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ORGANIZATIONAL INNOVATIONS IN THE REAL-ESTATE INDUSTRY USING AHP

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Abstract

The purpose of this research is to determine the important factors that influence the organizational innovations in real-estate industry. The research methods employed include a literature review, in-depth interviews, and focus group techniques which were used to identify seven facets of organizational innovation measurement, that is, leadership innovation, organizational structure and innovation management, employee's innovation, product development innovation, construction innovation, marketing innovation, and customer service innovation. The study was carried out in three important metro cities of India—Bangalore, Delhi, and Mumbai. Then, the empirical study adopted the techniques of the Analytic Hierarchy Process (AHP) to solicit opinions from 152 experts, collected through an interviewed questionnaire.

The results show that leadership innovation is the most important item in the hierarchy. In the second hierarchy, employee's innovation is the most important item. According to these results, the major recommendation from this study is that real-estate leaders, especially the top management, need to delineate the organization innovation vision, and share these thoughts with the staff. Also, employees' innovation should be encouraged and rewarded by the management.

Keywords: Organizational Innovation, AHP, Real-estate, India

Introduction

Innovation is defined as the successful implementation of creative ideas within an organization (Amabile, 1983, 1998; Amabile et al., 1996). The relationship of organizations with their environment provides the organizations with ideas that may result in innovation and economic performance (Jenssen, 1999). Hence, an increasing premium is placed on creativity and innovation in a competitive market (Mumford and Gustafson, 1988).

The real estate industry in particular residential construction has high degree of uncertainty in innovative adoption .It is apparent that organizations, in this kind of a market environment, need to be more creative and innovative to sustain, compete, grow, and lead (Koebel, 2004). Innovation through creativity is essential for the success and competitive advantage of organizations as well as for strong economies in the 21st century. Organizational innovation in real-estate industries is becoming more and more a necessity. Real-estate organizations in today's world are faced with a dynamic environment characterized by rapid technological change, mainly globalization. It is apparent that organizations, in this kind of a market environment, need to be more creative and innovative to sustain, compete, grow, and lead. This is why a growing number of practitioners and scholars in real-estate market have been attracted to this topic in recent decades.

The two purposes of this study are to probe the factors that influence organizational innovations in real-estate industry and to identify the relative weights associated with these factors.

Literature Review

Real-Estate Industry

Real-estate performance issues—continued strong growth in the Indian economy,

deregulation of the Indian capital markets since 2004, and less restrictive guidelines for foreign direct investment in real estate in India since February 2005—have seen significant improvements in the real-estate environment in India, for both local and international players. This has taken on increased importance as India significantly expands its economic growth to potentially be the world's third largest economy by 2020, and international real-estate investors seek global investment opportunities, particularly, in the emerging Asian real-estate markets.

With New Delhi as the political center, Mumbai as the financial center, and Bangalore as the IT center in India, are cities the main contributors to the real-estate market in India? Currently, Mumbai and Bangalore are seen as the top two Asian cities in terms of investor sentiment being largely driven by strong economic performance and offshoring demand for office space (Naidu et al., 2005). Newell and Kamineni (2005) state that the development of the Indian real-estate markets is also reflected in many of the leading real-estate advisory firms—Jones Lang LaSalle, Cushman and Wakefield, now being actively involved in India.

Prior to February 2005, foreign direct real-estate investment was not allowed in India for office and retail real estate, with permission from the Reserve Bank of India for foreign companies to acquire the real estate necessary for their business activities in India. One hundred percent of foreign direct investment was only allowed for IT/business parks or hotels, and large residential developments. In February 2005, India allowed 100 percent foreign direct investment in the construction and development sector to facilitate investment in the infrastructure sector covering housing, commercial real estate, hotels, resorts, recreational facilities, and infrastructure.

In 2004, the Securities and Exchange Board of India (SEBI) allowed capital funds to invest in India. This move made the international real-estate fund companies to start investing

based on project potential in India. Presently, apart from local real-estate funds companies such as ICICI, HDFC, and Kotak Reality, international players such as Tishman Speyer, Starwood capital, Apollo Sun, GE Commercial Financial Real Estate and Macquarie joins hand with developers to do projects successfully. (Sarathy, 2011)

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), developed at the Wharton Scholl of Business by Thomas Saaty (1980, 1994), allows decision makers to model a complex problem in a hierarchical structure showing the relationships of the goal, objectives (criteria), sub-objectives, and alternatives. Thus, a typical hierarchy consists of at least three levels, the goal(s), the objectives, and the alternatives.

Zahedi (1986) provided an extensive list of references on the AHP methodology and its applications. Further research extended by Marsh, Moran, Nakui, & Hoffherr (1991) developed a more specific method directly for decision-making. The Marsh's AHP had three steps ordering the factors (i.e. attributes) of a decision such that the most important ones receive greatest weight.

AHP enables decision-makers to derive ratio scale priorities or weights as opposed to arbitrarily assigning them. In so doing, AHP not only supports decision makers by enabling them to structure complexity and exercise judgment, but allows them to incorporate both objective and subjective considerations in the decision process. AHP has advantages in group making are (Dyer, Forman 1992):

• All values, individual and/or group, tangible and/or intangible are contented in group decision process with AHP.

• The discussion focuses on goal instead of options into the group.

• The discussion media in which is considered all factors is established with AHP.

• The discussion continues until consensus, due to provide opinions from each member.

The AHP is a method for breaking down a complex and unstructured situation into its component parts, then arranging those parts (or variables) into a hierarchical order. This method is based on the assignment of numerical values for subjective judgments on the relative importance of each variable, then synthesizing the judgments to determine which variables have the highest priority (Saaty, 1994).

The AHP is ideally suited to help resolve certain problems that arise when multiple criteria are used in performance evaluation. For example, the pair wise comparisons for measure (s) priority can be done using a ratio scale. This facilitates the incorporation of non-quantitative measures into the evaluation scheme, since it forces participants to translate all criteria into relative priority structures based on the scale. Thus, using the AHP means that non-quantitative assessments can be combined with quantitative assessments in rating a unit or an individual.

The AHP has been widely and successfully applied in a variety of decision-making environments (Zahedi, 1986; Golden, Wail, and Harker, 1989; Zopounidis and Doumpos, 1997, 1998, 1999a, 1999b, 2000a, and 2000b).

This study is based on group decision making. In addition to final preference weights, the AHP permits calculation of a value called the consistency index. This index measures transitivity of preference for the person doing the pair wise comparisons (Sinuany and Stern, Z. 1988).

To illustrate the meaning of transitivity of preference, if a person prefers choice A over B, and B over C, then do they in consistent fashion prefer A over C? This index provides a useful check, because the AHP method does not inherently prevent the expression of intransitivity of preferences when ratings are being performed. The AHP consistency index compares a person's

informed preferences ratings to those generated by a random preference expression process. An arbitrary but generally accepted as tolerable level of inconsistent preference scoring with the AHP is less than or equal to 0.1 (Sinuany and Stern, Z., 1988). A consistency ratio CR is computed for each comparison matrix. In an interactive application of AHP a matrix classified as being inconsistent (CR > 0.1) was given back to the decision making for modification until it fulfills the consistency condition. All of them were less of 0.1 (Mirkazemi et al. 2009). For determining weight of every alternative, arithmetic means was used based on formula 1:

$$r_{ij} = a_{ij} / \sum_{i=1}^{m} a_{ij} \qquad J = 1,2,3, \ldots \ldots, m \qquad \text{Formula 1}$$

Vectors of the arithmetic means of the coefficients of importance were rescaled in the manner that their sum equaled one. Then the symphonic means were calculated based on formula 2:

$$W_i = \sum_{i=1}^{m} r_{ij} / n \qquad J = 1,2,3, \ldots \ldots, m \qquad \text{Formula 2}$$

For the real-estate industries, identifying the factors that influence the organizational innovation is just as important as other decisions. The AHP can also be utilized to rank the importance of various alternatives. In this study, the application of the AHP technique helps identifying what are the factors that influence the organization innovations and their relative importance.

Organizational Innovation

Organizational innovation could enhance certain products, process or services and further enhance organizational effectiveness. Innovation includes product innovation, production process technology innovation, structure innovation and management system innovation (Robin,

2001). The effect on the plans is that it changes the organizational system, output and input relationship, technique or transfer process, organizational structure or design, collaboration, organizational personnel and roles, organizational culture and the situations experienced at different levels (Hodge, 1996). Thus, organizational innovation involves the reform of techniques, goals, personnel and culture.

Most past studies on organizational theory have been concerned with improvements in performance, and with how these targets can be achieved with the focus of interest being on improving technological ability (Chung, 2002 and Damanpour, 1997). However, there has been less of an emphasis on the concept of organizational innovation and on how related factors can be coordinated to improve the performance of an organization. The dimensions of organizational innovation are in fact extremely complex (Chung, 2002 and Chuang, 2005).

With relatively fewer studies having been conducted on organizational innovation based on the viewpoint of the organization as a whole, it is important to make in-depth explorations in terms of the context of organizational innovation. The objective level of organizational innovation was made as seven facets with in-depth literature review.

Seven Facets of Organizational Innovations

Leadership

Leadership can be help to exhibit higher levels of creativity at work (Shin and Zhou, 2003), establish a work environment supportive of creativity (Amabile et al., 1996, 2004), create an organizational climate serving as a guiding principle for more creative work processes (Scott and Bruce, 1994), and develop and maintain a system that rewards creative performance through compensation and other human resource-related policies (Jung et al., 2003).

Furthermore, leaders can have an impact not only on innovation within the firm but also on marketing the innovative products. For example, their active participation in selling the innovative products might decrease resistance from the potential customers (Ettlie, 1983). Thus, leadership is important for organization innovations.

Organizational Structure and Innovative Management

Through organizational structure and process tasks, competencies and responsibilities are divided, configured and assigned to organizational units and members. Organizational attributes such as specialization and function differentiation are seen to be conducive to innovation, whereas formalization and centralization inhibit innovative solutions (Damanpour, 1991). The environmental variables relevant for innovation management may strongly differ between firms (Tidd,2001). Organizational structure and innovative management are essential for organizational innovation.

Employees' Innovation

The shared system of values and beliefs is manifest in the behavior and actions of organizational members (Martins and Terblanche, 2003). It becomes advantageous for innovation by encouraging and supporting employees to question predominant ways of working, tolerating unsuccessful ideas without punishing innovative employees, and accepting and handling conflicts constructively (Blayse and Manley, 2004). Thus, employees' innovation plays a vital part in an organization's growth.

Product Development Innovation

Product development involves a complex coupling between market needs and technologies (Dougherty and Bowmen, 1995) and is a potential source of competitive advantage for a firm. A breakthrough focus aims to result in innovative products that are superior to those

of the competitors. Success enables a subsidiary to reap economic rent, and thus better profitability and sales results from its new products (Calantone et al., 2006). Furthermore, focusing on developing highly innovative products may foster a spirit of innovation (Szymanski et al., 2007), which encourages learning (Hurley and Hult, 1998). Thus, product development is innovation for any organizational growth.

Construction Innovation

The construction process normally starts when the client makes the decision to build. The dependency of constructional tasks on clients leads to the fact that to a certain extent each constructional task has to be responsive to the specific requirements of a single client. These changing demands may lead to problems that call for an innovative solution or may offer opportunities to propose a solution that meets the demands best (Hartmann, 2006).

It considers that innovations are not ends in themselves and, as supported by empirical studies, the managerial aim to enhance the competitiveness of a firm is a strong impetus for construction innovation (Mitropoulos and Tatum, 2000; Seaden et al., 2003). It connects the innovative idea with the strategic requirements of a firm and is influenced by variables of the internal environment. Construction innovation is the latest thread and approach for organization innovation.

Marketing Innovation

The management of innovation comprises all activities which aim at efficient implementation of novel ideas into effective marketing solutions (Drejer, 2002) and the capitalization and reinforcement of the capability and willingness of an organization to innovate (Trommsdorff, 1990). Thus, marketing strategy and solutions are part of organizational innovations.

Customer Service Innovation

Innovative solutions have to be analyzed with regard to the added value they offer to the customers and their satisfaction by the customers. The interviewed persons point out that it is difficult to introduce an innovation without a clearly visible added value for the customers. Otherwise the customers will not be willing to take on additional costs and risks associated with the innovation (Hartmann, 2006). The recent development of organizational innovation is customer service innovation.

Methodology

The facets of organization innovation are well established through literature review. Further, this study conducted expert groups twice to validate the attributes of seven objective facets of organizational innovation in real-estate industry. The AHP framework contains three levels—the goal level, the objective level, and the attribute level. The goal level refers to organizational innovation in real-estate industries. The objective level consists of seven facets, including leadership innovation, organizational structure and innovation management, employee's innovation, product development innovation, construction innovation, marketing innovation, and customer service innovation. Finally, the attribute level includes vision, company affairs and development, decision process, organizational structure, innovative management techniques, innovative encouragement techniques, creativity intention, creativity thinking, new product development, material technology, construction process, machinery and equipments, marketing strategic planning, market information systems, interactive marketing, service quality, and customer satisfaction. Based on these attributes, a questionnaire called an AHP-designed questionnaire was developed.

Sample

The AHP questionnaires were sent as 221 surveys to members of the Confederation of Real Estate Developers' Associations of India (CREDAI), in the city of Bangalore, Delhi and Mumbai. CREDAI is the largest apex body for private real-estate developers in India, and represents over 4,000 developers through its19-member associations across the country, which was selected to serve as the universe for this study. Membership in CREDIA means that these companies have all been accredited in the real-estate industry regardless of size. The survey was sent to the top management person who was handling these companies via mail as well as in person asking people to participate in the survey.

The primary respondents were owners, chief executive officers (CEOs), directors, vice-presidents and regional managers. The 22 samples was collected via interview carried out in completing the questionnaire for respondents on the director's level with prior appointment and 90 samples were collected through the initial mailing. The given deadline for data collection for the responses was of three months. The sampling procedure resulted in an overall response rate of 51 percent for both email as well as in personal and is considered to be a strong indicator. Extreme care was taken to ensure data quality.

Findings and Discussion

The leadership in objective level is highest followed by employee's innovation, construction innovation, product development innovation, marketing innovation, customer service innovation, and organizational structure and innovation management. (See Table 1. and Figure 1.)

In an organization, the top management's involvement and commitment towards organizational innovation is crucial. The decision process is regarded as the main contributor for organization innovation, as shown in Table 2.

Goal Level: Organizational Innovations

Objective Level

Attribute Level

1. Leadership innovation (0.23214)

1.1 Vision (0.08036)
1.2 Company affairs & development (0.03571)
1.3 Decision process (0.11607)

2. Organizational structure and innovation management (0.06250)

2.1 Organizational structure innovation (0.03571)
2.2 Innovation management techniques (0.00893)
2.3 Innovation encouragement method (0.01786)

3. Employees' innovation (0.18750)

3.1 Creativity intention (0.1250)
3.2 Creative thinking (0.06250)

4. Product development innovation (0.15179)

4.1 New product development (0.09822)
4.2 Material technology (0.05357)

5. Construction innovation (0.16071)

5.1 Construction process (0.12500)
5.2 Machinery and equipment (0.03571)

6. Marketing innovation (0.13393)

6.1 Market orientation and strategic planning (0.05357)
6.2 Market information systems (0.05357)
6.3 Interactive marketing (0.02679)

7. Customer service innovation (0.07143)

7.1 Service quality (0.02679)
7.2 Customer satisfaction (0.04464)

Figure 1. The Weight Ratios of Different Levels of Organizational Innovation
Source: Author.

Table 1. The Weight Ratios of Objective Level

Facets	**Weight**	**Order**
Leadership innovation	0.23214	1
Organizational structure and innovation management	0.06250	7
Employees' innovation	0.18750	2
Product development innovation	0.15179	4
Construction innovation	0.16071	3
Marketing innovation	0.13393	5
Customer service innovation	0.07143	6

Source: Author.

Table 2. Ranked Results of Pair-wise Comparisons for the
Importance of Leadership Innovation

Leadership Innovation	Priority	Priority Weighted	Rank
Vision	0.35	0.08036	2
Company affairs and development	0.15	0.03571	3
Decision process	0.50	0.11607	1

Source: Author.

The culture followed by innovation management and encouragement methods is ranked for organizational structure and innovation management as shown in Table 3.

It is a very important and prosperous sign for the real-estate industry that creative thinking and intention plays an important role in organization innovation as shown in Table 4.

Table 3. Ranked Results of Pair-wise Comparisons for the Importance of
Organizational Structure and Innovation Management

Organizational structure and innovation management	Priority	Priority Weighted	Rank
Organization culture innovation	0.57	0.03571	1
Innovation management techniques	0.14	0.00893	3
Innovation encouragement method	0.29	0.01786	2

Source: Author.

Table 4. Ranked Results of Pair-wise Comparisons for the Importance
of Employees' Innovation

Employees' innovation	Priority	Priority Weighted	Rank
Creativity intention	0.67	0.1250	1
Creative thinking	0.33	0.06250	2

Source: Author.

The management should take necessary steps towards improving innovation in objective

level of product innovation as shown in Table 5.

Table 5. Ranked Results of Pair-wise Comparisons for the Importance of
Product Development Innovation

Product development innovation	Priority	Priority Weighted	Rank
New product development	0.65	0.09822	1
Material technology	0.35	0.05357	2

Source: Author.

The ranking of the attributes of organization innovation are shown in Table 6.

Table 6. Ranked Results of Pair-wise Comparisons for the Importance
of Construction Innovation

Construction innovation	Priority	Priority Weighted	Rank
Construction process	0.78	0.12500	1
Machinery and equipment	0.22	0.03571	2

Source: Author.

The marketing in real estate companies plays very vital role. The ranking of its attribute of Marketing Innovation is as shown in Table 7.

Table 7. Ranked Results of Pair-wise Comparisons for the Importance
of Marketing Innovation

Marketing innovation	Priority	Priority Weighted	Rank
Market orientation and strategic planning	0.40	0.05357	1
Market information systems	0.40	0.05357	1
Interactive marketing	0.20	0.02679	2

Source: Author.

The customer service innovation is becoming concern for the real industry. This need to be really need to innovate .The Customer Service Innovation ranking of its attribute is shown in Table.8

Conclusion

According the result provided through AHP, leadership at objective level and decision process at attribute level is the highest. It is very important to note that employees' innovation followed leadership, which is the second highest factor in organization innovation. It is really a good sign for real-estate industries in India. The service quality is the attribute level is least, whereas the management should clearly look into future.

Table 8. Ranked Results of Pair-wise Comparisons for the Importance
of Customer Service Innovation

Customer service innovation	Priority	Priority Weighted	Rank
Service quality	0.38	0.02679	2
Customer satisfaction	0.62	0.04464	1

Source: Author.

Recommendations and Future Finding

The findings demonstrate that the key factors of organizational innovation of real estate are leadership innovation and employees' innovation. It is, therefore, suggested that the top management should encourage employees at all levels for an innovation process. Future studies could compare the factors of organizational innovation in real estate companies to other industries as well as to the developing countries.

Acknowledgements

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Appendix

QUESTIONAIRE

For all the following questions, please indicate your level of agreement. To mark your response just click on the appropriate box and indicate your statement, whenever necessary. For each question, mark only one choice and leave no question blank.

SECTION: 1
Name:
Age
☐ Less than 30 years

☐ 31 - 40 years

☐ 41 - 50 years

☐ 51 - 60 years

☐ Above 60 years

Gender

☐ Male   ☐ Female

Education

☐ No Reponse

☐ School

☐ Degree

☐ Master Degree

☐ Doctorate

Position

☐ Owner/Chairman   ☐ CEO/Similar position

Real estate experience

☐ 5 to 10 years   ☐ 10 years and above

City of workplace

☐ Bangalore   ☐ Delhi   ☐ Mumbai

SECTION: 2

Organizational innovation in real-estate industries is becoming more and more a necessity. Real-estate organizations in today's world are faced with a dynamic environment characterized by rapid technological change, mainly globalization?

Your Comments:

SECTION: 3

1. Innovativeness is important for individual growth and it plays a vital role in organizational growth. Do you emphasize the same when you advise someone in your organization?

   ☐ Yes   ☐ No

2. The focus on leadership Innovation helps to understand the company strategic positions in the real estate industries. Considering the Leadership Innovation in your organization, kindly choose any one option, which is most practiced?

   ☐ Vision

   ☐ Company affairs and development

   ☐ Decision Making

3. What is your Organization Structure?

   _____

4. What is Innovation management techniques used in your organization?

   _____

5. Kindly mention one of the Innovation encouragement method practiced in your organization?

   _____

6. Kindly choose any one of the following, which you feel that your organization is practicing the most?

   ☐ Organizational structure

   ☐ Innovation management

   ☐ Innovation encouragement

7. The shared system of values and beliefs is manifest in the behavior and actions of organizational members. It becomes advantageous for innovation by encouraging and supporting employees to question predominant ways of working, tolerating unsuccessful ideas without punishing innovative employees, and accepting and handling conflicts constructively?

