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Government Administration Efficiency and Economic Efficiency
For 23 Districts in Taiwan

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Abstract

In this study, the Seiford and Zhu (2002) undesirable modeling is used to measure the government and economic efficiencies of 23 counties or cities in Taiwan. We also carry on a correlation analysis upon the government and economic efficiencies. The data sources for this study consist of 23 counties or cities for the period from 2002 to 2005 as released by the Ministry of Economic Affairs of the R.O.C.

Our empirical results from the DEA (Data Envelopment Analysis)approach are summarized as follows: (1) The two most thriving region for economic activities are Taipei City and Taipei County, while areas for low economic activities include Penghu County, Taitung County, Chiayi County, and Tainan County. (2) Economic efficiency and government efficiency have no apparent difference. Economic efficiency and government efficiency show gradual annual declines. (3) Compared with various areas, Taipei City, Taichung City, Tainan City, Chiayi City, Taitung County, Hualian County, and Penghu County always rank #1 in both economic efficiency and government efficiency. (4) No matter for economic efficiency or

government efficiency, Taipei County, Taoyuan County, Hsinchu County, Changhua County, Nantou County, Yunlin County, Kaohsiung County, Pintung County, and Kaohsiung County rank at the worst level. (5) There is a positive relationship between economic efficiency and government efficiency. This result is consistent with Chen and Lee (2005).

Key Words: Data Envelopment Analysis, BCC, Undesirable Modeling, Government and Economic Efficiency

Introduction

The market mechanism of pure capitalism can produce the most desired commodities through the most efficient techniques. As a result, the capitalist system relies on the market mechanism to allocate resources within economies. However, if the market mechanism fails to allocate resources efficiently (called market failure), then the government must take part in the economic system operation to adjust the market failure, by providing policy formulation and guidance for the economic system's development. In other words, the household (that buys the commodities) and firm (that produces the commodities) sectors make up the economic activity foundation for the most efficient allocation of resources. The government must also provide legal and social frameworks and maintain competition and the reallocation of resources. Therefore, households, businesses, and the government have mutual effects in the economic system.

Theoretically, the better the administrative efficiency is that is provided by a government

department, the higher the efficiency is of an economic system that is created. With the

development of international and global financial markets, the current economic environment

faces severe challenges. A government plays a major role to influence its own economy's

development under this environment. According to the 2007-2008 Global Competitiveness

Report, there are 12 pillars of competitiveness: Institutions, Macro-economy, Infrastructure,

Health and Primary Education, High Education and Training, Goods Market Efficiency, Labor

Market Efficiency, Financial Market Sophistication, Technological Readiness, Market Size,

Business Sophistication, and Innovation. In the first pillar, Institutions compose the framework

among households, firms, and governments that interact to create wealth in the economic system

and play an important role to achieve sustained economic growth and long-term prosperity. From

the annual Global Competitiveness Reports, except for Education, Financial market,

Technological, and Innovation, we know that economic efficiency and government efficiency

also are important ingredients in the Global Competitiveness index.

Taiwan's 23 counties and cities in general currently have financial problems. In order to

solve these problems, the 23 counties and cities have adopted the enterprise managing concept to

promote government efficiency in order to improve their local business environment and

inhabitants' life quality. Furthermore, they hope to attract firms to invest in local businesses so as

to promote local competition. Thus, the issues of government and economic efficiencies have become more and more important.

The previous literature focuses mainly upon two major streams of research: (1) regional economic efficiency and (2) government administration efficiency. Studies on regional economic efficiency includes Charnes et al. (1989), Färe et al. (1994), Maudos *et al.*(2000), Martic and Savic (2001), Afonso and Aubyn (2005), Timmer and Los (2005), Ma and Goo (2005), and Mastromarco and Woitek (2006). Initially, the government is adopted as the input variable and then is used to explain the efficiency scores. Instead of economic activity indicators, those who take government expenditure as an input and infrastructure and the quality of life as outputs to measure government administration efficiency are Hughes and Edwards (2000), Worthington and Dollery (2002), Sun (2002), and Afonso and Fernandes (2006). From the above reviews we see that most studies on government and economic efficiencies are discussed separately, but they should be discussed together.

