed and answered the question: how should a company compete with others? by examining key success factors (KSF). The best answer to this question is the order winners and qualifiers model by Hill (2000), which uses an order-winning skeleton to assist managers in further understanding market demands and devising manufacturing strategies to support the order winners and qualifiers model designed for existing and future markets. Later, Slack (1994) prioritized the competitive factors of the operation management in making the right marketing strategies and improvements using Importance-Performance Analysis (IPA). Other researchers diverted their attention to the correlation between market share and this order-winning skeleton. Hörte and Ylinenpää (1997) found that managers and their customers thought very differently about order winners and qualifiers. In the research by Bommer *et al.* (2001), a good discussion on how a good manufacturing strategy for the order winners and qualifiers can increase a company's market share. Yet for manufacturers, the question to operation management is not about how to make manufacturing and marketing strategies, but how to win orders. There is no theory or empirical research that tested the effectiveness of these

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methods or that ensured how customers perceived order-winners and qualifiers and their quality attributes. To answer this question, this study uses Kano's model (Kano *et al*., 1984) to know what customers think about order-winners and qualifiers in terms of quality attributes. The goal of this study is to raise real questions and know their causation. This study integrates Kano's model and DEMATEL to effectively create manufacturing and marketing strategies for an industrial computer manufacturer.

MODEL REVIEW

Hill tactical management: Hill (2000) developed five steps to integrate corporate manufacturing and marketing strategies. These five steps must not be missed and recursion could occur in the process of assessing a manufacturing process order winners and qualifiers. To solve this problem, manufacturing strategies, necessary ventures and the entire logistical system must be in line with the company's marketing strategies and goals. The five steps are: (1) set the goals, (2) create marketing strategies for the goals, (3) know how a product's various qualities can win orders in its niche, (4) have a suitable manufacturing process and (5) construct the infrastructure for such production system. In the decision frame, the manufacturing strategy skeleton and decision model by Hill (2000) are clearly shown in Table 1, including the company's goals, marketing strategies, relation between manufacturing strategy and order winners and qualifiers and verifying the order winners and qualifiers are crucial to the manufacturing and marketing strategies and corporate goals.

The marketing strategy is significant and essential. Hill (2000) believed that this essential marketing strategy should be based on order winners and qualifiers that, in turn, are based on the market, organizational demands and manufacturing requirements. Practically a company's marketing strategies must be backed up by the manufacturing department to ensure that the plan can be perfectly implemented. The company must bridge market plans, commitments, the manufacturing process and its infrastructure. This bridge, in fact, is the order-winners and qualifiers.

An organization must well understand its markets in order to make relevant functional strategies to propose the appropriate goals and vision (Hill, 2000). For this purpose, the company should list all competitive factors by their importance (Slack, 1994). Hill (2000), Voss (1995) and Silveira (2005) discussed and concluded that the methods used to create manufacturing strategies must include an importance order based on market research. Some similar researches focused on satisfaction and better quality: to know one's customers and market demand through the competitive factors of a certain niche market. The market research results can help managers make marketing strategies and improve the company's performances in these factors. This approach is potent in the research on satisfaction. According to latest researches, Matzler *et al.* (2003) put forward a factor structure of satisfaction for the banking industry and used the importance-performance analysis to present four marketing strategies. In the auto industry, Matzler *et al.* (2004) analyzed the non-symmetrical relations between satisfaction and quality for different performances using multiple regression analysis dummy variables. In the process of finding competitive factors, some effective methods were discussed in exploratory researches. Griffin and Hauser (1993) suggested that 20~30 key clients be interviewed. Over 90% of the competitive factors or quality characteristics can be identified in highly consistent market segmentation. Many scholars adopted focus group interviews to find out competitive factors and product requirements. This is an "on the ground" method in which customer needs can easily be noticed in group discussions. A few focus group interview examples are: Krieg (2004) used it to know the quality characteristics of a successful product; Fam and Waller (2006) used it to determine why some TV advertisements are popular in Asia; Santhapparaj *et al.* (2006) identified the competitive

Table 1: Table of corporate goals, marketing strategy and the relation between manufacturing strategy and order-winners and qualifiers

Corporate Objectives	Marketing strategy	How do products qualify and win order in the marketplace?	Manufacturing strategy	
			Process choice	Infrastructure
1.Growth	1.Product markets and segments	1.Price	1.Choice of alternative processes	1.Function support
2.Survival	2.Range	2.Conformance quality	2.Trade-offs embodied in the process choice	2.Manufacturing planning and control system
3.Profit	3.Mix	3.Delivery speed	3.Role of inventory in the process configuration	3.Quality assurance and control
4.Return on investment	4.Volumes	4.Delivery reliability	4.Make or buy	4.Manufacturing systems engineering
5.Other financial measure	5.Standardization versus customization	5.Demand increases	5.Capacity	5.Clerical procedures
	6.Level of innovation	6.Color range	Size	6.Compensation agreements
	7.Leader versus follower alternatives	7.Product range	Timing	7.Work structuring
		8.Design	Location	8.Organizational structure
		9.Brand image		
		10.Technical support		
		11.After-sales support		

factors of the semiconductor industry in Malaysia through this method. Such interviews are very effective in identifying competitive factors or quality characteristics.

Kano's model separated quality characteristics into: attractive quality, one dimensional quality, must-be quality, indifference quality and reverse quality, of which the attractive quality and must-be one are of nonlinear effects (Kano *et al*., 1984). Yang (2003) took Kano's model, interviews with key customers and the importance-satisfaction analysis to improve home appliance maintenance service quality to advance corporate competitiveness. Yang (2005) modified Kano's model and integrated it into an importance-satisfaction analysis to provide more valuable information for making quality decisions. Others adopted a three-factor theory: basic factor, performance factor and excitement factor, to provide insight into issues about satisfaction. In the research on the healthcare services industry, Matzler and Sauerwein (2002) developed a three-factor methodology from the auto industry. Matzler *et al.* (2004) found the dissymmetry between the performance of quality characteristics and overall satisfaction. The manager acquired necessary information for making decisions after using the three-factor theory. Judging the researches above, several quality characteristics are supposed to have nonlinear effects upon a customers' feeling toward quality.