State your views:_____

_____

8. Kindly give your preference that your organization is practicing most, in daily routine?

☐ Creative Intention   ☐ Creative Thinking

9. Name the new product development happened in your organization, during last one year?

_____

10. Do you found any innovative technology observed in materials department in your organization, recently?

☐ Yes   ☐ No

If yes, kindly mention _____

11. Select anyone of the following that organization has adopted the most?

☐ New Development   ☐ Material Technology

12. Select any one preference given below; where you felt that most innovation is happening in your organization.

☐ Construction Process   ☐ Machinery and equipment

13. The Marketing Innovation comprises all activities which aim at efficient implementation of novel ideas into effective marketing solutions. Kindly select anyone of marketing innovation practiced in your organization?

☐ Market orientation and strategic planning

☐ Management Information System

☐ Interactive marketing

14. The customer service is vital to any organization. Considering for your organization or in your work place, kindly do select anyone, which is important for your organization?

☐ Customer Satisfaction   ☐ Service quality

Thank you…

A REVISED MODEL OF FUZZY EXTENDED AHP

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Abstract

Fuzzy Extended Analytic Hierarchy Process (FEAHP) was first developed by Chang (1996). FEAHP is an efficient tool to deal with fuzziness of the decision variables in the process of deciding the preferences.

However, Zhu, Jing and Chang (1999) pointed out that FEAHP was imperfect when two triangular fuzzy sets did not intersect. They proposed that when two triangular fuzzy numbers did not intersect, $\mu(d)$ should equal zero, and that the criteria/alternatives (of the model) would be eliminated, rendering the model irrelevant. Wang, Luo and Hua (2008) mentioned that because of the elimination of the criteria/alternatives, FEAHP may lead to a wrong decision, while useful decision information might not been considered.

In this paper, a revised model of FEAHP which can be operated without eliminating any criteria/alternatives is proposed. Therefore, this revised model of FEAHP becomes more effective in estimating the importance of decision criteria/alternatives. Two examples are given to demonstrate the calculation processes, and the results, of the revised FEAHP model.

Keywords: fuzzy extended analytic hierarchy process; pairwise comparison; membership function.

Introduction

Fuzzy Extended Analytic Hierarchy Process (FEAHP) was pioneered by Chang (1996). FEAHP utilizes the triangular fuzzy numbers and the extent analysis method to produce the synthetic extent values for pairwise comparisons. FEAHP can effectively handle both qualitative and quantitative data for all multiple attribute decision making problems (Chang, 1996). Recently, there have been many applications of FEAHP. The importance of weights for customer requirements for Quality Function Deployment (QFD) was proposed by Kwong and Bai (2003). Bozbura, *et al.,* (1996) present a new method of finding the fuzzy weights in fuzzy hierarchical analysis. Wang, *et al.*, (2006) proposed that the extent analysis was found to be the most widely used approach due to its computational simplicity.

Zhu, Jing, and Chang (1999) pointed out that FEAHP was imperfect when two triangular fuzzy numbers did not intersect. It would lead to an unreasonable answer where "zero is used as divisor" or "data is out of range". They also suggested that the $\mu(d)$ should be zero if two triangular fuzzy sets did not intersect. In this case, when $\mu(d)$ equals to zero, the corresponding weight of the criteria/alternatives will become zero. This brings about the criteria/alternatives we have chosen for the model that are irrelevant. The consequence is an illogical outcome because all the criteria/alternatives in FEAHP model were not carefully reviewed. Wang and Chin (2008) proposed the eigenvector method (EM) to generate interval or fuzzy weights estimate from an interval or fuzzy comparison matrix. Wang and Elhag (2006) investigated the normalization problem of interval and fuzzy weights.

Because of assigning irrelevant zero weights to some useful decision criteria and sub-criteria, Wang, *et al.,* (2008) pointed out that the weights of FEAHP did not represent the relative importance of criteria/alternatives. FEAHP would be misapplied to fuzzy AHP problems and

might lead to wrong decisions. In this paper, we propose the revised model of FEAHP which could operate effectively and avoiding eliminating any useful criteria/alternatives. The weights determined by the revised model of FEAHP represent the relative importance of decision criteria/alternatives. We briefly review FEAHP in Section 2. The revised model of FEAHP process is shown in Section 3. Two examples are given in Section 4. This paper is concluded in Section 5.

Fuzzy Extended AHP (FEAHP)

Constructing FEAHP Comparison Matrix

The fuzzy comparison matrix is denoted as (1996):

$$N = (n_{jo}{}^{i})_{m*m} \quad i=1,\ldots,m, \quad j=1,\ldots,m, \quad o=1,2,3$$

$$n_{jo}{}^{i} = (n_{j1}{}^{i}, n_{j2}{}^{i}, n_{j3}{}^{i})$$

When criteria/alternatives $C_i:C_j=(n_{j1}{}^{i}:n_{j2}{}^{i}:n_{j3}{}^{i})$, then

$$C_j:C_i=((n_{j3}{}^{i})^{-1}: (n_{j2}{}^{i})^{-1}: (n_{j1}{}^{i})^{-1})$$

Calculating the Synthetic Values

The value of fuzzy synthetic extent with respect to the ith object in the kth layer, as defined by Chang (1996):

$$F_i = \sum_{j=1}^{m} n_{jo}{}^{i} \otimes \left[\sum_{j=1}^{m} \sum_{i=1}^{m} n_{jo}{}^{i} \right]^{-1}$$

Where $\displaystyle \sum_{j=1}^{m} n_{jo}{}^{i} = \left(\sum_{j=1}^{m} n_{j1}{}^{i}, \; \sum_{j=1}^{m} n_{j2}{}^{i}, \; \sum_{j=1}^{m} n_{j3}{}^{i} \right)$

$$\sum_{j=1}^{m} \sum_{i=1}^{m} n_{jo}{}^{i} = \left(\sum_{j=1}^{m} \sum_{i=1}^{m} n_{j1}{}^{i}, \; \sum_{j=1}^{m} \sum_{i=1}^{m} n_{j2}{}^{i}, \; \sum_{j=1}^{m} \sum_{i=1}^{m} n_{j3}{}^{i} \right)$$

$$\left[\sum_{j=1}^{m}\sum_{i=1}^{m} n_{jo}{}^{i}\right]^{-1} = \left(\frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{m} n_{j3}{}^{i}} \quad , \quad \frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{m} n_{j2}{}^{i}} \quad , \quad \frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{m} n_{j1}{}^{i}} \right)$$

Pairwise Comparison

The values of $V(F_i \geq F_j)$ are as follows (1999):

If $f_{i1} \geq f_{j1}, f_{i2} \geq f_{j2}$, and $f_{i3} \geq f_{j3}$ then $(V(F_i \geq F_j))=1$ (1)

If not (1), then $(V(F_i \geq F_j))= \mathrm{hgt}(F_i \cap F_j) = \mu(d)$

Where $\mu(d) = \dfrac{(f_{i3} - f_{j1})}{((f_{i3} - f_{i2}) + (f_{j2} - f_{j1}))}$ (2)

When (1) is satisfied:

$V(F_i \geq F_j)=1$ (3)

When (2) is satisfied and with intersection:

$0 \leq V(F_i \geq F_j) \leq 1$ (4)

When (2) is satisfied and without intersection:

$V(F_i \geq F_j)=0$, and   (5)

$V(Fi \geq F_1, F_2, \ldots, F_j) = \min V(Fi \geq F_j) = w_i$ (6)

The weight vector of the kth layer is obtained as follows:

$W' = (w_1', w_2', \ldots, w_m')^{T}$

After normalization, the normalized weight vector, W, is:

$W = (w_1, w_2, \ldots, w_m)^{T}$ (7)

The Revised Model of FEAHP

In the designing of FEAHP or an AHP model, all the criteria/alternatives should be carefully selected. Therefore, the criteria/alternatives should not be removed. For example, if

we take away one criteria/alternatives from the first layer, the following criteria/alternatives in the lower layers have to be terminated. The criteria/alternatives of the revised model of FEAHP differ from the original structure because of the elimination of the criteria/alternatives.

Wang, *et al.,* (2008) concluded that because of the elimination, some useful decision criteria/alternatives and some comparison matrix information are wasted. Consequently, the weights of FEAHP could not represent the relative importance of criteria/alternatives and could not be used to establish weighted priorities. Wang, *et al.,* (2008) also specify that FEAHP could assign the worst decision alternatives to be the best one in solving a fuzzy AHP problem.

Because of the problems mentioned above, we propose the revised model of FEAHP.

Theorem 1. In fuzzy triangular pairwise comparison,

if $P \in U$, and $\max(n_{j1}{}^i) \leq P \leq \min(n_{j3}{}^i)$, then $V(F_i \geq F_j) > 0$

Proof. Let $P \in U$ and $\max(n_{j1}{}^i) \leq P \leq \min(n_{j3}{}^i)$,

$$F_i = \sum_{j=1}^m n_{jo}{}^i \otimes \left[\sum_{j=1}^m \sum_{i=1}^m n_{jo}{}^i \right]^{-1}$$

$$V(F_i \geq F_j) = \begin{cases} 1 & \text{if (1)} \\ \dfrac{(f_{i3} - f_{j1})}{((f_{i3} - f_{i2}) + (f_{j2} - f_{j1}))} & \text{if (2)} \end{cases}$$

For $\dfrac{(f_{i3} - f_{j1})}{((f_{i3} - f_{i2}) + (f_{j2} - f_{j1}))}$

F_i and F_j are fuzzy triangular numbers.

$f_{i3} \geq f_{i2} \geq f_{i1}$ and $f_{j3} \geq f_{j2} \geq f_{j1}$

$$\forall \ f_{j2} > f_{j1} \quad \text{or} \quad f_{i3} > f_{i2} \tag{8}$$

$$f_{i3} = \frac{\sum\limits_{j=1}^{m} n_{j3}{}^{i}}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i}} \geq \frac{m \otimes P}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i}}$$

$$f_{j1} = \frac{\sum\limits_{j=1}^{m} n_{j1}{}^{i}}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}} \leq \frac{m \otimes P}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}}$$

Since $\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i} < \sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}$, and

$$\left(\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i}\right)^{-1} > \left(\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}\right)^{-1} , \text{ then}$$

$$f_{i3} = \frac{\sum\limits_{j=1}^{m} n_{j3}{}^{i}}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i}} \geq \frac{m \otimes P}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j1}{}^{i}} > \frac{m \otimes P}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}} \geq \frac{\sum\limits_{j=1}^{m} n_{j1}{}^{i}}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{m} n_{j3}{}^{i}} = f_{j1},$$

$$f_{i3} - f_{j1} > 0 \tag{9}$$

From (8) and (9), $\dfrac{(f_{i3} - f_{j1})}{((f_{i3} - f_{i2}) + (f_{j2} - f_{j1}))} > 0$

This completes the proof.

Examples

Example 1

Considering the Turkish textile company example given by Wang, *et al*., (2008). The hierarchy of the firm selection is shown in Fig. 1.
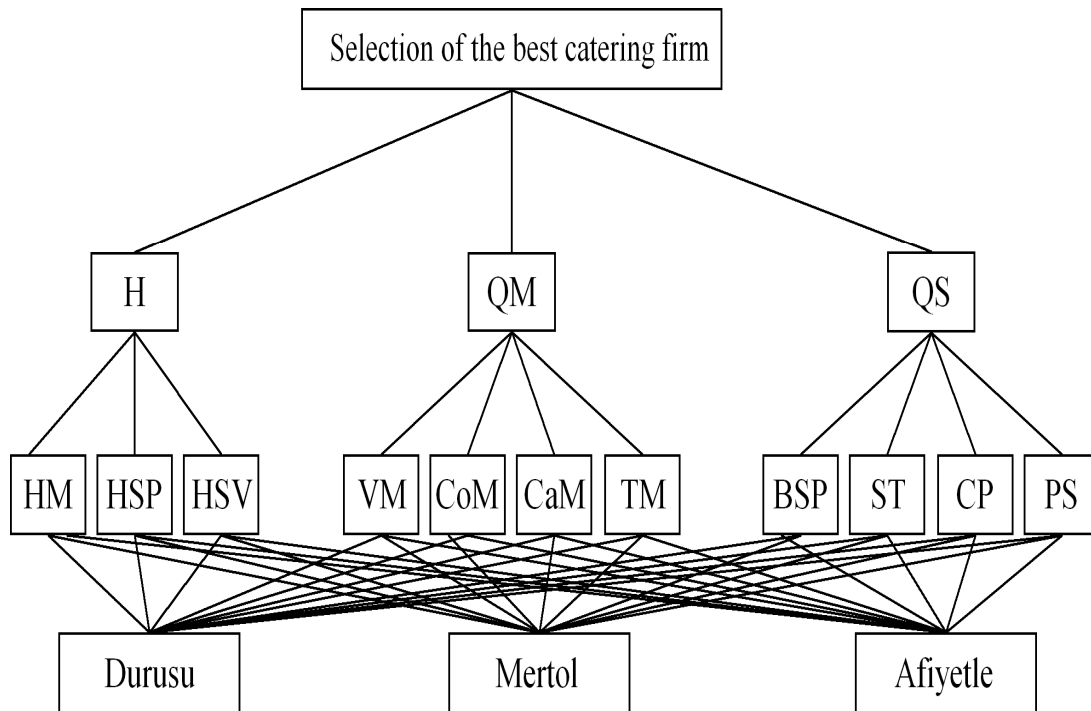
Fig. 1 Hierarchy of catering firm selection problem

The revised model of FEAHP solution process is as follows. The fuzzy comparison matrices could be translated into fuzzy linguistic comparison matrices. The linguistic variables with respect to importance of comparison are "Absolutely more important", "Very strongly more important", "Strongly more important", "Strongly important", "Weakly more important", "Weakly important", "Equally important" and "Just equal". For example, the fuzzy comparison matrix of the three decision criteria in Table 1 given by Wang, *et al.*, (2008) can be translated into the fuzzy linguistic comparison matrix shown in Table 2.

Table 1. Fuzzy comparison matrix of three decision criteria
given by Wang, *et al.,* (2008)

Criteria	H	QM	QS
H	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
QM	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)
QS	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(1, 1, 1)

Table 2. Fuzzy linguistic comparison matrix translated from Table 1

Criteria	H	QM	QS
H	Just equal	Equally important	1/Strongly important
QM	Equally important	Just equal	1/Weakly important
QS	Strongly important	Weakly important	Just equal

From Theorem 1, let P=1; the linguistic variables could be defined in Table 3. Table 2 then could be translated into Table 4 by utilizing the definitions given in Table 3.

Table 3. The linguistic valuables and corresponding triangular fuzzy numbers

Linguistic valuables	Corresponding triangular fuzzy numbers	The inverse of the corresponding triangular fuzzy numbers
Absolutely more important	(1, 4, 9/2)	(2/9, 1/4, 1)
Very strongly more important	(1, 7/2, 4)	(1/4, 2/7, 1)
Strongly more important	(1, 3, 7/2)	(2/7, 1/3, 1)
Strongly important	(1, 5/2, 3)	(1/3, 2/5, 1)
Weakly more important	(1, 2, 5/2)	(2/5, 1/2, 1)
Weakly important	(1, 3/2, 2)	(1/2, 2/3, 1)
Equally important	(2/3,1, 3/2)	(2/3, 1, 3/2)
Just equal	(1, 1, 1)	(1, 1, 1)

Table 4. Fuzzy comparison matrix

Criteria	H	QM	QS
H	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 1)
QM	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 1)
QS	(1, 3, 7/2)	(1, 2, 5/2)	(1, 1, 1)

By the translation and calculation process of the revised model of FEAHP, the comparison matrices and correspondent weights of the criteria/alternatives given by Wang, *et al,* (2008) are shown in Table 5-20.

Table 5. Fuzzy comparison matrix of three decision criteria

Criteria	H	QM	QS	Weights
H	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 1)	0.237
QM	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 1)	0.24
QS	(1, 3, 7/2)	(1, 2, 5/2)	(1, 1, 1)	0.52

Table 6. Fuzzy comparison matrix of three sub-criteria with respect to hygiene

Criteria	HM	HSP	HSV	Weights
HM	(1, 1, 1)	(1, 2, 5/2)	(1, 2, 5/2)	0.495
HSP	(2/5, 1/2, 1)	(1, 1, 1)	(2/3, 1, 3/2)	0.252
HSV	(2/5, 1/2, 1)	(2/3, 1, 3/2)	(1, 1, 1)	0.25

Table 7. Fuzzy comparison matrix of four sub-criteria with respect to quality of meal

Criteria	VM	CoM	CaM	TM	Weights
VM	(1, 1, 1)	(1, 2, 5/2)	(2/7, 1/3, 1)	(1, 3, 7/2)	0.269
CoM	(2/5, 1/2, 1)	(1, 1, 1)	(2/7, 1/3, 1)	(1, 4, 9/2)	0.265
Cam	(1, 3, 7/2)	(1, 3, 7/2)	(1, 1, 1)	(1, 3, 7/2)	0.343
TM	(2/7, 1/3, 1)	(2/9, 1/4, 1)	(2/7, 1/3, 1)	(1, 1, 1)	0.132

Table 8. Fuzzy comparison matrix of four sub-criteria with respect to quality of service

Criteria	BSP	ST	CP	PS	Weights
BSP	(1, 1, 1)	(2/9, 1/4, 1)	(1, 4, 9/2)	(2/7, 1/3, 1)	0.241
ST	(1, 4, 9/2)	(1, 1, 1)	(1, 4, 9/2)	(1, 3, 7/2)	0.350
CP	(2/9, 1/4, 1)	(2/9, 1/4, 1)	(1, 1, 1)	(2/7, 1/3, 1)	0.132
PS	(1, 3, 7/2)	(2/7, 1/3, 1)	(1, 3, 7/2)	(1, 1, 1)	0.277

Table 9. Fuzzy comparison matrix of three catering firms with respect to hygiene of meal

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 3, 7/2)	(1, 2, 5/2)	0.449
Mertol	(2/7, 1/3, 1)	(1, 1, 1)	(2/7, 1/3, 1)	0.18
Afiyetle	(2/5, 1/2, 1)	(1, 3, 7/2)	(1, 1, 1)	0.31

Table 10. Fuzzy comparison matrix of three catering firms with respect
to hygiene of service personnel

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	](1, 1, 1)	](2/3, 1, 3/2)	(2/9, 1/4, 1)	0.229
Mertol	(2/3, 1, 3/2)	](1, 1, 1)	(2/5, 1/2, 1)	0.236
Afiyetle	(1, 4, 9/2)	](1, 2, 5/2)	(1, 1, 1)	0.53

Table 11. Fuzzy comparison matrix of three catering firms with respect
to hygiene of service vehicles

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 1)	0.237
Mertol	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 1)	0.243
Afiyetle	(1, 3, 7/2)	(1, 2, 5/2)	(1, 1, 1)	0.519

Table 12. Fuzzy comparison matrix of three catering firms with respect to variety of meal

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(2/7, 1/3, 1)	(2/3, 1, 3/2)	0.230
Mertol	(1, 3, 7/2)	(1, 1, 1)	(1, 1, 1)	0.502
Afiyetle	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	0.266

Table 13. Fuzzy comparison matrix of three catering firms with respect to complementary meals

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 3, 7/2)	(2/3, 1, 3/2)	0.507
Mertol	(2/7, 1/3, 1)	(1, 1, 1)	(1, 1, 1)	0.208
Afiyetle	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	0.283

Table 14. Fuzzy comparison matrix of three catering firms with respect to calorie of meal

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(2/9, 1/4, 1)	(2/7, 1/3, 1)	0.179
Mertol	(1, 4, 9/2)	(1, 1, 1)	(2/7, 1/3, 1)	0.381
Afiyetle	(1, 3, 7/2)	(1, 3, 7/2)	(1, 1, 1)	0.439

Table 15. Fuzzy comparison matrix of three catering firms with respect to taste of meal

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(2/3, 1, 3/2)	(1, 1, 1)	0.250
Mertol	(2/3, 1, 3/2)	(1, 1, 1)	(2/9, 1/4, 1)	0.221
Afiyetle	(1, 1, 1)	(1, 4, 9/2)	(1, 1, 1)	0.527

Table 16. Fuzzy comparison matrix of three catering firms with respect to
behavior of service personnel

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 4, 9/2)	(1, 3, 7/2)	0.620
Mertol	(2/9, 1/4, 1)	(1, 1, 1)	(1, 1, 1)	0.188
Afiyetle	(2/7, 1/3, 1)	(1, 1, 1)	(1, 1, 1)	0.190

Table 17. Fuzzy comparison matrix of three catering firms with respect to service time

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 2, 5/2)	(2/7, 1/3, 1)	0.286
Mertol	(2/5, 1/2, 1)	(1, 1, 1)	(1, 4, 9/2)	0.380
Afiyetle	(1, 3, 7/2)	(2/9, 1/4, 1)	(1, 1, 1)	0.332

Table 18. Fuzzy comparison matrix of three catering firms with respect to
communication on phone

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 4, 9/2)	(2/3, 1, 3/2)	0.478
Mertol	(2/9, 1/4, 1)	(1, 1, 1)	(2/3, 1, 3/2)	0.235
Afiyetle	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	0.286

Table 19. Fuzzy comparison matrix of three catering firms with respect to
problem solving ability

Catering firms	Durusu	Mertol	Afiyetle	Weights
Durusu	(1, 1, 1)	(1, 1, 1)	(2/9, 1/4, 1)	0.188
Mertol	(1, 1, 1)	(1, 1, 1)	(2/7, 1/3, 1)	0.190
Afiyetle	(1, 4, 9/2)	(1, 3, 7/2)	(1, 1, 1)	0.620

Table 20. Results of the revised FEAHP model

Local weights of three catering firms with respect to hygiene

	HM	HSP	HSV	Local weights	LLSM
Weight	0.495	0.252	0.25		
Durusu	0.449	0.229	0.2372	0.3392	0.3624
Mertol	0.18	0.236	0.2432	0.2094	0.1878
Afiyetle	0.37	0.53	0.5196	0.4466	0.4498

Local weight of three catering firms with respect to quality of meal

	VM	CoM	CaM	TM	Local weights	LLSM
Weight	0.269	0.256	0.303	0.132		
Durusu	0.2308	0.50731	0.17991	0.2506	0.2796	0.2265
Mertol	0.5023	0.20876	0.381	0.2215	0.3333	0.3172
Afiyetle	0.2669	0.28395	0.4391	0.5279	0.3472	0.4563

Local weight of three catering firms with respect to quality of service

	BSP	ST	CP	PS	Local weights	LLSM
Weight	0.241	0.35	0.132	0.277		
Durusu	0.6207	0.2870	0.4782	0.1887	0.3654	0.3258
Mertol	0.1887	0.3809	0.2358	0.1906	0.2627	0.3047
Afiyetle	0.1906	0.3321	0.286	0.6207	0.3719	0.3696

Global weights of three catering firm with respect to the goal

	H	QM	QS	Global weights	LLSM
Weight	0.237	0.243	0.52		
Durusu	0.3393	0.2796	0.3654	0.3384	0.3096
Mertol	0.2094	0.3333	0.2627	0.2672	0.2831
Afiyetle	0.4466	0.3472	0.3719	0.3836	0.4072

The final results of the revised model of FEAHP are shown in Table 20 together with the LLSM weights given by Wang, *et al.*, (2008). The local weights of the firms with the respect to hygiene are Afiyetle＞Durusu＞Mertol. The local weights of the firms with the respect to quality of meal are Afiyetle＞Mertol＞Durusu. The local weights of the firms with the respect to quality of service are Afiyetle＞Durusu＞Mertol. The global weights of the firms are

Afiyetle＞Durusu＞Mertol. These results (local and global) are consistent with the LLSM results. From this example, the revised model of FEAHP is effective in estimating the importance of decision criteria/alternatives.