We also use the Seiford and Zhu (2002) DEA (Data Envelopment Analysis) undesirable model to measure the government and economic efficiencies in order to improve performance. Both desirable (good) and undesirable (bad) outputs and inputs may exist in a traditional DEA. In the private sector, the production process may generate undesirable outputs like pollution or waste under the estimation of economic efficiency, while the government sector may create

undesirable outputs like crime for the estimation of government efficiency. If we do not consider

the undesirable (bad) outputs, then it does not reflect the true government and economic

efficiency

In this paper we first resort to the DEA model on discussing government and economic

efficiencies together for the 23 districts in Taiwan and carry on a correlation analysis between

the two efficiencies. Second, we use the Seiford and Zhu (2002) DEA undesirable model to

measure the government and economic efficiencies in order to avoid over-evaluation and under-

evaluation without consider the undesirable (bad) outputs. The structure of this paper is listed as

follows: Introduction, Literature Review, Methodology and Data Resources, Empirical Results

and Conclusion.

Literature Review

The efficiency performance of the economic unit is always paid attention to by economic

and management domain. Many scholars focus on the manufacturing sector and evaluate

efficiency with firm-level data. Two typical approaches are exploited. The first approach is using

a statistical method to estimate efficiency as developed by Battese and Coelli (1992; 1995). The

other approach is using the linear programming approach to measure a firm's efficiency within

the industry. Many scholars have recently extended the categories of studying in efficiency

between regions or countries. They take regions or countries into the decision making units

(DMU) and measure their efficiency.

Charnes et al. (1989) used DEA to evaluate the economic efficiency of 28 cities in China in

1983-1984. The indictors of input are the number of employees, wage, and fixed asset

investment, and the indictors of output are the gross output value of industry, profit, tax, and

retail sales. The results show that DEA could be used to identify technical inefficiencies and

related waste for each city's economic activities in China.

Färe et al. (1994) took gross domestic product (GDP) as an output index, as well as capital

and employment as input indices, to analyze the efficiency of 17 countries in the OECD in 1978-

1988. The results present that U.S. productivity growth is slightly higher than the average of 17

OECD countries, which is due to technical change. The highest productivity growth index is

Japan.

Maudos *et al*. (2000) measured the efficiency of 17 autonomous regions in Spain over 30

years. The indictors of input are labor and capital, and the indictor of output is gross value added.

The results show that the rich countries have experienced the greatest growth in TFP

(particularly through greater technical progress), and technical change has worked against labor

productivity convergence, since it has always been greater in countries with higher labor

productivity.

Timmer and Los (2005) evaluated the economic efficiency of 40 countries around the world. They took labor GDP production per unit as the input variable and labor capital per unit as the output variable in 1975-1992. The results show that the change in the global production frontier is localized at high levels of capital intensity and that the effect is stronger in agriculture than in manufacturing.

Ma and Goo (2005) used capital and labor as input variables and revenue and profit as output variables to assess the relative efficiency and total factor productivity (TFP) between the 53 High- and New-Technology Industry Development Zones (HNTIDZs) in China. The results show that Xiamen, Chengdu, Huizhou, Wuxi, Shenzhen, Beijing, Shanghai, and Yangling achieved technical efficiency. In comparison, the others were relatively inefficient and should adjust according to input excesses and output deficits.

Under the category of macroeconomics, the government plays an important role in economic growth and promotion of welfare. From the amount of regional economic efficiency studies, how a government acts is also considered an important variable in efficiency measurement.

Mastromarco and Woitek (2006) adopted the stochastic frontier approach (SFA) to estimate the technical efficiency of 20 regions in Italia during 1970-1994. Except for labor and private capital stock, infrastructure is also taken as an input component. The result shows that the higher

the percentage is of public capital stock divided by total capital stock, the more helpful it will be

to upgrade technical efficiency. Furthermore, some scholars take the quality indices of residents'

life and the scale of infrastructure instead of production and profit as the input variables when

they are estimating regional economic efficiency.

Martic and Savic (2001) estimated the efficiency of 30 regions in Serbia in 1979-1980 by

the CCR model. The four inputs include land, fixed assets, energy, and the quantity of

population, and the output takes up the quality indices of life, including the total number of

physicians, the total number of pupils in primary school, and the employed ratio. The results

show that 17 out of 30 regions are efficient, in which 5 regions are from Vojvodina and 12

regions are from central Serbia, while all regions from Kosovo and Metohia are inefficient.