Many scholars pointed out that the performance of quality characteristics is related with satisfaction (Matzler *et al*., 2004; Oh, 2001; Sampson and Showalter, 1999; Chung *et al*., 2008). In other words, as the performance of quality characteristics becomes better, the gap between importance and performance will be closer rapidly and nearly meets the customers' expectation. At this time, the improved quality characteristics are less important than that of others which their performances are relatively low (Matzler and Sauerwein, 2002). Thus, the importance perceived by clients fails to show the relative importance of quality characteristics. To address this situation, some adopted statistical inferences to evaluate the relative importance of quality characteristics. Matzler and Sauerwein (2002), for instance, derived it from multiple regression analysis and named it implicit importance. Sampson and Showalter (1999) examined the causality among quality characteristics using a Structural Equation Model (SEM) and applied some influence coefficients to the relative importance of quality characteristics.

The traditional IPA model and followers made great contributions to this research technique. Still, these models have some potential problems that need to be studied further and discussed, including (1) the hypothesis about the linear relation among quality characteristics; (2) the hypothesis of the independence of each quality characteristic. Besides, Kano's model can identify the nonlinear effects of quality characteristics but it misses the causation or correlation among quality characteristics. For this reason, this study comes up with a new decision analysis that uses Kano's model to identify the quality attributes and nonlinear effects of order winners and qualifiers and to know what customers think about order-winners and qualifiers in terms of quality attributes, then figures out their core problems by analyzing the causation and interaction through DEMATEL to effectively create manufacturing and marketing strategies for an industrial computer manufacturer.

MATERIALS AND METHODS

This research uses Kano's model to discuss order-winners and qualifiers for the industrial computer industry to know their quality attributes. Looking into the causality among quality attributes never discussed, this study uses DEMATEL to find the answer and how each characteristic change one another. The integration of Kano's model and DEMATEL in this study can help managers discern core problems and solve them to avoid the enormous losses arising from wrong decisions. This method can rationalize the improvement of quality characteristics and resource allocation to provide effective and correct information for making marketing and manufacturing strategies. The integration of Kano's model and DEMATEL by this study has some subjects to be discussed: (1) Kano's model for analyzing order winners and qualifiers in order to know their quality attributes; (2) DEMATEL for analyzing the causality and interaction of order winners and qualifiers; (3) integration of Kano's model and DEMATEL for making relevant policies and improvements.

Kano's model: In 1984 Dr. Kano used a two-dimensional model to know and utilize product features to meet customer needs and expectations (Kano *et al*., 1984; Liu and Wu, 2008). This model was effective in assessing existing products and those to be developed, in order to meet customer needs and expectations and hence reach the company's goals. According to Kano's research, customers expected a product to satisfy three needs: a basic need, performance need and excitement need. The first need can be satisfied by the nature of a product, which means that this factor will make it unmarketable. That is to say, the basic quality characteristics can just stop complaints. This is because customers want other quality characteristics. Usually, satisfaction is positively related to these other quality characteristics. Moreover,

some quality characteristics are beyond the clients' expectation and they can make customers very excited. These excitement characteristics are the source of a products' competitiveness and which a company can uses to take a niche in the market. Matzler *et al.* (1996) deduced several good points from Kano's model: (1) it is better to know the customers' needs; (2) it prioritizes improvements; (3) it provides a valuable measurement in the process of developing a manufacturing system; (4) it helps a company to segregate the market; (5) it differentiates the market.

Kano recommended that when designing a product, a company should first discern the customers' needs and know what quality characteristics they value in order to best reach customers' expectations. To identify their perceptions and attitudes toward the quality characteristics of a product, a questionnaire should have positive and negative questions. To begin with, a question is raised to know how customers (testers) feel when a product contains all the essential quality characteristics. This kind of questionnaire aims to understand how customers (testers) feel when a product does not contain all essential quality characteristics. Customers may answer: I like it that way It must be that way I am neutral I can live with it that way and I dislike it that way, which can show what quadrant into matrix a certain quality characteristic of the product should be placed: basic need, performance need, or exciting need. From this matrix, a researcher can know what they need. There are five quality characteristics that will sway satisfaction according to Kano *et al.* (1984):

- **Must-be quality:** This is a very essential quality characteristic for customers. The customer will be very unsatisfied without it. In other words, if a quality characteristic is what they care about most, its existence will not make satisfaction better since it is the basic feature in the customers' view. Thus, must-be quality can just avoid complaints. It is a definite competitive factor essential to customers when they select a product. That is, without must-be quality, it is highly unlikely to attract the clients' eyes.
- **One-dimensional quality:** It is positively related with satisfaction degree. As the degree becomes higher, so will the satisfaction and vice versa. This quality is a definite competitive factor. Usually customers compare this quality in the products of different brands. When they find more of this characteristic in a certain brand, they will choose it for sure.
- **Attractive quality:** This is the factor that most influences satisfaction among the quality characteristics. Customers may or may not know if they need it, but they will be very happy when they find it in a product. As a product has more of this quality, satisfaction will increase and vice versa. Yet, customers will not dislike a certain product without this quality.
- **Indifferent quality:** It refers to a quality that is unable to sway satisfaction at all.
- **Reverse quality:** It will arouse bad feelings in customers, so satisfaction comes without it.

Classification of quality characteristics can be performed with Kano's questionnaire and matrix. This study tries to divide order winners and qualifiers into must-be quality, one dimensional quality and attractive quality for the purpose of making marketing and manufacturing strategies. To do this, each quality characteristic has five options, from positive attitude to negative, for testers to check. Table 2 shows functional and dysfunctional questions in the Kano's questionnaire on price. The first question is to know what customers think about that quality characteristic and how they will react without it, as shown in question 2. In this study, some quality characteristics must be compared on the basis of existing performances, such as price, delivery speed and quality consistency.

In Table 3, Kano's Quality Attributes Classification Matrix, A is attractive quality-customers will be very happy when they find it in a product. Yet, customers will not dislike a certain product without this quality. O is one dimensional quality- customers will be very happy to see this quality in a product and be disappointed if they don't. M is must-be quality that customers take for granted and will be very discontented with its absence. I is indifferent quality-quality that is unable to sway satisfaction at all. R: is reverse quality-it will arouse bad feelings in customers, so satisfaction comes without it. Q is questionable result, perhaps caused by an incorrect record or testers' misunderstanding of the question or even a defective check, which is normally unlikely to happen. Hence, the Q-rate is a measurement for an effective questionnaire, with 2% or below acceptable according to Matzler and Hinterhuber (1998).