Example 2

A Taiwanese semiconductor equipment service company wishes to conduct the evaluation criteria of engineers' management competencies in the semiconductor equipment service industry. The evaluation model consists of three criteria, and twenty sub-criteria. These are shown in Table 21, Table 22 and Fig 2.

Table 21. Evaluation model of criteria

Criteria		
conceptual skills (CS)	interpersonal skills (IS)	technical skills (TS)

Table 22 Evaluation model of sub-criteria

Sub-criteria	
Problem Analysis (PA)	Problem Solving (PS)
Objective Setting (OS)	Job Planning (JP)
Role-Modeling (RM)	Teamwork (Te)
Motivation/ Reward (MR)	Pressure Resistance (PR)
Conflict Resolution for Subordinates (CRS)	Cross-department Communication (CdC)
Strategy Planning (SP)	Effective Division (ED)
Responsibility (Res)	Professionalism (Pro)
Training/Coaching (TC)	Innovation (Inn)
Supervision (Sup)	Time Management (TM),
Language Proficiency (LP)	Performance Examination (PE)
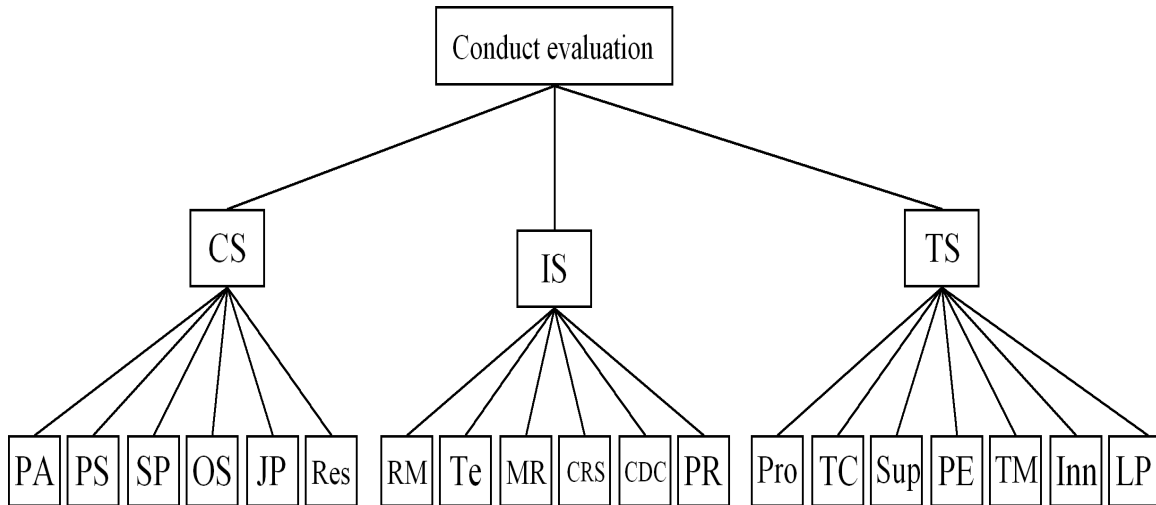
Fig.2 Hierarchy of semiconductor equipment service industry

The fuzzy AHP questionnaires were given to twelve experts. Eleven came from the semiconductor equipment maintenance outsourcing service company, including the president, two vice-presidents, six managers and three assistant managers. The twelfth was a manufacturer/provider. The revised model of FEAHP is utilized in this problem. From theorem 1, let p=1; the results are shown in Table 23-26.

Table 23. Fuzzy comparison matrix of main dimensions

	CS	IS	TS	Weights
CS	(1,1,1)	(0.33,0.4,1)	(0.33,0.4,1)	0.181
IS	(1,2.5,3)	(1,1,1)	(1,1.5,2)	0.439
TS	(1,2.5,3)	(0.5,0.67 ,1)	(1,1,1)	0.380

Table 24. Fuzzy positive reciprocal matrix of dimension conceptual skill

	PA	PS	SP	OS	JP	Res
PA	(1,1,1)	(0.4,0.5,1)	(0.4,0.5 ,1)	(0.4,0.5 ,1)	(0.33,0.4 ,2)	(0.22,0.25 ,1)
PS	(1,2,2.5)	(1,1,1)	(1,2,2.5)	(1,1.5,2)	(1,1.5,2)	(0.25,0.29,1)
SP	(1,2,2.5)	(0.4,0.5,1)	(1,1,1)	(0.33,0.4,1)	(0.33,0.4,1)	(0.2,0.22,1)
OS	(1,2,2.5)	(0.5,0.67,1)	(1,2.5,3)	(1,1,1)	(0.4,0.5,1)	(0.25,0.29,1)
JP	(1,1.5,2)	(0.5,0.67,1)	(1,2.5,3)	(1,2,2.5)	(1,1,1)	(0.25,0.29,1)
Res	(1,4,4.5)	(1,3.5,4)	(1,4.5,5)	(1,3.5,4)	(1,3.5,4)	(1,1,1)
Weight	0.088	0.173	0.116	0.152	0.181	0.290

The results of the weights of the main criteria CS, IS and TS are W= (0.181, 0.439, 0.380). The results of the weights of the sub-criteria CS are *W*= (0.088, 0.173, 0.116, 0.152, 0.181, 0.290). The results of the weights of the sub-criteria IS are *W*= (0.075, 0.132, 0.144, 0.113, 0.114, 0.162, 0.260). The results of the weights of the sub-criteria TS are *W*= (0.129, 0.150, 0.132, 0.177, 0.163, 0.128, 0.121). The corresponding weights of the criteria, sub-criteria are shown in Table 27. In this case, we discover that interpersonal skills have become the first priority when choosing potential candidates. Meanwhile, the competencies of "pressure resistance" and "cross-department communication" rank the second place on the criteria list.

Table 25. Fuzzy positive reciprocal matrix of dimension interpersonal skills

	RM	Te	ED	MR	CRS	CDC	PR
RM	(1,1,1)	(0.4,0.5,1)	(0.4,0.5,1)	(0.4,0.5,1)	(0.4,0.5,1)	(0.33,0.4,1)	(0.29,0.33,1)
Te	(1,2,2.5)	(1,1,1)	(0.4,0.5,1)	(1,2,2.5)	(1,1.5,2)	(0.4,0.5,1)	(0.25,0.29,1)
ED	(1,2,2.5)	(1,2,2.5)	(1,1,1)	(1,1.5,2)	(1,1.5,2)	(0.4,0.5,1)	(0.25,0.29,1)
MR	(1,2,2.5)	(0.4,0.5,1)	(0.5,0.67,1)	(1,1,1)	(1,1.5,2)	(0.4,0.5,1)	(0.22,0.25,1)
CRS	(1,2,2.5)	(0.5,0.67,1)	(0.5,0.67,1)	(0.5,0.67,1)	(1,1,1)	(1,1.5,2)	(0.22,0.25,1)
CDC	(1,2.5,3)	(1,2,2.5)	(1,2,2.5)	(1,2,2.5)	(0.5,0.67,1)	(1,1,1)	(0.25,0.29,1)
PR	(1,2,3.5)	(1,3.5,4)	(1,3.5,4)	(1,4,4.5)	(1,4,4.5)	(1,3.5,4)	(1,1,1)
Weight	0.076	0.132	0.144	0.113	0.114	0.162	0.260

Table 26. Fuzzy Positive Reciprocal Matrix of Dimension Technical Skills

	Pro	TC	Sup	PE	TM	Inn	LP
Pro	(1,1,1)	(0.4,0.5,1)	(1,1.5,2)	(0.4,0.5,1)	(0.33,0.4,2)	(1,1.5,2)	(1,1.5,2)
TC	(1,2,2.5)	(1,1,1)	(1,1.5,2)	(1,1.5,2)	(1,1.5,2)	(0.4,0.5,1)	(0.33,0.4,1)
Sup	(0.5,0.67,1)	(0.5,0.67,1)	(1,1,1)	(0.33,0.4,1)	(1,1.5,2)	(1,1.5,2)	(1,1.5,2)
PE	(1,2,2.5)	(0.5,0.67,1)	(1,2.5,3)	(1,1,1)	(1,1.5,2)	(1,1.5,2)	(1,1.5,2)
TM	(1,2.5,3)	(0.5,0.67,1)	(0.5,0.67,1)	(0.5,0.67,1)	(1,1,1)	(1,2,2.5)	(1,2,2.5)
Inn	(0.5,0.67,1)	(1,2,2.5)	(0.5,0.67,1)	(0.5,0.67,1)	(0.4,0.5,1)	(1,1,1)	(1,1.5,2)
LP	(0.5,0.67,1)	(1,2.5,3)	(0.5,0.67,1)	(0.5,0.67,1)	(0.4,0.5,1)	(0.5,0.67,1)	(1,1,1)
Weight	0.129	0.150	0.132	0.177	0.163	0.128	0.121

Table 27. Weights of main criteria/sub-criteria

main criteria	main criteria weight	sub-criteria	sub-criteria weight	Ranking
CS	0.181	PA	0.088	20
		PS	0.173	17
		SP	0.116	19
		OS	0.152	18
		JP	0.181	16
		Res	0.290	8
IS	0.439	RM	0.076	15
		Te	0.132	6
		ED	0.144	4
		MR	0.113	11
		CRS	0.114	10
		CDC	0.162	2
		PR	0.260	1
TS	0.380	Pro	0.129	12
		TC	0.150	7
		Sup	0.132	9
		PE	0.177	3
		TM	0.163	5
		Inn	0.128	13
		LP	0.121	14

Conclusions

This paper proposes a revised model of FEAHP which redefines the membership functions of the triangular fuzzy numbers to ensure no criteria/alternatives are deleted. Two examples are given to examine the efficiency of the revised FEAHP model. The characteristics of this revised FEAHP are summarized, as follows.

● The revised FEAHP model avoids assigning irrelevant zero weights to some useful decision criteria/alternatives.

● The hierarchical structure of the revised FEAHP model will not be oversimplified; and, none of the criteria/alternatives will be removed.

● The weights determined by the revised FEAHP model represent the relative importance of each decision criterion/alternative and could be used to determine their relative priorities.

● From the two examples provided, the results of the revised FEAHP model are   effective.

The revised FEAHP model allows all relevant information connected to fuzzy comparison matrices to be fully, and properly, utilized. Since FEAHP might, sometimes, lead to wrong conclusions (due to the elimination of important criteria), the revised model of FEAHP creates added effectiveness (by re-weighting the criteria, more properly.)

Acknowledgements

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GLOBAL PERSPECTIVE OF BUSINESS ETHICS AND SOCIAL RESPONSIBILITY

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Abstract

In this study, Wal-Mart's ethical behavior and social responsibility are reviewed. Later, corporate social responsibility is considered. This is followed by social obligations. In addition, values change and social responsibility are studied. Furthermore, marketing systems are identified. Moreover, international Marketing is considered. This is followed by corporate social responsibility. Finally, communication ethical mind is studied. An extensive topical bibliography is provided.

Keywords: Global Perspective, Business Ethics, Social Responsibility.

Introduction

Corporate Social Responsibility

Social responsibility is the social contract that exists between a company and its environment. Social responsibility refers to the enforced, implied, or felt obligation of managers, acting in their official capacity, to protect and serve the interests of groups other than themselves. A corporation's approach to social responsibility means corporate executives to be making decisions that closely meet the expectations of society. Various companies take action to promote a culture for moral problems. Grievances, open-door policies, procedures, and workforce benefit programs. Nowadays, stockholders have management more committed to social responsibility. For example, the environment service development at Allied Chemical is charged to control water and air pollution and healthful working conditions for workers. Coca-cola's food division supports expenditures on housing, education, and health services for migrant workforce. AT&T, Dow Chemical, Federal Express, BankAmerica, 3M, and Whirlpool all realize economic and social values. Dow Chemical invests in pollution control in a plant in Michigan. AT&T, Federal Express, BankAmerica, 3M, and Whirlpool realize that recycling is good for society, while it saves them disposal costs, and also increases profits. To meet the expectations of society, future managers need to be more ethical and socially responsible.

An organizational stakeholder is one whose interests are affected by organizational activities. The social contract means the set of unwritten and written assumptions and rules about acceptable interrelationships among the various elements of society, such as, government, and other organizations. Boards of Directors hold management accountable for meeting the interests of stakeholders. Employers expect a fair day's pay for a fair day's work and much more.

Social Obligations

Commercial businesses expect to compete with one another on an honorable basis. Moreover, government is essential to the social contract for every organization. Beyond the auspices of government, enterprises have a license to do business, along with trademarks, patent rights, and to accept some government intervention in organizational affairs. In addition, most citizens are afforded some leisure time. Profitable companies can pay taxes to the government and make donations to charities. Generally, every company tries to curb costs in order to keep prices low enough to attract consumers and still allow for profit. Some believe this concentration on profits through cost cutting causes quality to be neglected as a competitive tool. Businesses operate by public interest with the basic objective of satisfying the needs of society. Society demands more from large business. The following are expected to help society:

1) Provision of quality health care

2) Preserve of the environment by reductions in the level of pollution

3) Eliminate of poverty.

4) Provision of a sufficient number of jobs and career opportunities for all members of

society.

5) Provision of safe, livable communities with efficient transportation and good housing.

6) Improve the quality of working life of workers.

As part of their responsibility to citizens, companies should follow the spirit of the law. In fact, the regulations and laws controlling hazardous waste dumping mean to protect the public health, and the dumping of certain concentrations of substances is prohibited. In some case, dangerous but unregulated. The economic function remains the priority responsibility of businesses to society. Companies produce needed services and goods, provide employment,

contribute to economic growth, and earn a profit, with an awareness of changing social goals, demands, and values, as well as the reduction of environmental pollution, the efficient utilization of resources, the employment and development minorities and woman, and the safety of workers and consumers. Moreover, business should assist society in achieving such broad goals as the elimination of poverty and urban decay through a partnership of companies, other private institution and government agencies, as well as augmenting interest in voluntary social actions.

Value Changes and Social Responsibility

The American Management Association and the Committee for Economic Development, encourage managers and companies to become involved in socially responsible activities, such as follows:

1) Reduction of environmental pollution.

2) Financial and leadership aid for urban renewal.

3) A safety working environment.

4) Financial and managerial aid aim at improving medical care and health.

5) Financial assistance for education.

6) Promotion and better jobs opportunities for woman and minorities.

In the long term, those who do not apply power in a manner society considers responsible tend to lose it. If businesses hope to retain their social role and social power, they must be responsive to society's needs. In 1776, Adam Smith (1776, reprint ed. N. J.; Modern library, 1937, p.109) published The Wealth of Nations, as follows :

• People desire other institutions and business to be socially responsible.

• Business will benefit if it is socially responsible, so social responsibility is just a enlightened self-interest.

- Responsible businesses have better images, both as desirable places to work and honorable corporate citizens.

- Business ought to be involved in social programs because it monitors the necessary resources.

- Business exists only with the sanction of society, so it ought to serve society's interests.

- If business does not respect to society's needs, the public will press for more regulation.

- Socially responsible actions can augment profits in the long term.

In 1935, the Federal Revenue Act provided tax deductibility of charitable contributions. In 1953, A.P. Smith Manufacturing Company v. Barlow et al., the New Jersey Supreme Court determined that business support of higher education in society's best interest. Economist Milton Friedman (Capitalism and Freedom, Chicago : University of Chicago Press, 1962, P.133) said, "There is one and only one social responsibility of business: to use its resources and engage in activities designed to increase its profits which is to say engages in open and free competition, accepted ethical practices, in addition to national, international, and other laws."

At Lincoln Electric Company, stockholders and workers are one and the same. More than half the company's stock is owned by the workforce who are able to buy a limited shares each year at below market prices. Lincoln also uses a profit-sharing program, which adds to workers ownership interest, as well as all the top executives own Lincoln stock. The involvement of government in business activities is of essential importance to most managers. Ethics refer to what is bad and good, or wrong and right, or with obligation and moral duty.

Marketing Systems

The purpose of marketing is to guarantee that the proper product is offered to the consumers at the right location and price and with the correct amount of promotion, and

distribution. In the past, the complexity of this task was always overwhelming. Tying together a

marketing system concerning product development and analysis, marketing research, price

analysis, place analysis, sales and promotional analysis was always difficult without the benefits

of the computer. Nowadays, through computerized marketing systems, information is made

available to the marketing manager about such vital areas as advertising effectiveness and

product profitability.

International Marketing

Globalization of the world economy and the development of multinational companies

need business to sell their products and services in a variety of culturally diverse markets. To

achieve this goal products and services must be advertised and offered in a manner that is

consistent with the culture in which the commodity is offered. This needs a set of communication

strategies that are appropriate to the target market.

International marketing communication for the most part appears to be grounded in ways

of communicating with potential consumers overseas who are not dissimilar to consumers in

one's own home market in terms of access to communications infrastructure, education levels,

position at the upper end of the socioeconomic scale and who possess a degree of westernization.

The task to be achieved is to make your product or service brand meaningful to your audience.

Global branding is the process by which a corporation markets itself in a variety of culturally

diverse markets. Global branding is complicated by the diversity of nationalism, languages,

product attributes and culture.

Corporate Social Responsibility

The period from 1995 to 2005 is important for the development of corporate social

responsibility (CSR). The year 2005 was 10 years after Shell's debacle over the disposal of the

Brent Spar oil rig in the North Sea and 10 years since they were implicated in the death of Ken Saro-Wiwa, a Nigerian human rights activist who was murdered by his government for protesting the distribution of revenues from what was perceived to be Shell's damaging extrication of oil from the Ogoni region of Nigeria. This study concerns the links between business profitability and global social progress for the benefits of society. If a minority gain net material wealth in the short run at the gross expense of society, what real benefit is that? The emphasis ought to move from corporate social responsibility to brand integrity. Moreover, a link is made between the integrity of decision makers and customers and the integrity of companies via the integrity of their brands. While good progress has been made on corporate responsibility, they have not been successful because we have failed to understand that in the modern global companies, we have created a being less control than we want to think.

This study moves on to a new social responsibility agenda. Here integrity and brand are linked. What is able to be said about brand integrity? Is it possible to use to such brands as the United Nations, the Oxfam, and BBC the same loyalty without reason that is applied to the billions of annual sales of Coke, Dove soap, and M&Ms?

Corporate Social Responsibility (CSR) means a desire and a necessity to humanize the globalization process to create environment and social in the global commerce Has the creation of global markets reached all of the world's customers? The CSR has been resurgent over the last 10 years, and multi-stakeholder engagement, among government, business, and civil society, has resulted in any essential number of global voluntary corporate citizenship initiatives. Examples of essential global voluntary corporate citizenship initiatives include ethical workplace management systems certification sustainability management systems assurance learning platforms on international conventions on labor standard, human rights, anticorruption, and

environmental protection, as well as the standardization of reporting on financial, environment and social. So, has the world been learning to talk and listen?

While there is increasing understanding that the modern world, through the expansion of trade, technology and the companies of the development growth of global companies, there is an increasing awareness of the social and environmental impacts of their performance. Some companies become targets of protesting customers, environment or community activist groups. The CSR movement asks corporations lead social change on social and environmental issues? How is business progressing on these issues? Results of a global survey of CEOs indicate that they had four challenges, none of which included the CSR agenda: sustained growth; flexibility, speed, and adaptability to change: consumer retention and loyalty; creativity and stimulating innovation and enabling entrepreneurship.