Each questionnaire should be completed by one client. Functional and dysfunctional questions are put together in a type of question. Quality characteristics are categorized for customers. For instance, if a client is asked If the price will be much lower than the present price, how do you feel? and s/he answers: I like it that way. On the other hand, when a product is without a certain quality characteristic and the question is If the price is much higher than the present price, how do you feel? S/he

Table 2: Functional and dysfunctional questions in the Kano's questionnaire

If the price will be lower than present price much more, how do you feel	□	I like it that way
	□	It must be that way
	□	I am neutral
	□	I can live with it that way
	□	I dislike it that way
If the price will be higher than present price much more, how do you feel	□	I like it that way
	□	It must be that way
	□	I am neutral
	□	I can live with it that way
	□	I dislike it that way

Table 3: Kano's quality attributes classification matrix

Competitive factor		Dysfunctional form of the question				
		I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Functional form of the question	I like it that way	Q	A	A	A	O
	It must be that way	R	I	I	I	M
	I am neutral	R	I	I	I	M
	I can live with it that way	R	I	I	I	M
	I dislike it that way	R	R	R	R	Q

Table 4: Table of results

Quality attribute	A	O	M	I	R	Q	Total	Category
Price	22%	75%	3%	0%	0%	0%	100%	O
Delivery reliability								
Delivery speed								
……								
……								

answers: I dislike it that way. According to Kano's quality attributes classification matrix, price among order winners and qualifiers can be classified as O, one dimensional quality. However, others may think differently about price. Some may group it under attractive quality and others must-be quality, so all answers should be put in Table 4. Next, the percentage of a quality characteristic in Kano's matrix should be determined and the one accounting for the majority is the right one.

After analyzing order-winners and qualifiers and existing performance for the organization, a manager will usually make decisions and improvements accordingly. When quality conformity, for instance, is a must-be quality among order winners and qualifiers and the organization does not performance well in quality conformity, a manager will immediately tries to improve it. Yet, when this quality characteristic is independent, this decision is reasonable; otherwise it will be wrong. This is because some efforts to improve quality will reduce costs while others will increase cost, which consequently will affect product pricing. In this case, improving quality and pricing is interactive. If price is deemed a one dimensional quality, the improvement of quality conformity will greatly change the price and competitiveness. Therefore, this study applies DEMATEL to know the causality of quality characteristics and modify Kano's model.

Decision making trial and evaluation laboratory: Decision Making Trial and Evaluation Laboratory (DEMATEL) was developed by Battelle Memorial Institute of Geneva Research Center. DEMATEL has been used to solve intricate world problems such as race, famine, environmental protection, energy and others (Wu and Lee, 2007). Recently Japan, Korea and Taiwan brought DEMATEL into other domains. Tamura *et al.* (2006) used DEMATEL to discuss customer discomfort toward food and how to solve it. Hajime *et al.* (2005) used QFD, TRIZ and DEMATEL to settle design disputes over new products. Nanayo and Toshiaki (2002) assessed the medical system using a modified DEMATEL. Kenichi and Yoshihiro (2002) analyzed the functions and dysfunctions in a snow melting system using DEMATEL. Kim (2006) integrated PCA, AHP and DEMATEL to evaluate the impacts of agricultural information on the livestock industry. Wu and Lee (2007) used Fuzzy DEMATEL to identify managers' core capabilities. Lin and Wu (2008) applied Fuzzy DEMATEL to group decision making. Judging the above cases DEMATEL has been successfully and widely utilized in many domains. DEMATEL uses a matrix and cause-effect diagram to show the direct/indirect relations between quality characteristics in an intricate system and the degree that they interact with one another by comparing their interrelations. Both the matrix and diagram can serve as a reference for policy makers. This proves that DEMATEL can present a complicated system in a cause and effect diagram by separating quality characteristics into causes and effects. By quantifying the interrelations between quality characteristics, one can know how to tackle the core problems.

Definition of quality characteristics and creation of scale: By literature review, brainstorming, or Delphi method which is general and objective method in research, this study lists and defines quality characteristics of a certain complicated system and assumes there are n numbers of quality characteristics. Next, this study creates a pair-wise comparison scale to show the causation and its degree. This scale has four levels from 0, 1, 2, to 3, representing no influence low influence high influence and great influence (Lin and Wu, 2008). There is another scale with six levels from 0, 1, 2, 3, 4, to 5, representing no influence extremely low influence low influence moderate influence high influence and great influence (Kim, 2006). In Huang *et al.* (2007) the scale has 11 levels from 0 to 10, representing no influence to great influence. Thus, there is no fixed scale.

Direct-relation matrix: If the number of quality characteristics is n, this study makes the pair-wise comparison by questionnaires and Delphi method between the causation of quality characteristics and its degree and gets an n×n direct-relation matrix X, in which x_{ij} stands for how quality characteristic i influences on quality characteristic j. Quality characteristics x_{ii} at the corner of the matrix are set to 0.

$$X=\begin{bmatrix} 0 & x_{12} & \cdots & x_{1n} \\ x_{21} & 0 & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & 0 \end{bmatrix} \quad (1)$$

Meanwhile, a sign matrix S is created to show whether the influence is positive or negative, shown as + and -.

Normalized direct-relation matrix: The normalized direct-relation matrix has two algorithms. In Wu and Lee (2007), Lin and Wu (2008), Kim (2006) and Seyed-Hosseini *et al.* (2006), the normalized baseline is the row vector and the maximum, whereas in the study of Tzeng *et al.* (2007) the baseline is the column/row vector and the maximum. As:

$$\lambda=\frac{1}{\underset{1\le i\le n}{\text{Max}}\left(\sum_{j=1}^{n}x_{ij}\right)} \text{ or } \quad \lambda=\text{Min}\left[\frac{1}{\underset{1\le i\le n}{\text{Max}}\left(\sum_{j=1}^{n}x_{ij}\right)},\frac{1}{\underset{1\le j\le n}{\text{Max}}\left(\sum_{i=1}^{n}x_{ij}\right)}\right] \quad (2)$$

Using formulas 2 and 3, the direct-relation matrix X multiplied by λ gets the normalized direct-relation matrix N.

$$N=\lambda X \quad (3)$$

DEMATEL presumes that the sum of at least one i row must be in line with the formula (4). Lin and Wu (2008) believed that almost all cases can satisfy this presupposition.

$$\sum_{j=1}^{n}x_{ij}<\frac{1}{\lambda} \quad (4)$$

Hence, the normalized direct-relation matrix N can be educed a sub-random matrix.

$$\lim_{k\to\infty}N^k=O \text{ 且 } \lim_{k\to\infty}\left(I+N+N^2+\cdots+N^k\right)=(I-N)^{-1} \quad (5)$$

In this formula, O is the null matrix and I is the identity matrix.