Conclusions

Laws offer guides to ethical behavior, prohibiting acts that is able to be hurtful to others. Most agree that people ought to have responsibility of ethical guidance. Ethics deal with the strength of the relationship between what an organization and an individual believes to be correct and moral and what available sources of guidance suggest is morally correct. Moreover, Ethics concern the strength of the relationship between how one behaves and what one believes. Business ethics refer to the application of ethical principles to business activities and relationship. Deciding what is ethical always difficult. For example, Texas Instruments' ethics are the following: Good business and good ethics are viewed from legal, moral and practical standpoints. The trust and respect of all people: consumers, workers, government, stockholders, competitors, suppliers, friends, neighbors, general public, and the press are assets that are notable to be purchased. The business of TI must be the highest ethical standards. TI sets forth ethical

guidelines include gifts and entertainment, truthfulness in advertising, political contributions, improper use of corporate assets, payments in connection with business transactions, conflicts of interest, and proprietary information, as well as trade secrets. There are reasons to support industry associations to promote and develop ethics. It is difficult for a single company to pioneer ethical practices if its competitors take advantage of unethical behavior.

Methods to improve the quality of management decisions are as follow:

- Auditing implies the collection of complete, accurate data, and objective, not normally available in social areas.

- The business system, which previously concentrate on economic variables, may not have measurement techniques appropriate or control points to measuring social variables.

- It is difficult to determine how an action today might affect society's interests tomorrow.

- Special criteria or units of measurement may not be agreed upon.

- The enterprise may not have specific goals in social areas.

Many companies acknowledge responsibilities to numerous stakeholder groups other than corporate owners about specific objectives in social areas. A social audit is a systematic evaluation of a company's activities in terms of their social impact, and social performance. It is the policy of an enterprise that every workers have to a safe and healthful place to work and that accidents ought to prevented in any phase of its operation. Toward this end, the full cooperation of all workers are required, in order to prevent injury to workers or damage to equipment. The maintenance person must check the equipment to see that all guards and safety devices are securely operable and in place.

Nowadays, companies have the option of developing their own concept to solve environmental problems. Tomorrow, environmental issues will force legislators into taking

actions. The study of ethics in management have different directions. Ethics is catalyzing

managers to take socially responsible actions. Ethics concern good behavior obligation own

personal well-being and other human beings. Business ethics concern the capacity to reflect

values in the decision-making process, to point how these values and decisions affect stakeholder

groups, and to establish how managers are able to use these observations in day-to-day enterprise

management.

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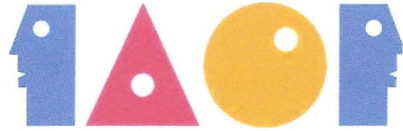
HOW BRAND EQUITY, MARKETING MIX STRATEGY AND SERVICE QUALITY AFFECT CUSTOMER LOYALTY: THE CASE OF RETAIL CHAIN STORES IN TAIWAN

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Abstract

Brand equity, marketing mix strategy, and service quality have been recognized as significant factors to affect customer loyalty. However, very limited studies have extensively examined the relationship among those variables. This quantitative study was to comprehensively examine the relationship between brand equity, marketing mix strategy, service quality and customer loyalty for consumers. The population in this research was identified as customers from four retail chain stores in Taiwan, resulting in 200 individual surveys for analysis. The findings supported the hypothesis that brand equity, marketing mix strategy, and service quality have significant and positive relationship to customer loyalty. The result identified the predictors of brand equity, marketing mix strategy and service quality on the customer loyalty. Finally, this research generated the recommendations for corporate operations and suggested future scholar studies.

Key Words: Brand Equity, Marketing Mix Strategy, Service Quality, Customer Loyalty

Introduction

Brand equity, marketing mix strategy, and service quality have been discussed in the academy field and recognized as an effective tool for building corporate competency in business world, while customer loyalty has been regards as the key indicator for customer retention. Tong and Hawley (2009) stated building a successful brand image will enhance companies' profitability and revenue and bring the industry's strong competitive benefit. A well-design marketing strategy is necessary to maintain and develop the business in a highly competitive business world (Kotler, 1997). In addition, for improving the customer loyalty, service quality has been argued the effective tool to improve the customer retention (Day, 1994). However, Rao and Monroe (1989) argued the study results of the relationship between price (marketing strategy mix) and service quality remain unclear. Metters, King-Metters, and Pullman (2003) argued the good service quality cannot ensure the profit for corporation. Very few studies have examined the relationship among brand equity, marketing mix strategy, service quality and customer loyalty, or how brand Equity, marketing strategy and service quality affect customer loyalty. The relationship between brand equity, marketing mix strategy, service quality and customer loyalty remains unclear. Therefore, the purpose and the significance for this study are: (a) to comprehensively examine the relationship between brand equity, marketing mix strategy, service quality and customer loyalty for the customers from retail chain stores, (b) to generate the recommendations for managerial application for the business of retail chain stores, and(c) to identify areas for future scholarly inquiry.

LITERATURE REVIEW

Brand Equity

Brand usually is being defined as the individualized characters or symbols to <u>distinguish</u> the products or companies from others. Boyd, Walker, and Larreche (1995) claimed Brand is also including product name, product symbol, and trademark. Further more, Kotler (1997) stated the brand itself possesses the concept of the copyright. Ailawadi and Keller (2004) defined Brand Equity as the profitability effect for leveraging asset and liability which related to product name, symbol, and brand. Although brand equity has become a strategic role for building core competency for companies, the measures of brand equity are existing lots of debates. Some brand equity models are provided by scholars, the most common brand equity model was defined by Aaker (1991). This model has been empirically applied in previous researches (Atilgan, Aksoy, and Akinci, 2005; Kim and Kim, 2004; Yoo, Donthu, and Lee, 2000). This model is stated that brand equity encompasses five dimensions, such as brand awareness, perceived quality, brand royalty, brand association, and other proprietary asset. Aaker (1996) also stated "The Brand Equity Ten" which encompassed five major categories related to buyer and market conception. The five major categories are including loyalty, perceived quality, associations, awareness, and market behavior.

<p align="center">MARKETING MIX STRATEGY</p>

Kotler (2003) identified the marketing mix is the set of selling tools for helping companies to aim the target customers in marketing. The most well known marketing strategy tools are the 4 Ps model. McCarthy and Perreault (1994) suggested the 4 Ps model that the marketing strategy encompasses four factors, such as Product, Price, Promotion, and Place. Kotler, Keller, Ang, Leong and Tan (2009) identified the dimensions of Product encompassed the different element, such as variety, quality, design, features, brand name, packaging, size, service, warranties, and return. Kotler et al (2009) pointed the dimensions of Price encompassed

the different element, such as list price, discount, allowance, payment period, and credit term. In addition, Kotler et al (2009) also pointed the dimensions of Promotion encompassed the different element, such as sales promotion, advertising, sales force, and public relationship. Finally, the dimensions of Place encompassed the different element, such as channel, coverage, assortments, location, inventory, and transport.

SERVICE QUALITY

Current enterprises recognize quality is the critical factor to maintain the competency for business development. Deming (1981) and Garvin (1987) identified the service quality is the satisfaction for matching the customers' demand. Garvin (1987) also indicated the consumer's perception of service quality is recognized by subjective judgment which is different to the perception of tangible product management. Regan (1963) and Fitzsimmons and Fitzsimmons (1997) pointed the service industry are heterogeneous, intangible, participated, non-separated, perishable and flexible site-selection. Scholars had developed different research approaches to measure the service quality. Parasuraman, Zeithaml, and Berry (1985) suggested the theory of Service Gap Model and SERVQUAL questionnaire (Parasuraman, Zeithaml, & Berry ,1988) pointed the five dimensions to measure the service quality are tangible, responsiveness, reliability, empathy, and assurance. Bolton and Drew (1991) also identified the SERVPERF scale to measure the service quality.

Customer Loyalty

Customer loyalty referred to the customer's attitude which affects to purchase the same brand products (Tellis, 1988). Oliver (1997) claimed the customer loyalty will drive customers to buy the same brand products under the changes for competitors' benefit offers. Jones and Sasser (1995) indicated the customer loyalty is the behavioral intention to maintain the relationship

between customer and service suppliers. Therefore, the customer loyalty may refer to the attitude that customer's desire and behavior to purchase the produce or service repeatedly. Muller (1998) pointed customer loyalty may help company to enlarge the market share. Sirohi, Mclaughlin, and Wittink (1998) stated customer loyalty may represent by customer satisfaction. Zeithaml, Berry and Parasuraman (1996) suggested the dimensions of customer loyalty such as recommendations to others, complains, the attentions to pay more, and the possibility to transfer to other companies.

The Relationship among Brand Equity, Marketing Mix Strategy, Service
Quality and Customer Loyalty

Keller (1993) argued brand image have significant impact on buyers' intention. Kotler (2003) suggested marketing mix strategy has significant impacts on customer behavior, such as loyalty. Parasuraman et al. (1985) suggest the service quality has the significant impact on the customer behavior. Zeithaml et al. (1996) suggest customer loyalty is one important facet of behavioral intentions by customers. Richard, Dick and Jain (1994) claimed brand image may affect the customer perception for service quality. Although scholars claimed the service quality is one of the vital issues to develop customer relationship, Metters King-Metters, and Pullman (2003) argued the good service quality cannot ensure the customer behavior, although service quality has positive impact on the customer loyalty. Kotler (2003) claimed price issue is most sensitive issue to affect the customer behavior comparing other factors. However, very few studies have extensively examined the relationship among brand equity, marketing mix strategy, service quality, and customer loyalty. Previous studies revealed that there is a significant relationship between brand equity, marketing mix strategy, service quality, and customer loyalty. Therefore, the basic theory concept for building the research hypothesis in this research is: Brand

equity, marketing mix strategy, and service quality have significant positive relationship to customer loyalty.

Methodology

Instrumentation

Four instruments have been adopted in this study: Brand Equity (seven items), Marketing Mix Satisfaction (14 items), Service Quality (21 items), and Customer Loyalty (three items). The *Brand Equity Questionnaires* are based on the definition by Aaker(1991)'s 5 factor model, while this study adopted four dimensions, such as Brand Awareness (one item), Brand Association (two items), Perceived Quality (two item) and Brand loyalty (two items) for examining the perception of brand equity by customers. The *Marketing Mix Satisfaction Questionnaires* are based on the definition by McCarthy and Perreault (1994)'s 4 Pc model which encompasses four dimensions, such as product (five items), price (three items), promotion (two items), and place (three items). The *Service Quality Questionnaires* were modified from the SERVQUAL questionnaire (Parasuraman, Zeithaml, and Berry ,1988) which encompasses five dimensions, such as Tangible (five items), Responsiveness (five items), Assurance (three items), Empathy (three items), and Reliability (five items). The *Customer Loyalty Questionnaires* were modified from the Behavioral Intentions Battery questionnaire developed by Zeithaml, Berry, Parasuraman (1996) and were encompasses two dimensions, such as Recommendations (two items) and Repeated purchase (one item).

Population and Data Collection

The customers shopping in the specific retail chain stores have had selected as an acceptable population for this study. To ensure the response rate, this research applied the method of convenience sampling. After contacting with senior managers of retail chain stores,

four stores in the Kaohsiung city of south Taiwan agreed to participate this research. Then, the researcher applied the method of random sampling. Each store randomly invited volunteer customers who shopping in the store to participate the questionnaire survey. A total of 215 customers participated this study. After deducting 15 invalid response, the total number of valid responses was 200, providing an adjusted response rate of 93%.

Validity and Reliability

The researcher examined the content validity and construct validity to discuss the validity issues in this research. The researcher developed the questionnaires which are based on the academy theory or existed questionnaire which developed by scholars or specialists to improve the content validity. The researcher also applied Factor Analysis following Varimax Rotation method to examine the construct validity and to reduce the dimensions for assessing the validity issue for questionnaires. The research also examined the internal consistency as an estimate of reliability for questionnaires.

The result of Factor Analysis of Brand Equity was summarized in Table 1, and resulted in two dimensions named Brand Familiarity and Brand Loyalty. The values of KMO test value (>.8), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the questionnaires are reasonable. The internal consistency as an estimate of reliability of the two parts of questionnaires ranged from .785 to .814.

The result of Factor Analysis of Marketing Mix Satisfaction was summarized in Table 2 and resulted in two dimensions named Store Operation and Product Value. The values of KMO test value (>.9), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the questionnaires are reasonable. The internal consistency as an estimate of reliability of the two parts of questionnaires ranged from .872 to .881.

Table 1. Factorial Validity and Scale Reliability of Brand Equity

	Factor 1	Factor 2
	Brand Familiarity	Brand Loyalty
Brand Familiarity 1-3	0.732-0.838	
Brand Loyalty 1-4		0.580-0.841
Eigen value	7.222	1.105
% of variance	55.354	12.822
Cumulative %	55.354	68.176
Cronbach's	0.814	0.785

Total: 7 items; KMO=.852, Cronbach's=.855, sample size=200

Table 2. Factorial Validity and Scale Reliability of Marketing Mix Satisfaction

	Factor 1	Factor 2
	Store Operation	Product Value
Store Operation 1-7	0.515-0.848	
Product Value 1-7		0.533-0.789
Eigen value	7.222	1.105
% of variance	51.587	7.890
Cumulative %	51.587	59.477
Cronbach's	0.872	0.881

Total: 14 items; KMO=.905, Cronbach's=.927, sample size=200

The result of Factor Analysis of Service Quality was summarized in Table 3. After deleted two low factor loading items, the Factor Analysis resulted in four dimensions named Tangible, Attentive, Responsiveness and Trust. The values of KMO test value (>.8), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the questionnaires are reasonable. The internal consistency as an estimate of reliability of the two parts of questionnaires ranged from .726 to .844.

Table 3. Factorial Validity and Scale Reliability of Service Quality

	Factor 1	Factor 2	Factor 3	Factor 4
	Tangible	Attentive	Responsiveness	Trust
Tangible 1-5	0.619-0.804			
Attentive 1-6		0.549-0.806		
Responsiveness 1-5			0.572-0.798	
Trust 1-3				0.634-0.759
Eigen value	7.334	2.059	1.308	1.106
% of variance	38.602	10.837	6.886	5.819
Cumulative %	38.602	49.439	56.325	62.144
Cronbach's	0.832	0.844	0.824	0.726

Total: 19 items; KMO=.874, Cronbach's=.911, sample size=200

The result of Factor Analysis of Customer Loyalty was summarized in Table 4 and resulted in two dimensions named Loyalty and Recommendation. The values of KMO test value (>.7), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the questionnaires are reasonable. The internal consistency as an estimate of reliability of questionnaires is .862.

Table 4. Factorial Validity and Scale Reliability of Customer Loyalty

	Factor 1	Factor 2
	Loyalty	Recommendation
Loyalty1-2	0.657-0.918	
Recommendation 1		0.920
Eigen value	2.362	.351
% of variance	78.740	11.708
Cumulative percentage	78.740	90.448

Total: 3 items; KMO=.735, Cronbach's=.862, sample size=200

Research Hypotheses and Questions

Based on the theory concept and the research purposes for this study, the researcher proposed three hypotheses and one research question as follows.

1. **Hypothesis 1: Brand equity has a significant and positive relationship to customer loyalty: a) Loyalty; b) Recommendation.**

2. **Hypothesis 2: Marketing mix strategy has a significant and positive relationship to customer loyalty: a) Loyalty; b) Recommendation.**

3. **Hypothesis 3: Service quality satisfaction has significant and positive relationship to customer loyalty: a) Loyalty; b) Recommendation.**

4. **Research question: How the variables of brand equity, service quality and marketing mix strategy predict the variable of customer loyalty?**

Results

For Hypothesis 1.

Regression analysis was applied to examine H1 and the results are summarized in Table 5. The results supports both H1a and H1b. Brand equity (β=.698, p<.05) presented the variance explanation of 19.6% (R^2=.196, p<.05, F=48.281) for the dimension of loyalty. In addition, brand equity (β=.696, p<.05) presented the variance explanation of 19.5% (R^2=.195, p<.05, F=47.943) for the dimension of recommendation.

For Hypothesis 2.

Regression analysis was applied to examine the H2 and the results are summarized in

Table 5. The results supports the hypothesis H2a and H2b. Marketing mix strategy (β=.876, p<.05) presented the variance explanation of 21.3% (R^2=.213, p<.05, F=53.676) for the dimension of loyalty. In addition, Marketing mix strategy (β=.630, p<.05) presented the variance explanation of 11.0% (R^2=.110, p<.05, F=24.541) for the dimension of recommendation.

For Hypothesis 3.

Regression analysis was applied to examine the H3 and the results are summarized in Table 5. The results supports the hypothesis H3a and H3b. Service quality (β=.719, p<.05) presented the explanation of 10.1% (R^2=.101, p<.05, F=22.275) for the dimension of loyalty. Service quality (β=.855, p<.05) presented the variance explanation of 14.30% (R^2=.143, p<.05, F =32.998) for the dimension of recommendation.

Table 5. Regression Analysis Capabilities such as Brand Equity, Marketing Mix, and Service Quality to Royalty and Recommendation

	Royalty			Recommendation		
	β	R^2	F	β	R^2	F
H1a & H1b	.698**	.196	48.281	.696**	.195	47.943
H2a & H2b	.876**	.213	53.676	.630**	.110	24.541
H3a & H3b	.719**	.101	22.275	.855**	.143	32.998

**p<.01 (2-tailed), *p<.05 level (2-tailed).

Research Question

The results are summarized in Table 6. Brand equity (β=.524), marketing mix strategy (β=.273) and service quality (β=.313) presented the variance explanation of 45.8% (R^2=.458, p<.05, F=55.241) for customer loyalty.

Table 6: Regression Analysis Capabilities such as Brand Equity, Marketing Mix,
and Service Quality to Customer Loyalty

	Customer loyalty				
	β	R^2	*Adjusted R^2*	*F*	*t*
Brand Equity	.524**	.458	.450	55.241	6.251
Marketing Mix	.273**				2.392
Service Quality	.313**				2.628

**p<.01 (2-tailed), *p<.05 level (2-tailed).

Discussion

Findings

The findings of H1a and H1b indicated brand equity has similar significant and positive relationship on both dimension of customer loyalty (β=.698 and .686). However, brand equity did not provide much explanation for the variance for both dimensions (R^2=.196 and .195) of customer loyalty. The findings of H2a and H2b indicated marketing mix strategy has significant and positive relationship on both dimensions of customer loyalty, while marketing mix strategy has stronger effect on the loyalty dimension (β=.876) than on the recommendation dimension (β=.630). Although marketing mix strategy did not provide much explanation for the variance of both dimensions for customer loyalty, marketing mix strategy did provide slightly more explanations for the variance for the loyalty dimension (R^2=.213) than the recommendation dimension (R^2=.110). The findings of H3a and H3b indicated service quality has significant and positive relationship on both dimensions of customer loyalty, while service quality has stronger effect on the recommendation dimension (β=.855) than on the loyalty dimension (β=.719). Although service quality did not provide much explanation for the variance of both dimensions for customer loyalty, service quality did provide slightly more explanations for the variance for the recommendation dimension (R^2=.143) than the loyalty dimension (R^2=.101). The findings of all hypotheses revealed that brand equity and marketing mix strategy have stronger effects on

loyalty dimension than on recommendation dimension, while service quality has stronger effect on the recommendation dimension than on the loyalty dimension. The findings of the research question indicated brand quality, marketing mix strategy, and service quality provided weak explanation (R^2=.458) for the variance for customer loyalty, while brand equity (β=.524) has stronger effect on customer loyalty than service quality (β=.313) and marketing mix strategy (β=.273).

Suggestions and Recommendations

The results indicated brand quality, marketing mix strategy, and service quality have significant and positive relationship with customer loyalty. Corporations may apply this concept to enhance corporate marketing strategy, especially the strategy of brand equity. After improving the brand image and loyalty for customers, corporations may effectively influence customer behaviors. In addition, the brand equity and marketing mix strategy have stronger effects on loyalty dimension than on recommendation dimension. Therefore, the retail stores may push sales amount or enhance the customer re-purchasing rate through focusing on brand and marketing strategies rather than focusing on improving service quality. Oppositely, service quality has stronger effect on recommendation dimension than loyalty dimension.

Therefore, the retail stores may enhance the customers' recommendation behaviors by improving service quality. However, the findings indicated brand quality, marketing mix strategy, and service quality did not provide much explanation for the variance of customer loyalty. This fact revealed the complexities of customer behaviors and the necessities for future study to identify more effective factors to influence the customer loyalty. This research suggests future research recommendations: 1). Due to time constraints and limited finances, this research utilized convenience sampling and focused on limited number store. Future study may extend the

research to more stores or customers through larger random selection, 2). Moreover, the population may extend to other countries for comparisons to understand the differences in cultures, and 3). Future study may identify more effective factors to influence the customer loyalty and to predict the customer behaviors, also generate future scholar studies.

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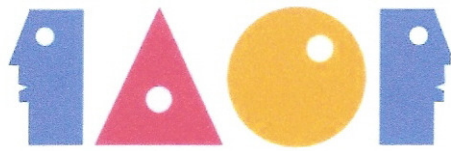
APPLICATION OF SIX SIGMA IN THE TFT-LCD INDUSTRY: A CASE STUDY

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Abstract

In the past few years, the TFT-LCD industry has become the driving force of the whole photonics market of Taiwan. As manufacturers are establishing the next generation of TFT-LCD production lines, the key competitive advantages of this industry have moved from mass-production to low cost, diverse product and application mix and technology leadership. Therefore, all the main makers of TFT-LCD panels, including AUO, CMO, CPT, HannStar and Innolux, have developed Six Sigma management systems to reduce defects, lower costs and improve competitiveness.

In the TFT-LCD manufacturing process, special adhesive sealant is used to bond the thin film transistor (TFT), color filter (CF) and liquid crystal display (LCD) substrates in the sealing process. This sealant is also used to prevent liquid crystal leakage as well as support the cell gap. Therefore, when a malfunction occurs in the sealant bonding process, liquid crystal leakage will lead to scrapping the panel and increased levels of pollution and waste. This kind of defect is called seal open. This paper deals with application of a Six Sigma project to reduce the seal open

defect rate. DMAIC phases (Define, Measure, Analyze, Improve, and Control) were utilized in the case company. Critical factors were found, and as a result the seal open rate fell significantly, even below the level of the original goal.

Keywords: Six Sigma Improvement, DMAIC, TFT-LCD, Seal Open Defect

Introduction

In today's ever-changing market environment, organizations want to reach goals of meeting customer's demand as well as improving the competitiveness. Purely relying on Total Quality Management and 'Re-engineering' is very difficult, and thus Six Sigma has emerged as an effective management approach. Six Sigma, a statistically-based quality improvement program, helps to improve business processes by cutting waste, reducing the costs associated with poor quality, and by improving the levels of efficiency and effectiveness of the related processes (Hoerl & Snee, 2002).

Six Sigma is a management tool for pursuing high quality of product and service, focusing on process improvement through a series of well-defined projects and a complete training program. It also uses profits and financial benefits as a performance measure to evaluate the related projects, and accomplishes its goals by utilizing an extensive set of statistical and advanced mathematical tools, and a well-defined methodology that produces significant results quickly. To succeed in this methodology, an organization should be willing and able to engage in a fundamental transformation of its culture (Mahesh et al, 2005). To date, Six Sigma activities have helped a lot of world-class enterprises, such as Motorola, Texas Instruments, IBM, AlliedSignal, 3M, and General Electric, to achieve significant performance improvements (e.g. Coel & Chen, 2008; Fuller, 2000; Sanders & Hild, 2000; Zu, Robbins & Fredendall, 2010)

Literature Review

Development of Six Sigma

Six Sigma as an improvement program has received considerable attention in the literature over the last ten years (e.g. Bergman & Kroslid, 2000; Harry, 1998; Hellsten & KlefsjoÈ , 2000; Hoerl, 1998; Hsu, 2010; KlefsjoÈ et al., 2001; Saghaei & Didehkhani, 2011).

The Six Sigma program has been considered a revolutionary approach to product and process quality improvement through the effective use of statistical methods (Harry & Schroeder, 2000; Eckes, 2000; Pande, et al., 2000). It is a useful problem-solving methodology and provides a valuable measurement approach. It has a statistical base and with proper utilization of methodologies can help to improve the quality of both product and process. In addition to providing data-driven statistical methods for improving quality, Six Sigma also focuses on some vital dimension of business processes, reducing the variation around the mean value of the process (Kanji, 2008). At many companies Six Sigma simply mean a measure of quality that strives for near perfection. It is a disciplined, for eliminating defects in any process, covering manufacturing and transactions, as well as products and services. The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of specific projects. This is accomplished through the use of its DMAIC methodology. Six Sigma has evolved into a business strategy in many large companies and its importance in small and medium-sized enterprises (SMEs) is growing everyday.(Kumar and Antony, 2008) In fact, the results are quicker and much more visible in smaller companies than in larger corporations (Antony, 2008).

Process improvement, process design/redesign and process management are the main strategies of any Six Sigma program. The five process improvement phases mentioned above are

as follows: Define (D), Measure (M), Analyze (A), Improve (I), and Control (C) (Pande, et al., 2000). This process, known as DMAIC, is both an improvement cycle and an effective problem solving methodology. Brewer et al. (2005) indicated that DMAIC is "the primary framework used to guide Six Sigma projects," a view that was also supported by Nilakantasrinivasan and Nair (2005).

A Six Sigma program may be introduced to any organization that deals with processes, variation and customer complaints. Kubiak (2003) also pointed out that the usage of a Six Sigma program "is not just limited to processes improvement." Therefore, Six Sigma can be applied equally to both manufacturing and non-manufacturing organizations. Successful use of the data-driven Six Sigma concepts helps organizations to eliminate waste, hidden rework and undesirable variability in their processes, resulting in quality and cost improvements, driving continued success.

The Phases of Six Sigma Implementation

In order to reduce variation, Six Sigma most commonly utilizes the DMAIC methodology (Hung & Sung, 2011; Starbird, 2002), which is defined in detail as follows.

Define.

The top management should identify the problem according to customer feedback and the strategy and mission of the company, then define customer requirements and set the appropriate goals.

Measure.

Measurement is a key transitional step in the Six Sigma process, one that helps the project team refine the problems being addressed and search for their root causes, which will be the

objective of the next step, Analyze. Therefore, the project team needs to validate the problem, refine the goal of the problem,, and measure input of key steps..

Analyze.

In this stage, the project team should use data analysis tools and process analysis techniques to identify and verify the root causes of the problems. Consequently, at this stage the project team needs to develop causal hypotheses, identify vital root causes, and validate hypothesis.

Improve.

The goal of the this stage is to find and implement solutions that will eliminate the causes of problems, reduce variations in a process, and prevent them from recurring. So the project team needs to develop ideas to remove root causes, test solutions, standardize solutions and measure results.

Control.

Once improvements have been made and the results documented, it is important to continue to measure the performance of the process routinely, adjusting its operations. It is thus necessary for the project team to establish standard measures to maintain performance and address problems as they arise. Without further control efforts, the improved process may well revert to its previous state.

Case Company

The case company was established in 1998. It specializes in the manufacturing of TFT-LCD products whose main applications are in notebook computer displays and desktop computer monitors. When it was first started, the case company built up a clear operating concept, namely providing people with healthy displays and thus being dedicated to the R&D, manufacture and

sale of low-radiation, low power consumption, compact and convenient TFT-LCD. Currently it has three LCD factories and one LCM factory in Taiwan. Its customers include many leading electronics companies, both in Taiwan and overseas.

In the TFT-LCD manufacturing process, special adhesive sealant is used to bond the thin film transistor (TFT), color filter (CF) and liquid crystal display (LCD) substrates in the sealing process (Figure 1). This sealant prevents the liquid crystal from leaking out of the panel, and also works as a frame to support the cell gap. Therefore, when the sealant is not spread completely then an opening occurs in the sealant and it will cause the liquid crystal to leak. This kind of defect is called seal open. When a seal open defect occur in the manufacturing process, it means that the LCD panel needs to be disposed, which will not only cause a financial loss, but also pollute the environment. The Seal Open of panel requires rework and decreases production capacity. The Quality Improvement Team based on traditional quality methods such as Q7 tools was established at the firm originally, and has led to significant improvements in performance, with the defect rate falling by nearly 50%, from 0.13% to 0.061%. However, during the improvement period, the team also found that the manufacturing process was still not stable and the defect rate varied drastically, proving that the manufacturing process is still uncontrolled. Consequently, the firm formed a Six Sigma project team, which was expected to improve both the process capability and process control ability.
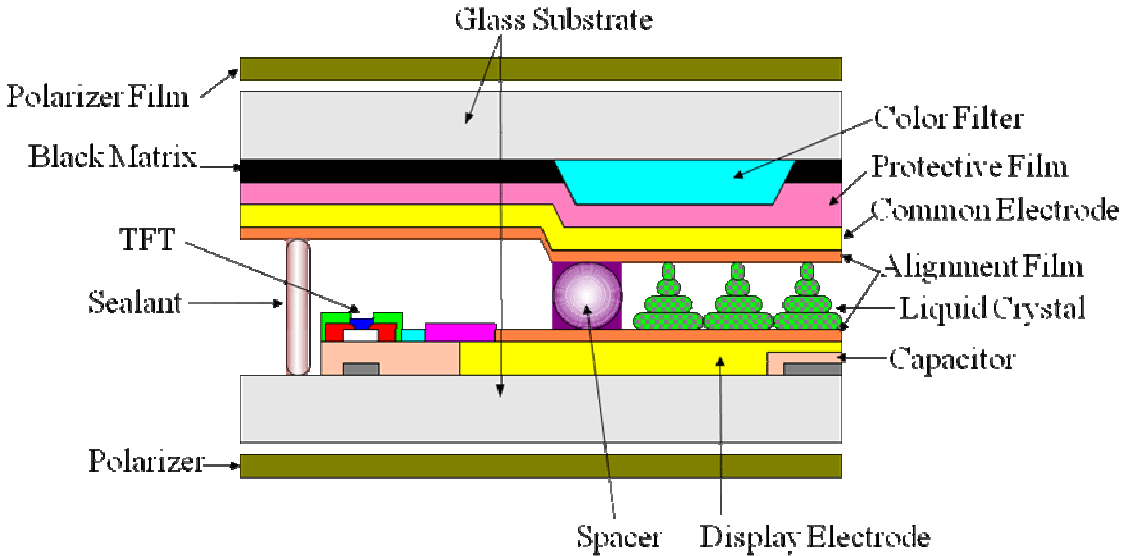
Figure 1. Structure of TFT-LCD panel

Define Phase

In the define phase, the company needs to select an appropriate Six Sigma project by considering the Voice of Customer (VOC), Voice of Process (VOP) and the company's strategic key performance indexes (Voice of Strategy, VOS). The overall project must be planned so that each component can be finished within six months. Among all possible improvement projects for the TFT-LCD Cell factory in the case company, it was found that many defects were due to upstream processes, such as the Array factory and CF (color filter) factory, which cannot be controlled in the Cell processes. Therefore, the most significant type of controllable defect, Cell NG Bubbles, was chosen. In addition, this defect is related to seal scrap of in-line scrap. These two defect types are both due to Seal Open, so the project was called 'Seal Open Defect Rate Improvement'.

After the project was decided on, the Six Sigma team members collected the weekly seal open defect rate data and calculated the project's baseline (average weekly defect rate) and the so-

called "entitlement" (which is the best performance of this defect, that is, the lowest weekly defective rate). After that, the project goal was set to reduce its seal open defect rate from its baseline to its entitlement by 70%, that is from 0.061% to 0.050 %.

Measure Phase

In the measure phase, the most important work is to know the overall situation concerning the project. The team members first used a process flow diagram concept to model all Cell processes to items that could be improved immediately. Figure 2 shows Cell ODF process flow diagram. Next, a cause and effect diagram was used to consider impact factors related to staff, machines, materials and methods. Figure 3 shows the cause and effect diagram for the Seal Open problem.
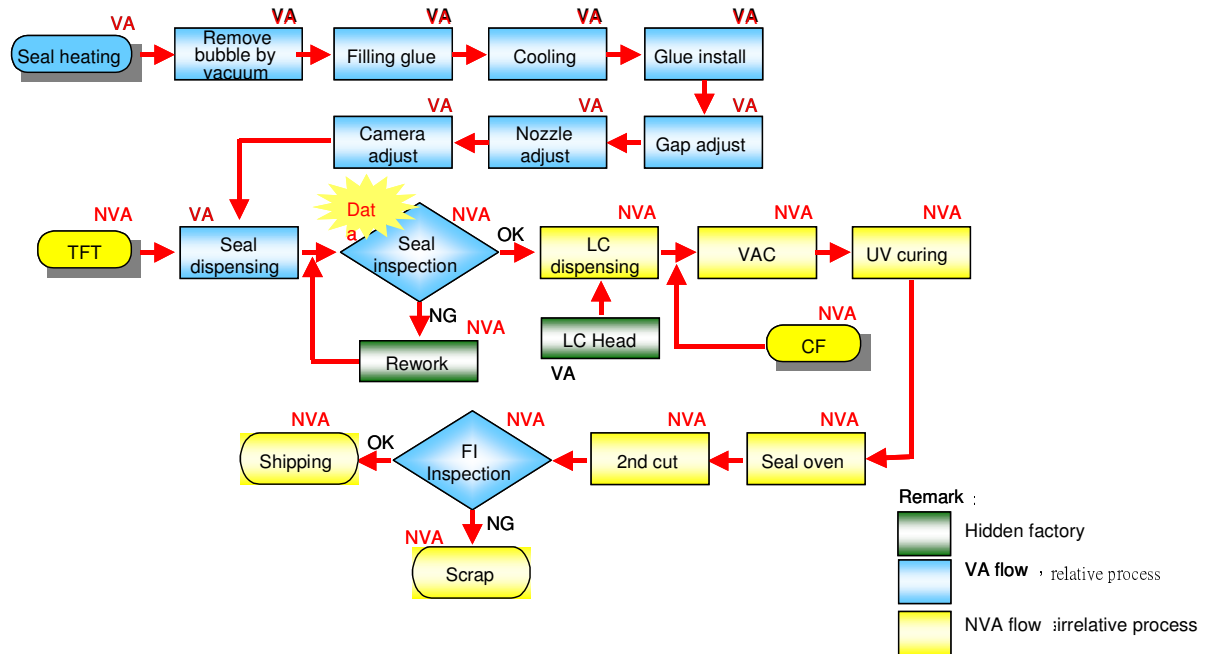
Figure 2. Cell Manufacturing Process Flow Diagram
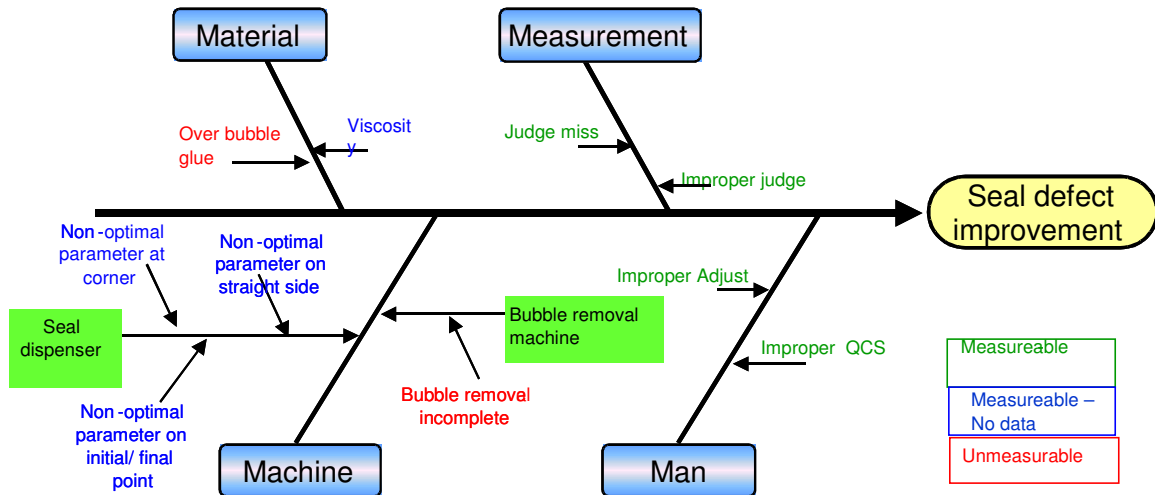
Figure 3. Seal Open Cause and Effect

Six Sigma focuses on data analysis, therefore the reliability of the data gathering systems used is very important before the analysis is conducted. Consequently, the agreement analysis of the measurement system by cell seal open judgment was performed to confirm the measurement accuracy performed by different inspectors. The generally accepted criterion is usually an assessment agreement score of more than 80%. Figure 4 shows the result of cell open judgment was 85% for attribute agreement analysis, and thus it met this criterion. Next, the process capability in current system level was computed. Figure 5 shows the Binomial Process Capability Analysis of seal open, and the result indicates that the process capability index was ZLT=3.2356, which means this process is a 3.2-sigma process for long term data, and therefore a 4.7-sigma process for short term data.
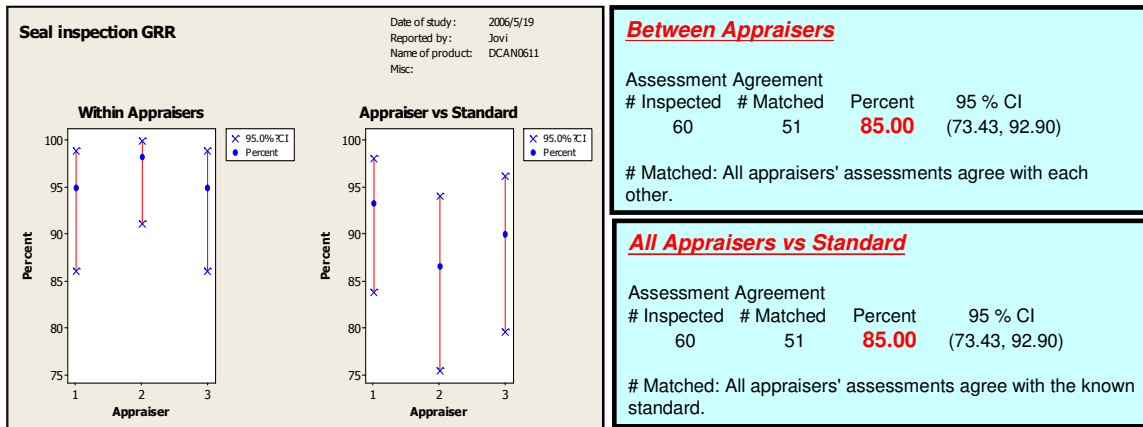
Figure 4. Seal Inspection GRR

Finally, combining the information from the process flow diagram with the cause and effect diagram, the Six Sigma team created a cause and effect matrix. By utilizing assessment indexes including the potential impact to Seal scratch, Seal open, Seal narrow, Seal deform and Bubble, the team member proposed total seven possible factors (X1-7) which they thought would impact project Y the most, and thus needed to be analyzed in the analyze phase. They were: initial speed (X1), initial accelerate/decelerate step (X2), corner speed (X3), corner accelerate/decelerate (X4), main seal dispense gap (X5), main seal dispense speed (X6), and main seal dispense pressure (X7). Table 1 shows the cause and effect selection matrix for the factors.
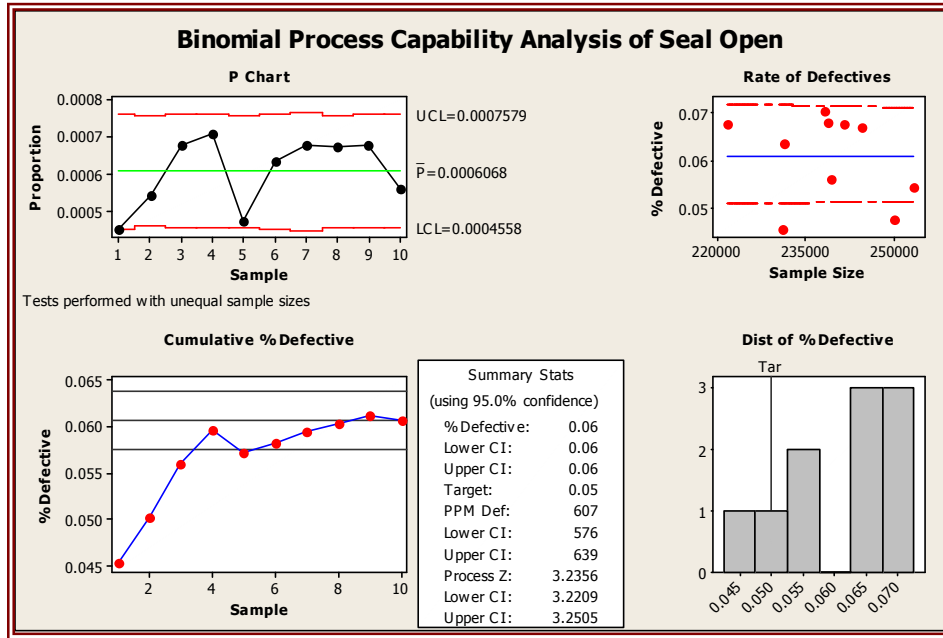
Figure 5. Binomial Process Capability Analysis Process of

Analyze Phase

In the analyze phase, these seven factors were divided into two groups to implement the design of the experiments (DOEs). Group 1included X1: initial speed, X2: (initial) accelerate/decelerate step, X3: corner speed, and X4: corner accelerate/decelerate; while and group 2 included X5: main seal dispense gap, X6: main seal dispense speed, and X7: main seal dispense pressure.

For group 1, the general linear model (GLM) was first used to analyze the data gained from the DOE results and the p-value of the model was not significant. The team members discussed why the model failed and found that the seal open defect rate was very low (baseline = 0.061%), meaning that the low resolution of data did not to meet the normal approaching requirement of np $\square$ 5. Therefore, they changed the analysis method to Binary Logistic Regression. This time they retained factors X2 and X4, as shown in Figure 6.