Direct/indirect relation matrix: Since the normalized direct-relation matrix *N* contains the properties of formula (5), the indirect/ direct-relation matrix T, or total-relation matrix, can be derived from formula (6) (Huang *et al.*, 2007). The indirect relation matrix H, or total-indirect-relation matrix, can be derived from formula (7) (Lin and Wu, 2008).

$$T=\lim_{k\to\infty}\left(N+N^2+\cdots+N^k\right)=N(I-N)^{-1} \quad (6)$$

$$H=\lim_{k\to\infty}\left(N^2+N^3+\cdots+N^k\right)=N^2(I-N)^{-1} \quad (7)$$

Suppose t_{ij} is the quality characteristic of total-relation matrix T and i, j = 1, 2… n. Formula (8) and (9) can help determine the sum of values in the rows and columns of the total-relation matrix T. D_i is the sum of row i. This means that quality characteristic i is the cause that affects the sum of the other quality characteristics. R_j is the sum of row j, which means that quality characteristic i is the effect of the sum of the other quality characteristics. D_i and R_j are derived from the total-relation matrix T, including both direct/indirect effects.

$$D_i=\sum_{j=1}^{n}t_{ij} \quad (i=1,2,\cdots,n) \quad (8)$$

$$R_j=\sum_{i=1}^{n}t_{ij} \quad (j=1,2,\cdots,n) \quad (9)$$

Causal diagram: D_k+R_k are the prominence and making k = i = j = 1, 2,… n to show the extent a quality characteristic affects or is affected by others and how prominent quality characteristic k is in all core problems. Make (D_k-R_k) a relation to show the difference of extent a

quality characteristic affects or is affected by others and whether quality characteristic k is more like a cause or an effect. The positive result proves k is more like a cause, or like an effect when the result is negative. This causal diagram, with (D+R) as X axis and (D-R) as Y axis, makes up a two-dimension diagram with the sign matrix S. This casual diagram can simplify sophisticated causality within a system. A policy maker can judge if a quality characteristic is a cause or an effect and how it affects or is affected by other quality characteristics from its position in the matrix in order to make right policies.

(D_k+R_k, D_k-R_k) of each quality characteristic will be figured out and the result doted on the causal diagram. When D_k-R_k is positive, quality characteristic k is a cause; when D_k-R_k is negative, quality characteristic k is a result. Bigger the sum of D_k+R_k is, more greatly a quality characteristic affects or is affected by others. According to the causal diagram, if the result of D_k-R_k is negative and the sum of D_k+R_k is small, quality characteristic k is more independent, i.e., k is less likely influenced by others. When the result of D_k-R_k is positive and the sum of D_k+R_k is small, quality characteristic k is independent as well, which means that k affects only a few quality characteristics. When the result of D_k-R_k is negative and the sum of D_k+R_k is big, quality characteristic k should be addressed first, but indirectly. When the result of D_k-R_k is positive and the sum of D_k+R_k is big, quality characteristic k is the trigger of core problems and hence must be solved first. Therefore, a policy maker can make plans to solve problems by finding out the triggers via the causality of quality characteristics and the degree of relations.

Integration of Kano's model and DEMATEL: Traditionally people use Kano's model to select quality characteristics and improve them. However, when a quality characteristic interacts with others, its alternation will affect the other attributes as well. So, a quality characteristic with great causal relations with others should be addressed first. To know this causation, the 2-dimension causal diagram created in accordance with the result of DEMATEL is suggested. This causal diagram has four quadrants and one origin at the center of each axis. Quadrant I is of high prominence and high relation, showing quality characteristics in this area are core problems and affect others, so they should be addressed first. Quadrant II has low prominence and high relation, showing that quality characteristics in this area are independent but can affect only a few quality characteristics. Quadrant III has low prominence and low relation, showing that quality characteristics in this area are independent and are affected by only some quality characteristics. Quadrant IV has high prominence and low relation, showing that quality characteristics in this area are core problems and affected by other quality characteristics. As result, there are only two situations related to the Kano's model result: quadrant I and IV. Low importance and relation are in line with the presumption of Kano's model- independence of quality characteristics. Thus, it is acceptable to make policies according to the Kano's model result. The integration of Kano's model and DEMATEL has two categories and four kinds of policies, shown:

Quality characteristic with high prominence and relation:

- If quality characteristics have attractive quality and other positively influential quality characteristics belonging to one dimensional quality or must-be quality, managers should keep improving these quality characteristics by adding edges to them but also to better the performance of other quality characteristics. However, if quality characteristics are affected by those related to reverse quality, managers should know how they affect others and to what extent they can be improved, if improvements are necessary. When quality characteristics are negatively affected by one dimensional quality and must-be quality, characteristics, one must consider the necessity for having more attractive quality. Yet, if quality characteristics are negatively affected by reverse quality, managers should keep improving them.
- If quality characteristics belong to one dimensional quality and other positively influential quality characteristics belong to attractive quality or must-be quality, they should be improved immediately in order to add edges to them but also to better the performance of other quality characteristics. However, if the affected quality characteristics belong to reverse quality, managers should know how they affect others and to what extent they can be improved, if improvements are necessary. When other negatively influential quality characteristics are attractive quality or must-be quality, one may consider the necessity for having more one dimensional quality. Yet, if other quality characteristics negatively affected are reverse quality, managers should keep improving the one dimensional quality.
- If quality characteristics belong to must-be quality and other positively influential quality characteristics are part of one dimensional quality or attractive quality, they should be improved immediately in order to add edges to them but also to better the performance of other quality characteristics.

However, if other positively influential quality characteristics belong to reverse quality, managers should know how they affect others and to what quality extent they can be improved and if improvements are even necessary. When other negative influential quality characteristics belong to reverse quality, managers should keep improving these quality characteristics.

- If quality characteristics belong to the reverse quality, managers should know how they affect others and the necessity for their improvement, regardless if others are positively affected or belong to which quality.

Quality characteristic with high prominence and low relation:

- If quality characteristics belong to the attractive quality and other positively influential quality characteristics belong to must-be quality or one dimensional quality, these influential quality characteristics should be improved immediately in order to increase their advantages and enhance the performance of those quality characteristics. If the two influential factors affect the quality characteristics negatively, it is ok to fulfill must-be quality only.
- If quality characteristics belong to the one dimensional quality and other positively influential quality characteristics belong to must-be quality or attractive quality, these influential quality characteristics should be improved immediately in order to increase their advantages and enhance the performance of those quality characteristics. If the influential factors are reverse quality, managers should know how they affect others and to what extent they can be improved and if improvements are even necessary. If the two influential factors affect the quality characteristics negatively, it is ok to fulfill must-be quality only.
- If quality characteristics belong to the must-be quality and other positively influential quality characteristics are one dimensional quality or attractive quality, these influential quality characteristics should be improved immediately. If the influential factors are reverse quality, managers should know how they affect others and to what extent they can be improved, if improvements are necessary. If the two influential factors affect the quality characteristics negatively, it is ok to fulfill must-be quality only.
- If quality characteristics belong to the reverse quality and other positively influential quality characteristics are must-be quality one dimensional quality or attractive quality, one may consider the necessity for improve the three characteristics. However, if the three affect the quality characteristics negatively, they must be improved immediately.

This decision-making methodology can help managers know core quality problems and address them. With causation analysis via DEMATEL, an organization can classify quality characteristics with extremely little relation as ones without any relations with others. This method can simplify quality management, analysis and decision making.

RESULTS AND DISCUSSION

This study takes an industrial computer manufacturer in Taiwan as the research subject. The Kano's model and DEMATEL are used to analyze the order winners and qualifiers to provide information for making marketing and manufacturing strategies and improving customer satisfaction. The case here is a 24 year-old large computer manufacturer in Taiwan that has 500 employees, 20% of the market and ISO 9001 Quality Management System and ISO 14001 Environmental Management System Certification. This company is listed on the stock market and its business has grown steadily. So, we chosen this company as our case study research is representative in industrial computer manufacturers. This study surveyed the company's customers using questionnaires based on the order winners and qualifiers model. Their answers were analyzed using the Kano's model and DEMATEL to define core problems and make improvements. The conclusions from this analysis can be used to make marketing and manufacturing strategies to advance the company's competitiveness.

Kano's model and DEMATEL questionnaire and survey: In 2008 this study surveyed counter-parties about their satisfaction with order winners and qualifiers at an industrial computer company. The quality characteristics were devised into functional and dysfunctional questions, in which the performance of each product/company characteristic is included. A scalogram with 9 satisfaction degrees by Slack (1994) was used to determine the customers' perception of this company's performance. Fourteen quality characteristics are asked about using a scale in which 1= very unsatisfied to 9 = very satisfied. The 14 characteristics were determined using Hill (2000) and their effectiveness was approved using 20 customers and 15 senior officials. Griffin and Hauser (1993) held that in an interview with 20~30 customers 90~95% of the quality characteristics of homogeneous markets could be

defined. The testers were existing counter-parties to whom a part of the 320 questionnaires were mailed. The rest were mailed to executives with the customer purchasing and QA departments. At the end of this activity, 192 effective questionnaires were collected, constituting a 60% recovery rate.

In the DEMATEL questionnaire, based on the 14 order winners and qualifiers model by Hill (2000), a 14 order winners and qualifiers sign matrix and direct-relation matrix was co-designed by 15 senior officials. + shows positive relation and - shows negative relation between two order winners and qualifiers. The scale for the direct-relation matrix is the scalogram by Huang *et al.* (2007), with 11 levels ranging from 0 as no influence to 10 as great influence. The analysis software is SPSS R14 and EXCEL 2003. The collected questionnaires were classified into order winners and qualifiers via Kano's model. The causations were determined using the DEMATEL model. In this way, the company can know what core problems to address to make the right marketing and manufacturing strategies.

Analysis result: The order winners and qualifiers identified from customer answers were analyzed using Kano's model and classified in Table 3 and 4. Quantified results are shown by percentage in Table 5; the majority can best represent each order winner or qualifier. Table 5 shows: Delivery speed (OW3), Design leadership (OW9) and Brand name (OW12) are attractive quality; Price (OW1), Quality conformance (OW4) and Design (OW7) are one dimensional quality; Delivery reliability (OW2), Distribution (OW8), Technical liaison and support (OW13) and After-Sales support (OW14) are "must-be quality; Demand increases (OW5), Product range (OW6), Being an existing supplier (OW10) and Marketing and sales (OW11) are indifference quality. The order winners and qualifiers in this survey contain no reverse quality, and Q-Rate is 0%, below 2%, which means this survey is acceptable.

The order winners and qualifiers are listed in Table 6 in order by their average performance: satisfied-Distribution (OW8), Being an existing supplier (OW10) and Product range (OW6); satisfied to so-so- Design (OW7), Design leadership (OW9), After-Sales support (OW14), Brand name (OW12) and Marketing and sales (OW11); the rest are so-so. In this survey Quality conformance (OW3) has the lowest average performance. Design leadership (OW9) and Delivery speed (OW3) have bigger standard deviation, showing the company in question is unstable in the two respects. According to Kano's model and performance analysis in Table 6, order winners and qualifiers attributed to must-be quality but do

Table 5: Order-winners and qualifiers analyzed by Kano's model

Code	Order-winners and qualifiers	A (%)	O (%)	M (%)	I (%)	R (%)	Total	Attribute
OW1	Price	18.8	62.5	15.6	3.1	0.0	100.0	O
OW2	Delivery reliability	9.4	28.1	62.5	0.0	0.0	100.0	M
OW3	Delivery speed	62.5	31.3	6.3	0.0	0.0	100.0	A
OW4	Quality conformance	12.5	65.6	21.9	0.0	0.0	100.0	O
OW5	Demand increases	25.0	21.9	12.5	40.6	0.0	100.0	I
OW6	Product range	9.4	15.6	6.3	68.8	0.0	100.0	I
OW7	Design	25.0	43.8	3.1	28.1	0.0	100.0	O
OW8	Distribution	12.5	9.4	62.5	15.6	0.0	100.0	M
OW9	Design leadership	43.8	25.0	3.1	28.1	0.0	100.0	A
OW10	Being an existing supplier	6.3	21.9	9.4	62.5	0.0	100.0	I
OW11	Marketing and sales	9.4	9.4	6.3	71.9	3.1	100.0	I
OW12	Brand name	65.6	18.8	3.1	12.5	0.0	100.0	A
OW13	Technical liaison and support	6.3	15.6	68.8	9.4	0.0	100.0	M
OW14	After-sales support	3.1	12.5	78.1	6.3	0.0	100.0	M

Table 6: Quality attributes of order-winners and qualifiers and performance analysis