Table1. Cause and Effect Selection Matrix for Xs

0: No relationship

1: Minor relationship

3: Fair relationship

9: Strong relationship

		Priority	9	9	5	3	1	Total
			Seal scratch	Seal open	Seal narrow	Seal deform	Bubble	
No	Process	Input index						
1	Main Seal	Dispense height	9	9	9	9	0	234
2		Dispense speed	9	9	9	9	0	234
3		A_Time	1	9	1	3	0	104
4		SuckBack1	1	9	0	0	0	90
		Z raise height	0	0	0	0	0	0
.		Z raise speed	0	0	0	0	0	0
.		Pressure	9	9	9	9	0	234
	….	…	…	…	…	…	…	…

StdOrder	RunOrder	X1	X2	X3	X4
2	1	1	-1	-1	1
20	2	1	1	-1	-1
18	3	1	-1	-1	1
1	4	-1	-1	-1	-1
13	5	-1	-1	1	1
19	6	-1	1	-1	1
6	7	1	-1	1	-1
17	8	-1	-1	-1	-1
8	9	1	1	1	1
10	10	1	-1	-1	1
14	11	1	-1	1	-1
3	12	-1	1	-1	1
5	13	-1	-1	1	1
24	14	1	1	1	1
4	15	1	1	-1	-1
11	16	-1	1	-1	1
22	17	1	-1	1	-1
21	18	-1	-1	1	1
12	19	1	1	-1	-1
16	20	1	1	1	1
15	21	-1	1	1	-1
7	22	-1	1	1	-1
23	23	-1	1	1	-1
9	24	-1	-1	-1	-1

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P-value	Odds Ratio	95% CI Lower	Upper
Constant	7.08502	0.262223	27.02	0.000			
x1							
1	-0.139339	0.200457	-0.70	0.487	0.87	0.59	1.29
x2							
1	-0.462238	0.201717	-2.29	**0.022**	0.63	0.42	0.94
x3							
1	-0.108502	0.197607	-0.55	0.583	0.90	0.61	1.32
x4							
1	-0.325940	0.203926	-1.60	**0.110**	0.72	0.48	1.08

Log-Likelihood = -769.102
Test that all slopes are zero: G = 8.111, DF = 4,   **P-Value = 0.088**

Goodness-of-Fit Tests

Method	Chi-Square	DF	P-value
Pearson	23.0313	3	0.000
Deviance	21.0119	3	0.000
Hosmer-Lemeshow	22.9543	5	0.000

➢ x2   P-value = 0.022 < 0.05，significant.
➢ x4   P-value = 0.110 > 0.05，not significant。Because Sample Sizes of experiment are not enough, we retain the factor.

Figure 6. Logistic Regression of Seal Open vs Group 1

For group 2, one-way ANOVA was used to analyze the significance of factor Head, which was shown to be insignificant. Therefore we combined different data for different heads after testing that they were an insignificant factor by ANOVA. The new combined data was analyzed by the GLM model. We found X7 (covariate), X5*X6, and X5*X6*X7 were all significant, and the result are shown in Figure 7.

Finally, we retained five factors for use in the improve phase.

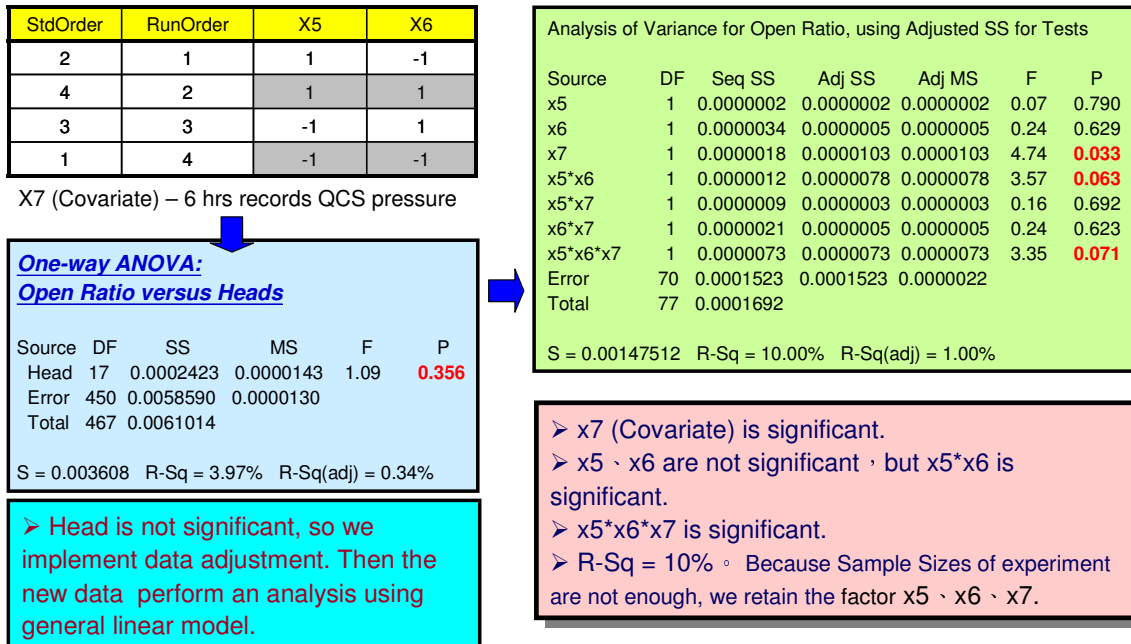| StdOrder	RunOrder	X5	X6
2	1	1	-1
4	2	1	1
3	3	-1	1
1	4	-1	-1

X7 (Covariate) – 6 hrs records QCS pressure

One-way ANOVA:
Open Ratio versus Heads

Source	DF	SS	MS	F	P
Head	17	0.0002423	0.0000143	1.09	0.356
Error	450	0.0058590	0.0000130		
Total	467	0.0061014			

S = 0.003608   R-Sq = 3.97%   R-Sq(adj) = 0.34%

➢ Head is not significant, so we implement data adjustment. Then the new data perform an analysis using general linear model.

Analysis of Variance for Open Ratio, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
x5	1	0.0000002	0.0000002	0.0000002	0.07	0.790
x6	1	0.0000034	0.0000005	0.0000005	0.24	0.629
x7	1	0.0000018	0.0000103	0.0000103	4.74	0.033
x5*x6	1	0.0000012	0.0000078	0.0000078	3.57	0.063
x5*x7	1	0.0000009	0.0000003	0.0000003	0.16	0.692
x6*x7	1	0.0000021	0.0000005	0.0000005	0.24	0.623
x5*x6*x7	1	0.0000073	0.0000073	0.0000073	3.35	0.071
Error	70	0.0001523	0.0001523	0.0000022		
Total	77	0.0001692				

S = 0.00147512   R-Sq = 10.00%   R-Sq(adj) = 1.00%

➢ x7 (Covariate) is significant.
➢ x5、x6 are not significant，but x5*x6 is significant.
➢ x5*x6*x7 is significant.
➢ R-Sq = 10%。 Because Sample Sizes of experiment are not enough, we retain the factor x5、x6、x7.

Figure 7. GLM Analysis of Seal Open vs Group 2 (with

Improve Phase

In the improve phase, we used a 24-1 fractional factorial design with two replicates and eight central points. After reducing, the model showed that the most important factors are (initial) accelerate/decelerate step, corner accelerate/decelerate, main seal dispense gap, main seal dispense speed, and main seal dispense pressure as a covariate factor. The DOEs were executed at three lines, ODF Line1 for product A, and ODF Line2 and Line3 for product B. The results of the DOE are shown in Figure 8. After that the response optimization outcome of the DOE was employed for the pilot run, with the results shown in Figure 9. The pilot run results show that the defect rate of the new parameters is far better than that of original ones. Moreover, a two proportion test shows that their difference is significant at p value = 0.000.
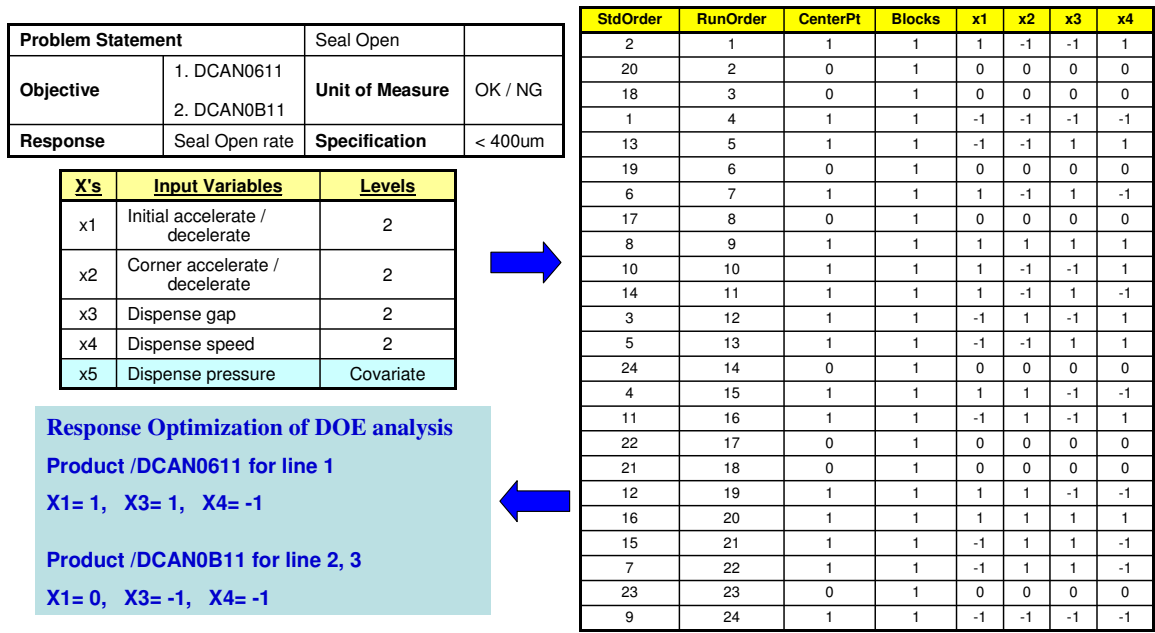
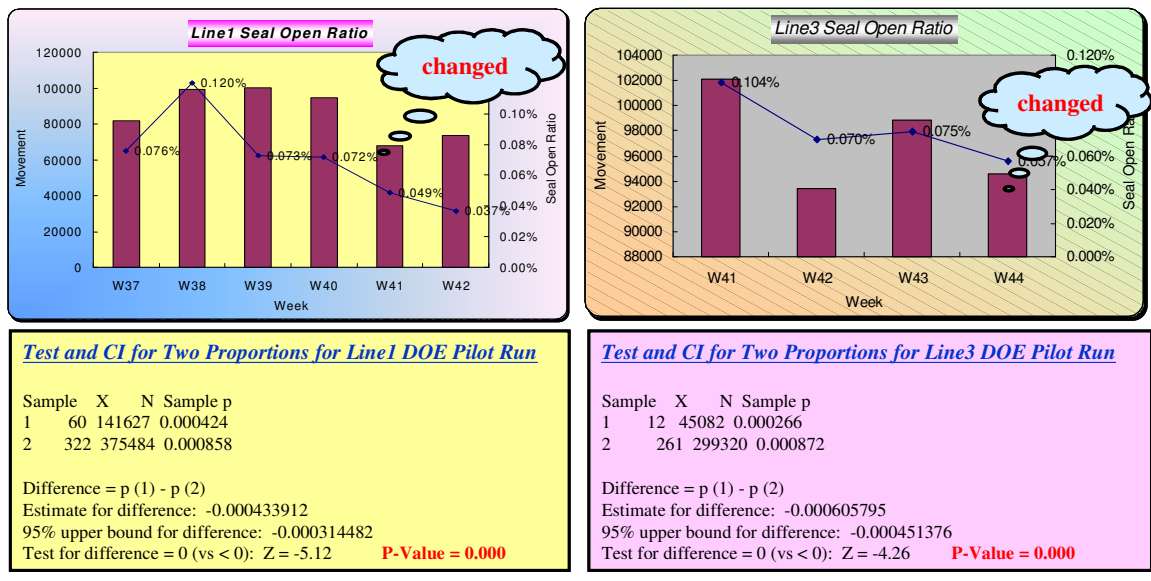| Problem Statement		Seal Open	
Objective	1. DCAN0611	Unit of Measure	OK / NG
	2. DCAN0B11		
Response	Seal Open rate	Specification	< 400um

X's	Input Variables	Levels
x1	Initial accelerate / decelerate	2
x2	Corner accelerate / decelerate	2
x3	Dispense gap	2
x4	Dispense speed	2
x5	Dispense pressure	Covariate

Response Optimization of DOE analysis

Product /DCAN0611 for line 1

X1= 1,   X3= 1,   X4= -1

Product /DCAN0B11 for line 2, 3

X1= 0,   X3= -1,   X4= -1

StdOrder	RunOrder	CenterPt	Blocks	x1	x2	x3	x4
2	1	1	1	1	-1	-1	1
20	2	0	1	0	0	0	0
18	3	0	1	0	0	0	0
1	4	1	1	-1	-1	-1	-1
13	5	1	1	-1	-1	1	1
19	6	0	1	0	0	0	0
6	7	1	1	1	-1	1	-1
17	8	0	1	0	0	0	0
8	9	1	1	1	1	1	1
10	10	1	1	1	-1	-1	1
14	11	1	1	1	-1	1	-1
3	12	1	1	-1	1	-1	1
5	13	1	1	-1	-1	1	1
24	14	0	1	0	0	0	0
4	15	1	1	1	1	-1	-1
11	16	1	1	-1	1	-1	1
22	17	0	1	0	0	0	0
21	18	0	1	0	0	0	0
12	19	1	1	1	1	-1	-1
16	20	1	1	1	1	1	1
15	21	1	1	-1	1	1	-1
7	22	1	1	-1	1	1	-1
23	23	0	1	0	0	0	0
9	24	1	1	-1	-1	-1	1

Figure 8. Result of DOE for A and B

Line1 Seal Open Ratio

changed

0.120%
0.076% 0.073% 0.072%
0.049%
0.037%

Line3 Seal Open Ratio

changed

0.104%
0.070% 0.075%
0.037%

Test and CI for Two Proportions for Line1 DOE Pilot Run

Sample   X   N   Sample p
1   60 141627 0.000424
2   322 375484 0.000858

Difference = p (1) - p (2)
Estimate for difference: -0.000433912
95% upper bound for difference: -0.000314482
Test for difference = 0 (vs < 0): Z = -5.12   **P-Value = 0.000**

Test and CI for Two Proportions for Line3 DOE Pilot Run

Sample   X   N   Sample p
1   12 45082 0.000266
2   261 299320 0.000872

Difference = p (1) - p (2)
Estimate for difference: -0.000605795
95% upper bound for difference: -0.000451376
Test for difference = 0 (vs < 0): Z = -4.26   **P-Value = 0.000**

Figure 9. Result of Pilot Run for DOE Response

P Chart of Seal Open

UCL=0.999670
P̄=0.999537
LCL=0.999404

Tests performed with unequal sample sizes
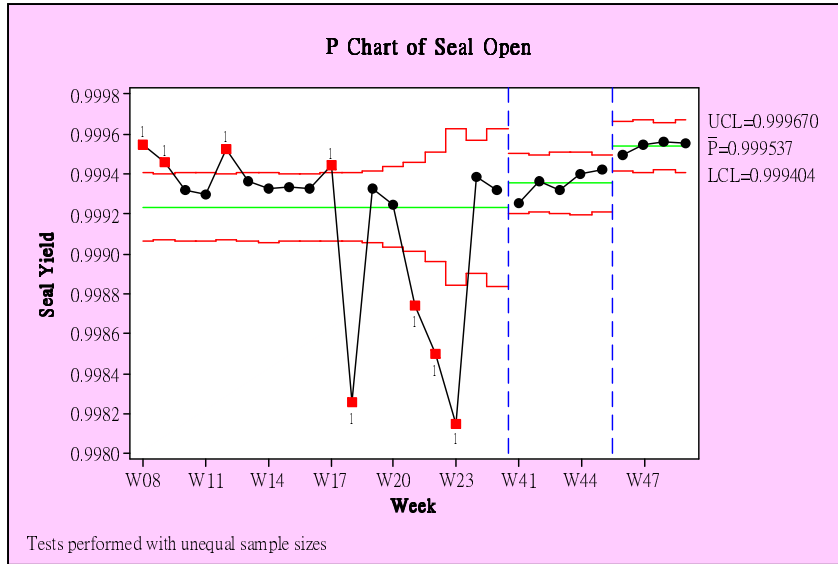
Figure 10. P Chart of Seal Open

Control Phase

In the control phase, we need to further maintain and control the project improvement performance after the improvement solutions have been proposed. A control plan concerning all the critical steps, critical factors and critical process parameters was established according to the findings from the hidden factory and Lean production discussion in the measure phase, the critical factors and FMEA result in the analyze phase, and the results f the DOE in the improve phase. The control plan contains a p-chart of the seal open defect-free rate to monitor the process, and the data is shown in Figure 10. In addition, all the related documents, such as FMEA, standard operation procedure, drawings, training material, process check list, and so on, were also revised at this point based on conclusions from previous phrases.

Project Realization

This project used Six Sigma methodology to carry out the target improvement within six months, and the results demonstrate that the project managed to achieve the goal that was set in the define phase of the DMAIC process. After four months since the project was closed, the financial saving from this project was NT$14.6M, and may be estimated nearly USD 1,500,000 annually.

Discussion

Although the case company has been engaging in improvement projects for years, it was afraid of failure in implementing Six Sigma projects at the beginning. However, these projects were extremely successful. Thus the case company decided to continue implementing Six Sigma projects over the long run. Five features are worth noting from this project:

First, the projects were carefully and systematically chosen to coincide with the company's long-term development. From the champions' first proposed projects according to their department's KPI, the projects most important and relevant to KPI were selected. On one hand, the success of these projects can be coincided with the strategy of the company. On the other, resource could be committed because the coincidence with KPI and the improved process can be assured to proceed.

Secondly, project teams were formed to work with these projects. Appropriate Black Belts and also cross function teams were chosen to work with collective wisdom and concerted efforts. In addition, these projects were important opportunity to train the BBs how to be better leaders in this context.

Thirdly, a SMART (Specific, Measurable, Aggressive yet Achievable, Relevant to corporation goal, Time-bounded) goal was set in each project. Setting a 70% improvement means

that it is achievable during a six-month project period. After the project goal is achieved, another project can be initiated to continuously improve quality of the same product.

Fourthly, the pursuit of the true causes of the defects was systematic and data driven. The DMAIC stages were employed, and statistical data analysis was used to find the reasons for the defects.

Lastly, a long-term monitor and control process was implemented to ensure the improvements could be maintained for a long time. Relevant SOP and documents were collected and distributed, possible error-proof measures were carried out, and an integrated process control was made and applied.

Conclusions

Increasing competitive pressure from global markets and technological developments has resulted in the continual demand for improvement methodologies in operations management, and TFT-LCD manufacturing is no exception to this trend. As manufacturers establish the higher generation TFT-LCD production lines, the key competitive advantages of this industry vary from mass-production to low cost, diverse product and application mix and technology leadership.

This paper deals with an application of Six Sigma to reduce the seal open defect rate. The DMAIC phases (Define, Measure, Analyze, Improve, and Control) are utilized in the case company. At first, the project goal was set and the related financial savings were estimated. Process maps, Measure Systems Analysis (MSA), process capability analysis and the potential factors for seal open issues were investigated in the measure phase. The data gathered was then analyzed statistically, using a proportion test, ANOVA, covariate analysis, and logistic regression in the analyze and improve phases. Critical factors were found and consequently the seal open defect rate decreased significantly, to even lower than the original goal.

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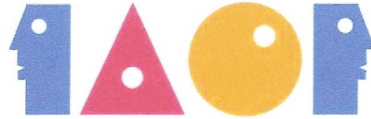
WHY ORGANIZATIONS FAIL:
A CONVERSATION ABOUT AMERICAN COMPETITIVENESS

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Abstract

This paper offers a systemic organizational solution to the problems encountered by the U.S. government departments and corporations that the United States federal government has recently had to bail out. It also extends the applicability of a systemic organizational theory, called *Requisite Organization Theory* (Jaques, 1996) and *General Theory of Managerial Hierarchy* (Jaques, 2002). Ivanov recently expanded this work while conducting organizational studies in the U.S. Department of the Army and private corporations since 2000. Over the past fifty-years, this systemic research has been carried out and tested in the U.S. Army, Church of England, national and international corporations (Rio Tinto, Bank of Montreal, others), foreign governments, and organizations.

There is a bleeding wound within our large organizations, in the organizational system itself, in all corporations and government departments alike, slowly undermining society. This bruise fails good leaders and capable CEOs. It demolishes good institutions within our democratic societies because it diminishes trust in the organization and trust between people. Having become an invisible and silent trauma, the organizational system fails us individually and collectively in cloaking the workplace in suspicion and mistrust, resulting in low productivity.

There is an alternative. Instead of mistrust and suspicion our organizations generate because of systemic faults, we could redesign our organizations based on new scientific principles. This would increase trust in the organization and people, and create a healthier and more productive workplace. Citizens and national leaders must start noticing this anguish, starting with a realistic self-assessment and reevaluation of their organizations – systems presently not designed to succeed.