Code	Order-winners and qualifiers	Quality attributes	Performance (average)	Performance (standard deviation)
OW1	Price	O	5.91	1.67
OW2	Delivery reliability	M	5.93	1.45
OW3	Delivery speed	A	5.81	2.12
OW4	Quality conformance	O	5.02	1.33
OW5	Demand increases	I	5.60	1.75
OW6	Product range	I	7.04	1.44
OW7	Design	O	6.48	1.41
OW8	Distribution	M	7.14	1.24
OW9	Design leadership	A	6.29	2.98
OW10	Being an existing supplier	I	7.10	1.34
OW11	Marketing and sales	I	6.01	1.29
OW12	Brand name	A	6.06	1.61
OW13	Technical liaison and support	M	5.83	1.71
OW14	After-sales support	M	6.08	1.95

Table 7: Prominence and relation of order-winners and qualifiers

OW	Order-Winner Criteria	D	R	D+R	D-R
OW1	Price	0.13	1.54	1.66	-1.41
OW2	Delivery reliability	0.23	0.34	0.68	0.01
OW3	Delivery speed	1.04	0.87	2.07	0.32
OW4	Quality conformance	1.27	1.15	2.56	0.27
OW5	Demand increases	0.48	0.00	0.51	0.51
OW6	Product range	0.20	0.38	0.58	-0.18
OW7	Design	1.40	0.00	1.81	1.81
OW8	Distribution	0.23	0.00	0.35	0.35
OW9	Design leadership	1.02	0.20	1.37	0.97
OW10	Being an existing supplier	0.00	1.37	1.37	-1.37
OW11	Marketing and sales	0.00	1.35	1.35	-1.35
OW12	Brand name	0.25	0.68	0.93	-0.42
OW13	Technical liaison and support	0.20	0.06	0.26	0.15
OW14	After-sales support	0.31	0.00	0.33	0.33

not earn satisfaction should be improved immediately; they are Delivery reliability (OW2), Technical liaison and support (OW13) and After-Sales support (OW14). For those attributed to one dimensional quality but do not earn satisfaction, such as Price (OW1), Quality conformance (OW4) and Design (OW7), the company must put forward a right policy to segregate the market. For those attributed to attractive quality but do not earn satisfaction, such as Delivery speed (OW3), Design leadership (OW9) and Brand name (OW12), the company should have a policy for finding a niche.

DEMATEL can help researchers know the causation among order winners and qualifiers Formula (6) can derive a direct/indirection relation matrix, D_i and R_i of which are calculated using formula (8) and (9). As result, prominence (D_i+R_i) and relation (D_i-R_i) are determined, as shown in Table 7.

The sum of prominence (D_i+R_i) and relation (D_i-R_i) divided by 14 order winners and qualifiers is the average, or the estimated value of the central tendency of the causal matrix that can be used to demarcate the causal diagram into the four quadrants, shown in Fig. 3. According to Fig. 3, Quality conformance (OW4), Delivery speed (OW3), Design (OW7) and Design leadership (OW9) are of high prominence and high relation; these order winners and qualifiers can affect others. Price (OW1), Marketing and sales (OW11) and Being an existing supplier (OW10) are of high prominence and low relation; these are affected by others. The rest of the order winners and qualifiers can be ignored or deemed as independent factors for their prominence is below the average of 1.13.

Since the causality of order winners and qualifiers is so complicated, those with influence degree below 0.1 can be assumed to be independent factors Fig. 1. The rest of the order winners and qualifiers can be dotted on the causal diagram to show their causation in a simple way. In Fig. 2, + means positive influence. For instance, Quality conformance (OW4) is positively related with Price

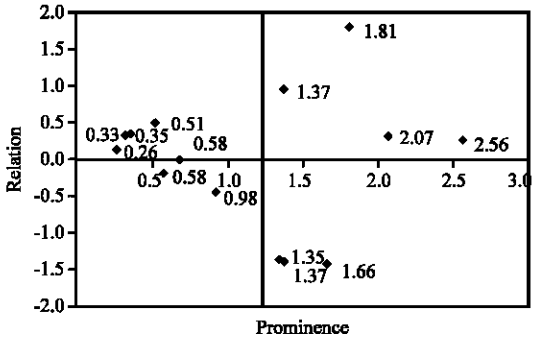

Fig. 1: Order winners and qualifiers in the causal matrix

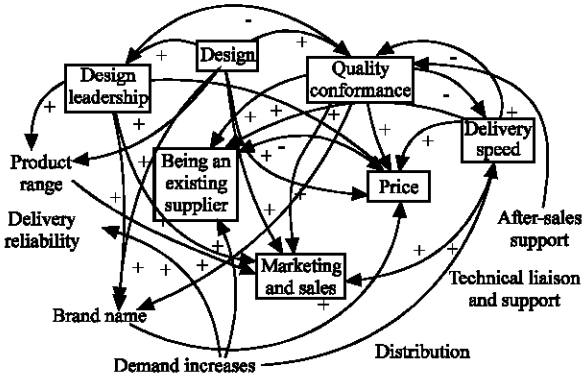

Fig. 2: Causal diagram of the order winners and qualifiers

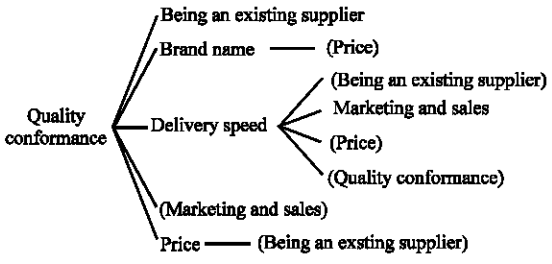

Fig. 3: Uses tree of quality conformance (OW4)

(OW1). - means negative influence; Price (OW1) is in reverse proportion to Being an existing supplier (OW10). The arrow, with the arrow as the result and the other end as the cause, shows what factor one order winner affects. Order winners and qualifiers with a brim means they are of great prominence.

DISCUSSION

According to Table 6, 7 and Fig. 1, the order winners and qualifiers that are attributed to must-be quality but do not earn satisfaction, such as Delivery reliability (OW2), Technical liaison and support (OW13) and After-Sales support (OW14), should be improved immediately. Managers can make policies according to Kano's model since they are of low prominence and relation, i.e. more independent. For those attributed to one dimensional quality but do not earn satisfaction, such as Price (OW1), Quality conformance (OW4) and Design (OW7), the company must put forward a right policy to segregate the market. The last two can affect other order-winners and qualifiers but also be affected easily by other quality characteristics since they are of high prominence and relation; Price (OW1)'s high prominence and low relation make it affected by other quality characteristics. It is very reasonable by all accounts to make countermeasures in accordance with nothing but Kano's model's results. Yet, the decision is correct only when all order-winners and qualifiers are independent factors; otherwise, a decision on the ground of their independence will not help an organization reach its goals, not even with more resources. Thus, this study takes Quality conformance (OW4) and Price (OW1) attributed to one dimensional quality as the case, to demonstrate decision-making on the basis of integrating Kano's model with DEMATEL.

According to Table 6, 7 and Fig. 2, Quality performance (OW4) is the order winners and qualifiers of high prominence and relation. So, what is the result when Quality performance (OW4) is improved? First of all, a uses tree of Quality performance (OW4) should be created (Fig. 3) first. According to Fig. 2 and 3, improved Quality performance (OW4) betters Price (OW1, coefficient of 0.32) and Marketing and sales (OW11, coefficient of 0.19), deteriorates Delivery speed (OW3, coefficient of 0.25), enhances Brand name (OW12, coefficient of 0.18) and increase the opportunities of Being an existing supplier (OW10, coefficient of 0.34). Usually, better quality is tantamount to more quality costs. However, when the company's quality beats that of its competitors', it will raise the price. Yet, Price (OW1) is part of one dimensional quality and its performance is only so-so, so if better quality leads to unimproved Price (OW1) or unaffordable Price (OW1), this goes against the company's goals.

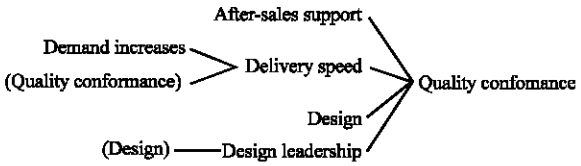

Fig. 4: Causes tree of quality conformance (OW4)

Better Quality performance (OW4) promises better Marketing and sales (OW11), but also causes surplus resources and waste. Because Marketing and sales (OW11) and Being an existing supplier (OW10) are part of indifference quality, it is unnecessary to pour more resource for better performance. As to better Quality performance (OW4) will conduce to worse Delivery speed (OW3) and poor competitiveness as result; since Delivery speed (OW3) is attractive quality, better Quality performance (OW4) guarantees better Brand name (OW12) for sure, but just slightly. In conclusion, improvement of Quality conformance (OW4) cannot benefit the company.

According to the situation above, to improve Quality performance (OW4) the company must know which order winners and qualifiers affect it and this relies on a causes tree (Fig. 4). According to Fig. 2 and 4, Quality performance (OW4) may be affected by Design leadership (OW9, coefficient of 0.23), Design (OW7, coefficient of 0.29), Delivery speed (OW3, coefficient of 0.24) and After-Sales support (OW14, coefficient of 0.13). Design (OW7) is one dimensional quality and After-Sales support (OW14) is must-be quality; Design leadership (OW9) and Delivery speed (OW3) are attractive quality. The next step is to find order-winners and qualifiers that can improve Quality performance (OW4). Thus, improved Design (OW7) contributes to better Quality conformance (OW4, coefficient of 0.29) and Design leadership (OW9, coefficient of 0.20), since Design leadership (OW9) is judged as attractive quality. In this study the marketing strategy is Design leadership (OW9) and the company does not rise above others in design and frequently sends imperfect products to the market. Consequently, Quality performance (OW4) is deteriorating. Therefore, Design (OW7) is the first one to be improved immediately. After that, the efforts can turn to After-Sales support (OW14), partly because it is not up to satisfaction but also because improvement of this must-be quality, according to Fig. 4, can advance Quality conformance (OW4, coefficient of 0.13), one dimensional quality and will not affect another one dimensional quality- Price (OW1). Coefficient of Price (OW1) is too small to be influential.

In the end, this study discusses the negative effects of Design (OW7). According to Fig. 4, improvement of

Design (OW7)-one dimensional quality- will increase another one dimensional quality: Price (OW9, coefficient of 0.28). Meanwhile, better quality can bring down costs, so this policy can lead to little negative effects. Likewise, DEMATEL finds the independence of After-Sales support (OW14) and only Quality conformance (OW4) can affect it, so there is no negative effect as well. Judging the analysis of Quality conformance (OW4) and Price (OW1), Kano's model help the company modify the two one-dimensional-quality order winners and qualifiers, if both are independent factors. When the two order winners and qualifiers interact with others, policies should be made in accordance with their causality. By combining Kano's model and DEMATEL, this study help the company discern that improvement of Design (OW7) and After-Sales support (OW14) is the first priority and it can also solve problems in Quality conformance (OW4) and Design leader (OW9) without many negative effects.

CONCLUSIONS

Traditionally, a questionnaire is the main vehicle used to identify customer satisfaction. All researchers have adopted a scale with quantified levels of performance. The averages for importance and performance for all quality characteristics are used to create an importance-performance matrix, in order to know what quality characteristics should be scaled down, improved, or maintained for the benefit of the company's competitiveness. In this part, traditional IPA model and IPA followers contribute much, but there are some potential problems to be further discussed and studied: (1) the hypothesis about the linear relation among quality characteristics; (2) the hypothesis of the independence of each quality characteristic. Kano's model can identify the nonlinear effects of quality characteristics, successfully classify order-winners and qualifiers and define what benefits improvement of certain factors can bring forth. Yet, Kano's model misses the causation among quality characteristics. For this reason, this study developed a new decision analysis that uses Kano's model to identify the quality attributes and nonlinear effects of order winners and qualifiers and identifies the core problems by analyzing the causation and interaction through DEMATEL and Kano's model.

This study creates a new method by combining Kano's model and DEMATEL, which can solve the potential problems arising in the traditional model and also the complicated, contradictory problems often uncovered in practices. The proposed method helps define what quality characteristics can be improved with the least resources. With an industrial computer manufacturer in Taiwan as the study case, this study proved that the combination of Kano's model and DEMATEL can assess the importance and performance of quality characteristics more reasonably and address the problems with intertwined relations using the least resources. The proposed method can fully tap information from customer responses for effective and correct marketing and manufacturing strategies. Industrial computer manufacturers in Taiwan have very high similarity in their competitive characteristics and operational behaviors, so this particular company's results can be generalized. For the future studies, scholars can consider Fuzzy theory in Kano's model and DEMATEL to solve the vagueness of thoughts and language in making decisions. Decision makers always give assessments according to their past experience and knowledge. In order to integrate various experience and opinions from different decision makers, it is better to convert the linguistic estimation into fuzzy numbers for group decision making in the real world. Moreover, this study just proposed a logic procedure for decision making by a combination of Kano's model and DEMATEL. In the future, scholars can use the IPA model to simplify the decision making procedure.