Keywords: Organizational Failure, Competiveness, Requisite Organization Theory

Introduction

"Organizations, worldwide, … treat employees like commodities, generate general suspicion and mistrust, undermining self-esteem, generate conflict over compensation and in interpersonal relationships, cause unnecessary suffering for employees and their families, undermine the good society, and withal, reduce the potential productivity and effectiveness of even the best companies to 50% of what they might achieve."

Elliott Jaques, 2002

Organizations often fail because of catastrophic malfunctions in structure. These malfunctions are difficult to notice because of time delay in organizational cause and effect. Time flows differently in organizations than in the physical world. For example, when a ship sails, or a rocket is launched, it is easier to see the cause and effect within days/months or minutes/seconds. When the CEO of a large corporation makes a decision, the effects are often not clear for years or even generations from when the decision was made.

CEO decisions about the future of their enterprises are the most critical factors in any organization's survival. For example, a CEO's decision to invest $100M today to develop a new geopolitical region would not provide clear results for at least ten years. This investment decision would include analyzing the types of economic developments (commercial or industrial) that might occur, predicting the type of investments adjacent countries would make, travel patterns that would emerge in ten to twenty years in the region, to deciding the terms of the investment, risk, and other compounding factors.

If the decision in year 0 is wrong, the organization will deal with a crisis in year 10. By this time, the people who made the decision may likely have already left the organization. In year 10, no one remembers how the organization even got into the "current" crisis.

We make such decisions every day in our organizations, at every organizational level. They are most profound when they occur at senior levels. When incorrect, these decisions lead the organization from one crisis to the next. This problem is compounded by the time-delayed crises of the year 0 decisions in larger societal, economic, military, political, and organizational systems.

Year 0: Decision Made   *Time of Cause and Effect*   **Year 10: Cause and Effect**

Figure 1. Example of an Organizational Time Impact of a Ten-Year Decision.

Wrong structure of the organization is even more difficult to link to failures even when the CEO makes good decisions. U.S. Army General Max Thurman said that the U.S. loss in Vietnam was partly because of the incorrect structures of the U.S. battalions. He argued that the Vietnamese battalions of 300 troops were far more effective than the larger U.S. battalions of 900 troops. This organizational structure contributed to the overall failure of possibly good decisions at the strategic levels (Carnegie, 2008).

The question then becomes how can organizational structures sabotage good strategic decisions, and why? The author's research shows that improper structures prevent organizations from succeeding by pulling down and collapsing the organization, stagnating it from one crisis to the next.

Paradoxically, each person wants to do his or her best in the workplace. The structures of our organizations do not allow this to happen because they constrain the person into a too limiting role. This forces the person to work at 5 to 30% (at best) of his or her capability, creating massive underemployment and all kinds of symptomatic behaviors within our

organizations. This workplace arrangement contributes to the healthcare crisis in the United States by deteriorating the long-term health of employees and their families (Lynch, 2000), (Wilkinson, 1996). For example, when people are perennially stressed and depressed, they overeat and develop unhealthy behaviors, leading to obesity and health disorders. Jackson, Knight, and Rafferty (2010) write that people resort to unhealthy behaviors (overeating, smoking, drugs, substance abuse) to help alleviate stress. Some lose a will to live (Harvey, 1999), (Lynch, 2000).

The data from a recent study of a U.S. federal organization (Ivanov, 2011) showed that close to 40% of employees felt underemployed.
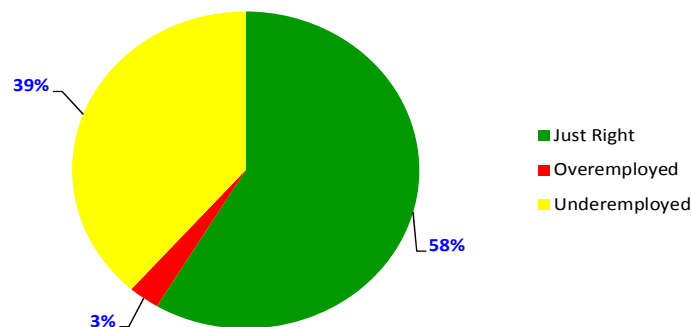
Figure 2. Underemployment, a U.S. Federal Government Organization.

During the study, Ivanov surveyed each employee how he or she felt about the level of work in the role. Close to 40% of people admitted that they were underemployed and could work at higher-levels. This finding is consistent among multiple studies, and confirms Jaques' findings (2002). Conducting a similar study in European and American corporations, Ivanov (2006) found that 50% of employees felt underemployed at work:
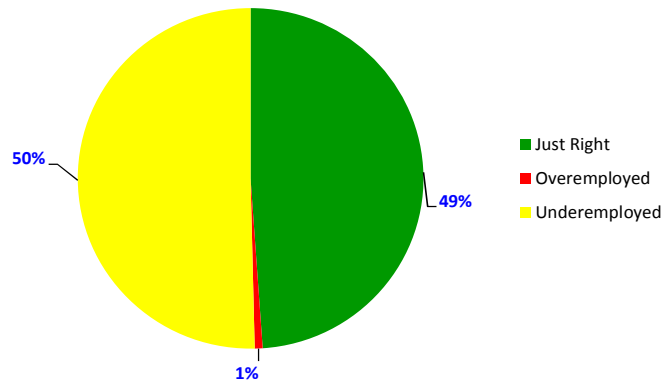
Figure 3. Underemployment, U.S. and European Corporations.

When people cannot work and contribute productively, they feel demoralized and wasteful. The person feels that the organization does not value and care. Employee, in this mode, cannot be fully engaged, innovative, and productive.

Furthermore, this data is understated because many employees are afraid to report honestly how underemployed they really are in the places of their employment because of the fear that the data could be reported back to their managers. Ivanov, working with graduate business students, mostly MBAs, asked the same question during his graduate business courses. In this setting, there was no relationship between the person's answer and the employment organization. The students, who have been employed fulltime in government, military, and corporate structures, admitted much higher levels of underemployment in the workplace.

The crisis that disintegrated the former Soviet Union in the 1990s, organizationally, was no different from what is happening with many United States organizations today. The United States may have a higher propensity to handle the crisis because it has private corporations, which, despite oppressive structures, innovate to survive, disappear from the market, or get

bailed out by the U.S. government. The U.S. federal and state governments, however, have no option to disappear or be bailed out despite its failing organizations (organizations that produce little and are wasteful).

The Soviet Union disintegrated partly because all of its organizations were state-run, dysfunctional, and constraining. Identically, they suffered from role compression, double-talk (Sharansky, 1998), and depression. Lower-level employees painfully observed their organizations falling apart because of inept higher-up management structures. These non-performing organizations contributed to Taleb's *Black Swan* crisis (2007), unpredictably disintegrating the former U.S.S.R. and most of its organizations. People were left out of work, and many had to leave the country. To many, it was a catastrophe because they lost jobs and means to earn a living. Recent and unexpected U.S. bankruptcies of major corporations, such as Lehman Brothers, high-levels of unemployment, outsourcing of manufacturing and other jobs abroad are modern crises in contemporary America.

Dixon (1976) studied incompetent leaders and leadership structures of the western militaries, finding similar dysfunctions. The U.S. departments of the federal and state governments suffer from identical systemic issues, all of which are addressable. Thus, these structures require analysis and optimization to free people to work effectively.

Ivanov has studied these systems since 2000, in European and American corporations, and agencies of the U.S. federal government (2006). He collected data and analyzed several headquarter organizations of the U.S. Department of the Army in 2007-2009 (2011). Ivanov developed a structured survey to gather data, in accordance with the General Theory of Managerial Hierarchy (2006). This data assesses the structure of all organizational roles by work levels.

The analysis shows that many organizations are compressed. For example, in one large organization, strategic executive roles were pushed down into the low mid-management level (Ivanov, 2011). Thus, no strategic work was done by this organization.

The current financial bailouts will not solve these types of organizational crises because we have not changed how our government and corporations function fundamentally. The latest solution to bail out and create more oversight over the failing structures is flawed because it would create another dysfunctional management layer over our already suffocating and failing organizational structures. Replacing senior management of failed corporations may not help because the system would remain the same and could become even worse.

Fixing our organizations and government departments is a solution that America drastically needs. Rethinking organizations based on new scientific principles, described later in this paper, could increase American productivity from an average 20-25% percent to over 80-90% percent. This would offer a way out by healing a major flaw within the capitalist democracy: its poorly designed organizations.

Jaques (1950s—2002) discovered a universal structural pattern appropriate to all hierarchical organizations, such as corporations, government departments, combat military, and others. This model reflects how work varies in terms of its underlying complexity from level to level (Clement, 2008). Understanding this arrangement, in turn, permits one to describe how these organizations actually function in reality. Disregarding this structure generates substantial internal stress, which culminates in undermining the organization and society in general (Clement, 2008). This failure, however, does not come instantly. Rather, it surfaces at much later dates. In effect, these failures are time-delayed.

The following table reflects the universal structure of all hierarchical organizations by work levels (strata):

Table 1. Universal Structure of Hierarchical Organizations

Stratum	Type of Company	Example	Annual Revenue, *Comments*
9	N/A	N/A	*Organizations of this type do not exist (have not been found yet).*
8	Large Multi-National	Exxon-Mobil, GAZPROM, Shell, U.S. Department of Defense	Over $100B/year
7	Multi-National	Google, Apple, Oracle	$10 to $100B/year
6	N/A (long-term)	AOL	*Stratum 6 corporation is unstable, and would either grow to Stratum 7, or fall apart into stand-alone Stratum 5 companies.*
5	Business Unit of a Multi-National, or a Stand-Alone Company	Most Universities	$100M to $1B/year
4	Small Business Unit or a Stand-Alone Company		$10 to $100M/year
3	Small Stand-Alone Small Business		$1 to $10M/year
2	Mom-and-Pop Shop		up to $1M *These "shops" are inherently unstable; they either fall apart, or grow to higher strata.*

According to this pattern, a stable and viable organization could have the top role (usually, CEO or President) in stratum 3, 4, 5, 7, or 8. There are no stratum 9 corporations. Expanding Jaques' theory, the author's research suggests that no stratum 6 corporation could survive long-term, and would either grow to stratum 7, or split into smaller stratum 5 companies.

A stratum of work determines the level of work in the role (complexity of work in the role), and the level of decision-making in that role. At the higher organizational strata, executives must adopt a longer and longer planning horizon (time span of 10-20 years) if their corporations are to succeed in the long run (Clement, 2008). This longer focus encompasses dealing with strategic uncertainty found at these levels (Raynor, 2007).

In a compressed organization, most people function in lower-strata roles. They focus on short-term solutions, without creating strategic plans for a longer future. The short-term solutions may be adequate for smaller organizations, but not for larger and especially mega-organizations, such as the United States federal government, or large multi-national corporations.

For example, the structure of a stable stratum 7 company always has six management levels:
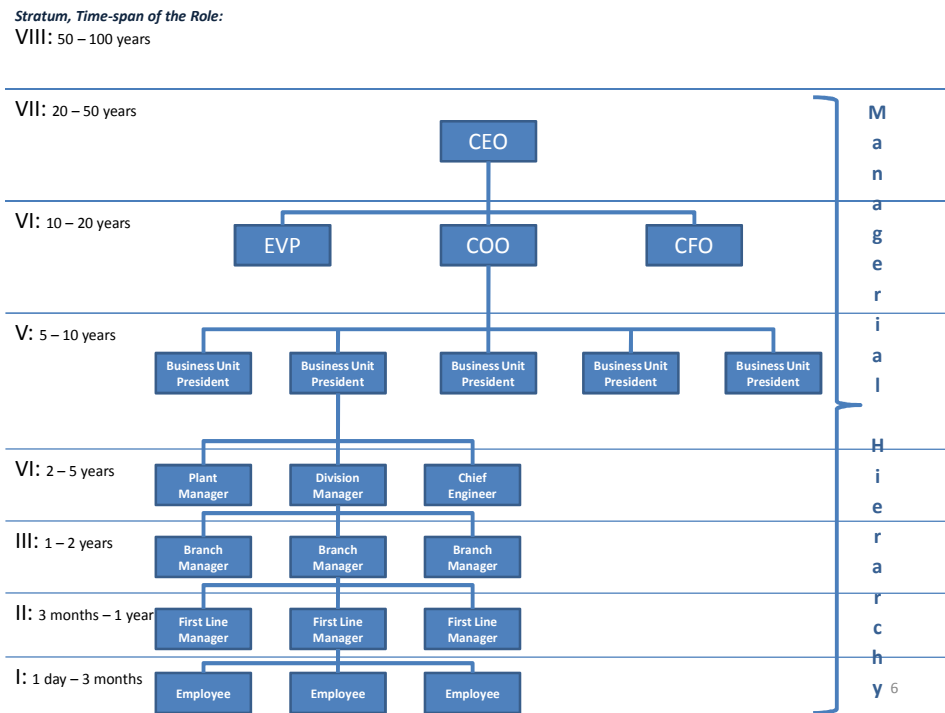
Figure 4. Optimal Hierarchical Structure of a Stratum 7 Organization.

In this structure, each managerial level adds value, and the entire organization works effectively to support the work of the CEO. The stratum 7 CEO makes decisions based on *generational thinking*, developing plans and strategy for next generations of customers, technology, and the next frontier. This would be the longest task in the role, defined as *time-span of the role* (Jaques, 1996). For example, the education executive would think about the next generation of incoming students into the school system. The military executive would plan for the next generation of weapon systems, and the upcoming new generation of troops, Generation Z versus Generation X. The corporate executive would think about the next generation of products, next generation of customers, and other future strategic positions. The decisions that these executives make get carried out effectively by the internal organizational systems.

Unfortunately, studies show that this structure is a rare occurrence in modern corporations or government departments ((Ivanov, 2006), (Ivanov, 2011), (Clement, 2008), (Jaques, 2002)). Most organizations have either too many levels or too few. Both arrangements lead to organizational role compression:
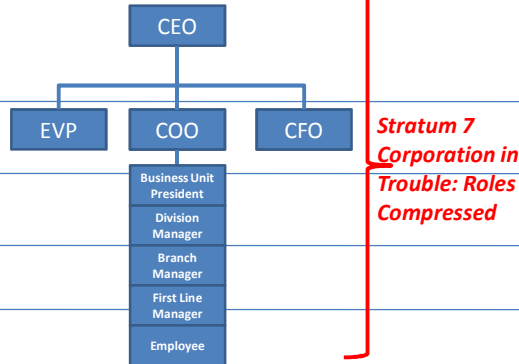
Figure 5. Common Problems in Hierarchical Structures: Compression.

The above structure defeats the stratum 7 organization, and compresses its work to a stratum 5 business unit, causing multiple reorganizations. Eventually, it fails the organization. Functioning at a lower stratum, this corporation has effectively stopped developing new strategic business units (Clement, 2008), working on new groundbreaking products and innovations, and thinking about the next generations of products, customers, and markets. Its current organizational structure is filled with conflict, and consists of pervasive double-talk, mistrust, and fear. Eventually compression leads to stagnation and failure. Managers breathe down the necks of their subordinates, and subordinates, in fear, submit to *bull* (Dixon, 1976) and non-value added work (Clement, 2008). Within a few years, this company will have failed by losing its market share, and may be bought by another corporation.

This is the most common problem that faces all western corporations and governments. Pumping more money into this organization through the bailout strategies simply delays the inevitable crash. Any rescue package must include a structural redesign that would allow the organization to succeed and innovate by raising the level of work of all employees. Hersberg's *job enrichment* and Argyris' *job enlargement* (1957) are comparable, but less precise ideas on how to increase the level of work in employment roles.

The compressed organizational structure (figure 5) is unworkable, suppressing, and unstable, causing multiple reorganizations, and ultimately time-delayed future crises. Taleb (2007) describes these types of organizational crashes as unanticipated and unpredictable Black Swan events. No one can work productively because of system-imposed conflicts, creating a volatile and non-desired future.
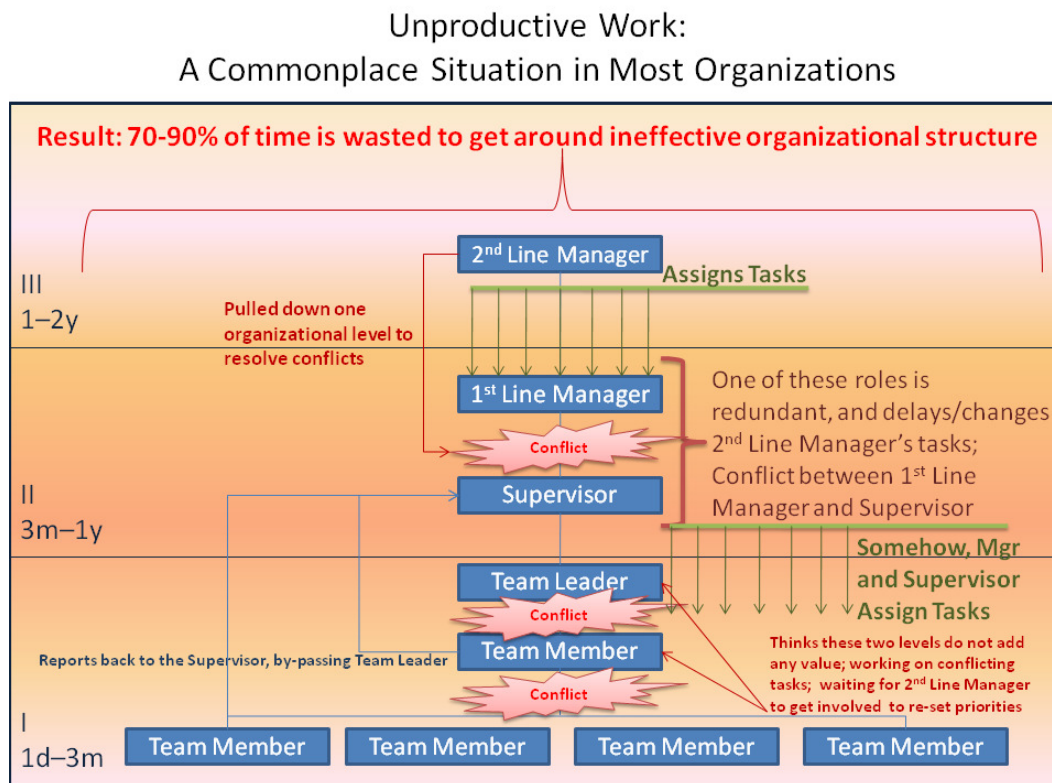
Figure 6. Compression Conflicts.

Compression does not allow people to work, and stagnates the organization. It collapses the work structure and extinguishes productive energy to deal with unnecessary and avoidable conflicts, non-value-added tasks (for example, unnecessary meetings, daily progress reports), and crises. Managers and subordinates do not work effectively because the manager does not add value to the work of the subordinate.

In a compressed organization, the manager and subordinate are often required by the organization to work within the same stratum. For people to work effectively in a hierarchical organization, the manager and subordinate must be one stratum apart because this structure creates a value-added relationship. If there are too many levels, the organization begins to stagnate.

The best way to solve this type of a major design flaw is to take a time-span-based snapshot of the current organizational structure to discover extra and missing layers. On this basis it is possible to rethink whether the roles are in their proper levels, and increase the level of work in all organizational roles as needed. Research in the U.S. Department of Defense and private corporations shows that this type of a diagnostic is easily achievable (Ivanov, 2008), (Clement, 2008). In a properly designed organization, each work stratum adds value, and eliminates conflicts.
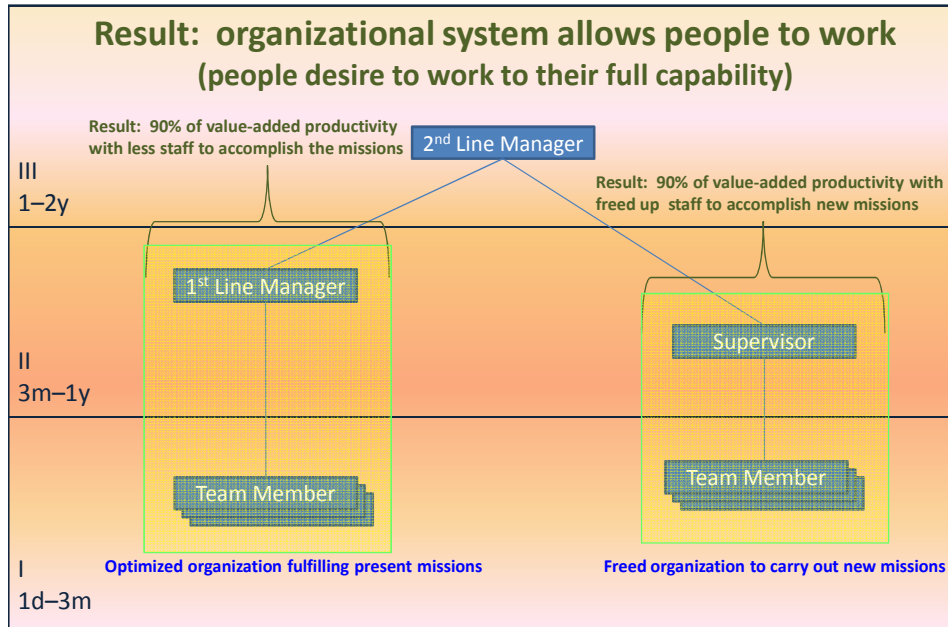
Figure 7. A Properly Designed Organization.

This organization is structured for optimal performance. Theoretically, this design could boost organizational productivity from 5-30% to 80-90% systemically because it eliminates bull and frees people to work productively. This organizational system is based on the scientific stratification of work of value-adding manager-subordinate relationships. The organizational design embeds trust between people because the manager and subordinate are working together to achieve common goals free of organizational absurdity and discord.

Instead, most organizations and government departments "resolve" conflicts by creating additional, duplicative, management structures, which compress the organizational work levels further. Draining organizational resources and people, these false solutions increase conflict and lower productivity.

In war, the improper organization leads to casualties and defeat (Dixon, 1976). In peacetime organizations, the casualties, the long-term health impacts on employees and their

families (Lynch, 2000), (Wilkinson, 1996), and organizational meltdowns are time-delayed, invisibly threatening and undermining the democratic societies.

In order to begin to address the healthcare costs, economic and political crises, and trust in the society and organizations, it is not enough to channel new money into the economy by funding organizations structurally designed to fail. It is imperative to restructure the organizations and government departments for effective work relationships, resulting in healthier and more productive systems and individuals. Proper organizational design could increase American competiveness to get the country out of the current crisis, increase trust in the workplace, and help preserve the democratic societies to withstand and prevail through well-designed, healthy, and reliable organizations.

End Note

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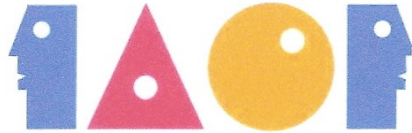
EXPLORING THE RELATIONSHIP BETWEEN CUSTOMER INVOLVEMENT, BRAND EQUITY, PERCEIVED RISK AND CUSTOMER LOYALTY: THE CASE OF ELECTRICAL CONSUMER PRODUCTS

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Abstract

Literature reviews supported the concept that customer involvement, brand equity and perceived risk are significant factors to affect customer loyalty. However, very limited studies have extensively examined the relationship among those variables. This quantitative study was to comprehensively examine the relationship between customer involvement, brand equity, perceived risk and customer loyalty for customers. The population for this research was identified as the consumers having the shopping experience for digital camera. The findings supported the hypothesis that customer involvement, brand equity, and perceived risk have significant and positive relationship to customer loyalty. The findings also identified the predictors of customer involvement, brand equity, and perceived risk on the customer loyalty, and generated the recommendations for corporate operations and future scholar studies.

Key Words: Customer Involvement, Brand Equity, Perceived Risk, Customer Loyalty, Electrical Consumer Product

Introduction

Customer involvement, brand equity, perceived risk and customer loyalty have been recognized as effective tools for building corporate competency in business world, while customer loyalty has been regarded as the key indicator for customer retention, and have been discussed in the academy field to explore customer behavior. Jones and Sasser (1995) recognized the customer involvement is a significant factor to influence customer behavior and argued the different level of customer involvement will affect customer purchasing behavior. Tong and Hawley (2009) stated building a successful brand image will enhance companies' profitability and revenue, and bring the industry's strong competitive benefit. Bauer (1960) stated perceived risk of customer will influence purchasing behaviors and purchasing policy from customers. Garretson and Clow (1999) claimed customers sense different risks when purchasing goods or services. Customer's purchasing desire will decrease when customers perceive higher purchasing risk. Customer loyalty has been explained as a psychology tendency, while this tendency will drive customers to repeatedly purchase the same brand goods or services during the period, reduce the possibilities to switch other companies' goods or services, and improve the company's profit in long term.

Previous studies revealed that customer involvement, brand equity, perceived risk may have significant impacts on customer loyalty, while very few studies have examined the relationship among customer involvement, brand equity, perceived risk and customer loyalty, or how customer involvement, brand equity, and perceived risk affect customer loyalty. The issues for the relationship between customer involvement, brand equity, perceived risk and customer loyalty remain unclear. Therefore, the main purposes for this study are: (a) to comprehensively examine the relationship between customer involvement, brand equity, perceived risk and

customer loyalty, (b) to generate the recommendations for managerial application for the business of electrical consumer products, and(c) to identify areas for future scholarly inquiry.

Literature Review

Customer Involvement

Engle, Blackwell, and Miniard (1982) suggested involvement is a psychology stratification plane for encouragement, awareness, and interest. Smith and Hunt (1978) recognized the involvement is a specific process that will be influenced by external changing factors (product, communication, or situation) and internal changing factor (enduring ego) from past experience. The status will affect the different level of care or consideration for researching, processing and pursuing (interest) by customers. Mittal and Lee (1998) suggested the six dimensions for the resource for involvement are product value, brand value, recreation, brand recreation, brand risk, and product function. Laurent and Kapferer (1985) also stated four dimensions for involvement are: (a) the importance of product, (b) risk awareness for purchasing, (c) symbolization or value, and (d) hedonic value. Greenwald and Leavitt (1984) recognized the involvement as the degree of personal concerns for the subjects based on personal need, value, and interest. Zaichkowsky (1985) suggested three factors for affecting involvement, such as personal factors, product stimulus, and situation.

Brand Equity

Brand usually is being defined as the individualized characters or symbols to <u>distinguish</u> the products or companies from others. Boyd, Walker, and Larreche (1995) claimed Brand is also including product name, product symbol, and trademark. Further more, Kotler (1997) stated the brand itself possesses the concept of the copyright. Ailawadi and Keller (2004) defined Brand Equity as the profitability effect for leveraging asset and liability which related to product

name, symbol, and brand. The measures for brand equity are existing lots of debates. Some brand equity models are provided by scholars, the most common brand equity model was defined by Aaker (1991). This model has been empirically applied in previous researches (Atilgan, Aksoy, and Akinci, 2005; Kim and Kim, 2004; Yoo, Donthu, and Lee, 2000). This model is stated that brand equity encompasses five dimensions, such as brand awareness, perceived quality, brand royalty, brand association, and other proprietary asset. Aaker (1996) also stated "The Brand Equity Ten" which encompassed five major categories related to buyer and market conception. The five major categories are including loyalty, perceived quality, associations, awareness, and market behavior.

Perceived Risk

Cox (1967) stated customer will perceive risk when the purchased goods or services are under expectation. Many scholars tried to identify the definitions for perceived risk. Baird and Thomas (1985) identified the definition of perceived risk as the consumer's subjective evaluation when purchasing commercial goods. Woodside (1968) suggested perceived risk should encompass three factors, such as social, function, and value, while Rouslius (1971) argued three more factors should be added to the scope for perceived risk, such as time, ego, money. Peter and Tarpey (1975), and Brooker (1983) suggested perceived risk encompassed two dimensions, such as: (a) non-personal factors (the expectation for product function): financial, function, hard or soft ware, and time risk, and (b) personal factor: psychology and social risk. Assael(1994), and Dowling and Staelin (1994) suggested personal characteristic will result in different degree for perceived risk. Clow, Baack, and Fogliasso (1998) also argued the intangible property for service goods will bring more risk awareness for customers.

Customer Loyalty

Customer loyalty referred to the customer's attitude which affects to purchase the same brand products (Tellis, 1988). Oliver (1997) claimed the customer loyalty will drive customers to buy the same brand products under the changes for competitors' benefit offers. Jones and Sasser (1995) indicated the customer loyalty is the behavioral intention to maintain the relationship between customer and service suppliers. Therefore, the customer loyalty may refer to the attitude that customer's desire and behavior to purchase the produce or service repeatedly. Muller (1998) pointed customer loyalty may help company to maintain and develop the market share. Sirohi, Mclaughlin, and Wittink (1998) stated customer loyalty may be represented by customer satisfaction. Zeithaml, Berry and Parasuraman (1996) suggested the dimensions to measure the customer loyalty are including recommendations to others, complains, the attentions to pay more, and the possibility to transfer to other companies.

*The Relationship among Customer Involvement, Brand Equity, Perceived Risk
and Customer Loyalty*

Zeithaml et al. (1996) suggested customer loyalty is one important facet of behavioral intentions by customers. Petty and Cacioppo (1983) argued higher involved customers will result in higher customer loyalty. Oppositely, lower involved customer will not pay much intention on brand choice, function evaluation, research process. Keller (1993) argued brand image have significant impact on buyers' customer behavior, such as loyalty. Murray and Schlacter (1990) claimed the purchasing desire of customer will increase when customer's perceived risk is decreasing. In the other words, perceived risk will directly affect customer loyalty. Some studies examined some important factors may affect the customer loyalty. However, very few studies have extensively examined the relationship among customer involvement, brand equity, perceived risk and customer loyalty. Previous studies revealed that there is a significant

relationship between customer involvement, brand equity, perceived risk and customer loyalty. Therefore, the basic theory concept for building the research hypothesis in this research is: Brand equity, marketing mix strategy, and service quality have significant and positive relationship to customer loyalty.

Methodology

Instrumentation

Four instruments were adopted in this study: Consumer Involvement (10 items), Brand Equity (7 items), Perceived Risk (4 items), and Customer Loyalty (6 items). The *Consumer Involvement* Questionnaires are based on the definition by Kabferer and Laurent (1993)'s CIP theory (Consumer Involvement Profile), which encompasses five dimensions, such as interest (3 items), pleasure (2 items), sign value (2 items), perceived risk important (1 item), and perceived risk probability (2 items). The *Brand Equity Questionnaires* are based on the definition by Aaker (1991)'s 5 factor model, while this research adopted four dimensions, such as Brand Awareness (1 item), Brand Association (2 items), Perceived Quality (2 items) and Brand loyalty (2 items) for examining the perception of brand equity by customers. The *Perceived Risk Questionnaires* were modified from the model by Peter and Trapey (1975) and Brooker (1983), which encompasses three dimensions, such as finance risk (1 item), function risk (1 item), and social risk (2 items). The *Customer Loyalty Questionnaires* were modified from the Behavioral Intentions Battery questionnaire developed by Zeithaml, Berry, Parasuraman (1996) and were encompasses four dimensions, such as Repeated Purchase(1 item), Price toleration (2 items), Recommendations (2 items) and cross purchase (1 item).

Population and Data Collection

The consumers who have had the shopping experience for digital camera have been selected as an acceptable population for this study. To ensure the response rate, this research applied the method of convenience sampling based on anonymous survey. After contacting with available person agreeing to participate this research, the researcher distributed the hard copy of questionnaires to participants directly. A total of 220 consumers have had participated this study. After deducting 30 invalid response, the total number of valid responses was 190, providing an adjusted response rate of 86 %.

Validity and Reliability

The researcher examined the content validity and construct validity to discuss the validity issues for this research. The design of the questionnaires were based on the academy theory or existed questionnaire developing by scholars or specialists to improve the content validity, and applied Factor Analysis following Varimax Rotation method to examine the construct validity and to reduce the dimensions for assessing the validity issue for questionnaires. The research also examined the internal consistency as an estimate of reliability for questionnaires. The result of factor analysis of consumer involvement was summarized in Table 1, and resulted in two dimensions named Personal Interest and Mistake Probability. The values of KMO test value (>.8), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the questionnaires are reasonable. The internal consistency as an estimate of reliability of the two parts of questionnaires ranged from .708 to .893.

The result of factor analysis of brand equity was summarized in Table 2 and resulted in two dimensions named Brand Acceptance and Brand Value. The values of KMO test value (>.8), Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the

questionnaires are reasonable. The internal consistency as an estimate of reliability of the

questionnaire is .890

Table 1: Factorial Validity and Scale Reliability of Consumer Involvement

	Factor1	Factor2
	Personal Interest	Mistake Probability
Interest 1-3	0.782-0.801	
Pleasure 1-2	0.744-0.790	
Sign 1-2	0.678-0.795	
Important1	0.508	
Risk1-2		0.852-0.857
Eigen value	4.827	1.424
% of variance	48.273	14.237
Cumulative%	48.273	62.510
Cronbach's	0.893	0.708

Total: 10 items; KMO=.864, Cronbach's=.869, sample size=190

Table 2: Factorial Validity and Scale Reliability of Brand Equity

	Factor1	Factor2
	Brand Acceptance	Brand Value
Awareness1	0.804	
Association1-2	0.818-0.853	
Quality1-2	0.649-0.757	
Loyalty1	0.650	
Loyalty2		0.931
Eigen value	4.282	0.742
% of variance	61.168	10.606
Cumulative%	61.168	71.774

Total: 7 items; KMO=.898, Cronbach's=.890, sample size=190

The result of factor analysis of perceived risk was summarized in Table 3 and resulted in

two dimensions named Social Risk and Value Risk. The values of KMO test value (>.7), Bartlett

test (<.05) and factor loading values (>.5) demonstrated the construct validity for the

questionnaires are reasonable. The internal consistency as an estimate of reliability of the two

parts of questionnaires ranged from.760 to .790.

Table 3: Factorial Validity and Scale Reliability of Perceived Risk

	Factor1	Factor2
	Social Risk	Value Risk
Finance1		0.786
Function1		0.914
Social 1-2	0.836-0.900	
Eigen value	2.564	0.729
% of variance	64.106	18.232
Cumulative%	64.106	82.338
Cronbach's	0.760	0.790

Total: 4 items; KMO=.734, Cronbach's=.810, sample size=190

The result of factor analysis of customer loyalty was summarized in Table 4 and resulted

in two dimensions named Recommendation and Loyalty. The values of KMO test value (>.8),

Bartlett test (<.05) and factor loading values (>.5) demonstrated the construct validity for the

questionnaires are reasonable. The internal consistency as an estimate of reliability of

questionnaires ranged from .756 to .844.

Table 4: Factorial Validity and Scale Reliability of Customer Loyalty

	Factor1	Factor2
	Recommendation	Loyalty
Repeat		0.533
Price1-2		0.794-0.902
Recommendation 1-2	0.859-0.873	
Cross	0.765	
Eigen value	3.452	0.926
% of variance	57.533	15.437
Cumulative %	57.533	72.970
Cronbach's	0.756	0.844

Total: 6 items; KMO=.812, Cronbach's=.851, sample size=190

Based on the theory concept and the research purposes for this study, this research proposed three hypotheses and one research question as follows.

1. Hypothesis 1. Customer involvement has significant and positive relationship to customer loyalty: a) Recommendation; b) Loyalty.

2. Hypothesis 2. Brand equity has significant and positive relationship to customer loyalty: a) Recommendation; b) Loyalty.

3. Hypothesis 3. Perceived risk has significant and positive relationship to customer loyalty: a) Recommendation; b) Loyalty.

4. Research Question 1. How the variables of customer involvement, brand equity and perceived risk predict the variable of customer loyalty?

Results

Hypothesis 1.

Regression analysis was applied to examine the H1 and the results are summarized in Table 5. The results supports the hypothesis H1a and H1b. Customer involvement (β=.735, p<.05) presented the variance explanation of 22.4% (R^2=.224, p<.05) and F value (.54.165) for recommendation dimension. In addition, customer involvement (β=.463, p<.05) presented the variance explanation of 8.9% (R^2=.089, p<.05) and F value (18.316) for loyalty dimension.

Hypothesis 2.

Regression analysis was applied to examine the H2 and the results are summarized in Table 5. The results supports the hypothesis H2a and H2b. Brand equity (β=.963, p<.05) presented the variance explanation of 42.0% (R^2=.420, p<.05) and F value (136.098) for recommendation dimension. In addition, brand equity (β=.472, p<.05) presented the variance

explanation of 10.1% (R^2=.101, p<.05) and F value (21.148) for loyalty dimension.

Hypothesis 3.

Regression analysis was applied to examine the H3 and the results are summarized in Table 5. The results supports the hypothesis H3a and H3b. Perceived risk (β=.324, p<.05) presented the explanation of 6.5% (R^2=.065, p<.05) and F value (13.022) for recommendation dimension. In addition, perceived risk (β=.244, p<.05) presented the variance explanation of 3.7% (R^2=.037, p<.05) and F value (7.169) for loyalty dimension.

Table 5: Regression Analysis Capabilities such as Customer Involvement, Brand Equity, and Perceived Risk to Recommendation and Royalty

	Recommendation				Royalty		
	β	R^2	*F*		*β*	R^2	*F*
H1a & H1b	.735**	.224	54.165		.463**	.089	18.316
H2a & H2b	.963**	.420	136.098		.472**	.101	21.148
H3a & H3b	.324**	.065	13.022		.244**	.037	7.169

**p<.01 (2-tailed), *p<.05 level (2-tailed).

Research Question 1.

Regression analysis was applied to examine the research question and the results are summarized in Table 6. Brand equity (β=.541) and customer involvement (β=.231) presented the variance explanation of 53.6% (R^2=.536, p<.05) and F value (71.760) for customer loyalty, while perceived risk presented no significant statically relationship with customer involvement.

The result for Correlation Analysis to examine the relationship among all variables are summarized in Table 7, revealing there is a positive and statistically significant (p<.05) relationship between overall brand equity (r=.702), customer involvement (r =.554) and perceived risk (r =.490) and customer loyalty.

Table 6. Regression Analysis Capabilities such as Customer Involvement, Brand Equity, and Perceived Risk to Customer Loyalty

	Customer Loyalty				
	β	R^2	Adjusted R^2	F	t
Customer Involvement	.231**	.536	.529	71.760	3.649
Brand Equity	.541**				9.456
Perceived Risk	.000				0.697

**p<.01 (2-tailed), *p<.05 level (2-tailed).

Table 7. Overall Correlations among All Variables

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.000	1										
3	0.404**	0.206**	1									
4	0.412**	-0.137	0.000	1								
5	0.294**	0.138	0.143*	0.225**	1							
6	0.186**	0.272**	0.185*	0.077	0.000	1						
7	0.494**	0.075	0.605**	0.257**	0.206**	0.149*	1					
8	0.310**	0.051	0.159*	0.352**	0.196**	0.068	.000	1				
9	0.892**	0.450**	0.451**	0.302**	0.330**	0.292**	0.473**	0.298**	1			
10	0.557**	0.109	0.856**	0.517**	0.238**	0.201**	0.648**	0.318**	0.542**	1		
11	0.344**	0.287**	0.231**	0.221**	0.747**	0.665**	0.255**	0.192**	0.443**	0.313**	1	
12	0.579**	0.090	0.565**	0.427**	0.286**	0.156**	0.769**	0.639**	0.554**	0.702**	0.318**	1

**p<0.01 level, *p<0.05 level (all 2- tailored)
1.Personal Interest, 2.Mistake Probability, 3.Brand acceptance, 4.Brand Value, 5.Social risk, 6.Value Risk, 7.Recommendation, 8.Loyalty, 9.Customer Involvement, 10.Brand Equity, 11.Perceived Risk, 12.Customer Loyalty.

Discussion

Findings

The findings of H1 indicated customer involvement has significant and positive relationship on both dimensions of customer loyalty, while customer involvement has stronger effect on the recommendation dimension (β=.735) than on the loyalty dimension (β=.463).

Although customer involvement did not provide much explanation for the variance for both dimensions of customer loyalty, customer involvement did provide slightly more explanations for the variance for the recommendation dimension (R^2=.224) than the loyalty dimension (R^2=.089). The findings of H2 indicated brand equity has significant and positive relationship on both dimensions of customer loyalty, while brand equity has stronger effect on the recommendation dimension (β=.963) than on the loyalty dimension (β=.472). Although brand equity did not provide much explanation for the variance for both dimensions of customer loyalty, brand equity did provide more explanations for the variance for the recommendation dimension (R^2=.420) than the loyalty dimension (R^2=.101). The findings of H3 indicated perceived risk has significant and positive relationship on both dimensions of customer loyalty, while perceived risk has stronger effect on the recommendation dimension (β=.324) than on the loyalty dimension (β=.244). Although perceived risk did not provide much explanation for the variance of both dimensions for customer loyalty, perceived risk did provide slightly more explanations for the variance for the recommendation dimension (R^2=.065) than the loyalty dimension (R^2=.037). The findings of all hypotheses revealed all the customer involvement, brand equity and perceived risk factors have stronger effects on recommendation dimension than on loyalty dimension. From the findings of the research question, the results indicated all the customer involvement, brand equity, and perceived risk factors provide weak explanation (R^2=.536) for the variance of customer loyalty, while brand equity (β=.541) has stronger effect on customer loyalty than customer involvement (β=.231). And perceived risk has no significant statistically relationship with customer loyalty (p >.05).

Suggestions and Recommendations

The results suggested customer involvement, brand equity, and perceived risk have

significant and positive relationship to customer loyalty. Corporations may apply this result to improve corporate marketing strategy, especially the strategy of brand equity. After building up strong brand image and loyalty for customers, corporate may effectively influence customer behaviors. In addition, all the factors, such as brand equity, customer involvement, and perceived risk have stronger effects on the dimension of recommendation than on the dimension of loyalty for customers. Therefore, the corporate may need to develop other effective strategies to improve the loyalty for customers. In addition, the findings indicated brand equity, customer involvement, and perceived risk did not provide much explanation for the variance for customer loyalty, especially for explanation of the variance for the dimension of loyalty. This fact revealed the complexities of customer behaviors and also revealed the necessities for future study to identify more effective factors to influence the customer loyalty.

This research suggests future research recommendations: 1).Due to time constraints and limited finances, this research utilized convenience sampling and only focused on limited number population. Future study may extend the research through larger random selection, 2).Moreover, the population may extend to other countries for comparisons to understand the differences in cultures, and 3) Future study may try to identify more effective factors to influence the customer loyalty and to predict the customer behaviors, also generate future scholar studies.

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