REFERENCES

Bommer, M., B. O'Neil and S. Treat, 2001. Strategic assessment of the supply chain interface: A beverage industry case study. Int J. Phys. Distribution Logistics Manage., 31: 11-25.

Chung, Y.C., Y.W. Hsu and C.H. Tsai, 2008. An empirical study on the correlation between critical DFSS success factors, DFSS implementation activity levels and business competitive advantages in Taiwan's High-tech manufacturers. Total Qual. Manage. Bus. Excellence, 19: 595-607.

Fam, K.S. and D.S. Waller, 2006. Identifying likeable attributes: A qualitative study of television advertisements in Asia. Qual. Mar. Res. Int. J., 9: 38-50.

Griffin, A. and J.R. Hauser, 1993. The voice of the customer. Mar. Sci., 12: 1-27.

Hajime, Y., I. Kenichi and M. Hajime, 2005. An innovative product development process for resolving fundamental conflicts. J. Jap. Soc. Precision Eng., 71: 216-222.

Hill, T., 2000. Manufacturing Strategy: Text and Cases. 3rd Edn. The McGraw-Hill Companies, Inc., Palgrave, Basingstoke, ISBN-13: 978-0256106664 .

Hörte, S.A. and H. Ylinenpää, 1997. The firm's and its customers' views on order-winning criteria. Int. J. Operat. Prod. Manage., 17: 1006-1019.

Huang, C.Y., J.Z. Shyu and G.H. Tzeng, 2007. Reconfiguring the innovation policy portfolios for Taiwan's SIP Mall industry. Technovation, 27: 744-765.

Kano, N., N. Seraku, F. Takanashi and S. Tsjui, 1984. Attractive quality and must-be quality. J. Jap. Soc. Qual. Control, 14: 39-48.

Karras, G., T.M. Smith and J.S. Reece, 1999. The relationship of strategy, fit, productivity and business performance in a services setting. J. Operat. Manage., 17: 145-161.

Kenichi, F. and N. Yoshihiro, 2002. Study on function and failure analysis of snow melting machines. Trans. Jap. Soc. Mechanical Engineers, 68: 3447-3455.

Kim, Y.H., 2006. Study on impact mechanism for beef cattle farming and importance of evaluating agricultural information in Korea Using DEMATEL, PCA and AHP. Agric. Inform. Res., 15: 267-280.

Krieg, R., 2004. Impact of structured product definition on market success. Int. J. Reliability Qual. Manage., 21: 991-1002.

Lin, C.J. and W.W. Wu, 2008. A causal analytical method for group decision-making under fuzzy environment. Expert Syst. Appl., 34: 205-213.

Liu, C.H. and H.H. Wu, 2008. A fuzzy group decision-making approach in quality function deployment. Qual. and Quan., 42: 527-540.

Matzler, K., H.H. Hinterhuber, F. Bailon and E. Sauerwein, 1996. How to delight your customers. J. Prod. Brand Manage., 5: 6-18.

Matzler, K. and H.H. Hinterhuber, 1998. How to make product development projects more successful by integrating Kano's Model into quality function deployment. Technovation, 18: 25-38.

Matzler, K. and E. Sauerwein, 2002. The Factor Structure of customer satisfaction: An empirical test of importance grid and the penalty-reward-contrast analysis. Int J. Service Ind. Manage., 13: 314-332.

Matzler, K., E. Sauerwein and K.A. Heischmidt, 2003. Importance-performance analysis revisited: The role of factor structure of customer satisfaction. Service Ind. J. 23: 112-129.

Matzler, K., F. Bailom, H.H. Hinterhuber, B. Renzl and J. Pichler, 2004. The asymmetric relationship between attribute-level performance and overall customer satisfaction: A reconsideration of the importance-performance analysis. Ind. Marketing Manage., 33: 271-277.

Nanayo, F. and T. Toshiaki, 2002. A new method of paired comparison by improved DEMATEL method: Application to the integrated evaluation of a medical information which has multiple factors. Jap. J. Med. Inform., 22: 211-216.

Oh, H., 2001. Revisiting importance-performance analysis. Tourism Manage., 22: 617-627.

Oke, A., 2005. A framework for analyzing manufacturing flexibility. Int. J. Operat. Prod. Manage., 25: 973-996.

Sampson, S.E. and M.J. Showalter, 1999. The performance-importance response function: Observations and implications. The Service Ind. J., 19: 1-25.

Santhapparaj, A.S., J. Sreenivasan and J.C.K. Loong, 2006. Competitive factors of semiconductor industry in Malaysia: The managers' perspectives. Competitiveness Rev.: An Int. Business J. Incorporating J. Global Competitiveness, 16: 197-211.

Seyed-Hosseini, S.M., N. Safaei and M.J. Asgharpour, 2006. Reprioritization of failures in a system failure mode and effects analysis by decision making trial and evaluation laboratory technique. Reliab. Eng. Syst. Safety, 91: 872-881.

Silveira, G.J.C., 2005. Market priorities, manufacturing configuration and business performance: An empirical analysis of order-winners framework. J. Operat. Manage., 23: 662-675.

Slack, N., 1994. The importance-performance matrix as a determinant of improvement priority. J. Operat. Prod. Manage., 14: 59-75.

Stalk, Jr. G., 1988. Time the next source of competitive advantage. Harvard Business Rev., 66: 41-51.

Tamura, H., H. Okanishi and K. Akazawa, 2006. Decision support for extracting and dissolving consumers' uneasiness over foods using stochastic Dematel. J. Telecommun. Inform. Technol., 4: 91-95.

Tzeng, G.H., C.H. Chiang and C.W. Li, 2007. Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. Exp. Syst. Appl., 32: 1028-1044.

Vickery, S.K., 1991. A theory of production competence revisited. Decision Sci., 22: 635-643.

Voss, C.A., 1995. Alternative paradigms for manufacturing strategy. Int. J. Operat. Prod. Manage., 15: 5-16.

Wu, W.W. and Y.T. Lee, 2007. Developing global managers' competencies using the fuzzy DEMATEL method. Exp. Syst. Appl., 32: 499-507.

Yang, C.C., 2003. Establishment and applications of the integrated model of service quality measurement. Managing Service Qual., 13: 310-324.

Yang, C.C., 2005. The refined Kano's model and its application. Total Qual. Manage., 16: 1127-1137.