Afonso and Aubyn (2005) compared the efficiency of education and medical treatment in

24 countries of the OECD by DEA application and free disposable hull (FDH) application. The

indicators of input are the numbers of teachers, doctors, nurses, and sickbeds. The indicators of

output are measured by the students' performances of PISA, the average age, and the infant

survival rate. The results show that efficient outcomes across sectors and analytic methods seem

to cluster around a small number of core countries, (Japan, South Korea, and Sweden) even if for

different reasons. Instead of economic activities indicators, it takes government expenditure as an

input and infrastructure and the quality of life as outputs to measure government administration efficiency in each locality.

Hughes and Edwards (2000) used the CCR and BCC models of DEA to evaluate the efficiency of 73 Minnesota counties. The outputs are the total property value of the counties, and the government expenditures of education, social services, transportation, public safety, environmental protection, and administration. They considered the poverty rate, crime rate, employment opportunities, water, and land area as input variables. The result indicates that the dominant source of public sector inefficiency is an inappropriate scale of operations. It implies that some counties' jurisdictions are too large to serve the population efficiently, and that the size and concentration of public power are also responsible in part for observed inefficiencies.

Worthington and Dollery (2002) employed the contextual and non-discretionary inputs DEA to measure the relative efficiency of the 173 NEW local governments. The results show that the number of councils assessed as perfectly efficiency.

Sun (2002) employed the output-oriented BCC model to measure the relative efficiency of the 14 police administrators in Taipei city. The indicators of input include the expenditure of police administrators, the numbers of police officers employed, the number of civilians employed, and the equipment assets used by the police. The indicators of output include the cases of violence, burglary, and crime as well as the ability to deal with traffic control and

emergency. The results show that differences in operating environment, such as resident

population and location factors, do not have a significant influence upon the efficiency of police

precincts.

Afonso and Fernandes (2006) discussed local government efficiency from the view of

administration servers, education, social activity, and environment protection. They used the

DEA-BCC model to measure the expenditure efficiency of 51 local governments of Portugal in

2001. The input uses the total expenditures of the local governments. The indictors of output

include the number of residents and schools, social services for elders, the amount of clean water

supplied, the cleaning and carrying of litter, and the amount of recycling. The results show that

the 51 municipalities could have achieved, on average, roughly the same level of local output

with about 41% fewer resources - i.e. local performance could be improved without necessarily

increasing municipal spending.

Through a look at the previous studies, we know that the scope of research in efficiency

extends from the analysis between firms or enterprises to countries or areas. The categories of

efficiency are economic efficiency and government efficiency. However, the relationship

between economic efficiency and government efficiency is still seldom discussed in past years

and now we turn to focus on this point of view.

Methodology and Data Resources

Methodology

Ever since Farrell (1957) proposed the concept of the frontier function to measure efficiency,

many scholars have used linear programming or the frontier function method to estimate

efficiency and productivity. Charnes et al. (1978) extended Farrell's model to multiple inputs-

outputs pattern and employed mathematical programming to develop an efficient frontier and to

estimate the efficiency score. This approach is named "Data Envelopment Analysis (DEA)". The

Charnes, Cooper, and Rhodes (CCR) efficiency concept is subject to the strong hypothesis of

constant returns to scale. Banker, Charnes, and Cooper (BCC) proposed a variable returns to

scale model. The BCC model can determine the returns to scale for each DMU. The BCC models

can be formulated as:

$$\max : \theta$$

$$s.t. \quad \sum_{j=1}^{n} z_j x_j + s^- = x_0$$

$$\sum_{j=1}^{n} z_j y_j - s^+ = \theta y_0,$$

$$\sum_{j=1}^{n} z_j = 1,$$

$$z_j \geq 0, \quad j = 1, \cdots, n$$

Here, θ is the score of the DMU, y_j is the j-th output, x_j is the j-th input, z_j is the weight of the

j-th DMU, and s^- and s^+ are the input slacks and the output slacks, respectively.

In the methodology we know that the traditional DEA (CCR or BCC) model relies on the

assumption that inputs have to be minimized and outputs have to be maximized. However, many

production processes may produce undesirable outputs, such as the number of defective

products, waste, and pollution. In other words, there exist desirable (y_j^g) and undesirable (y_j^b)

outputs. Obviously, desirable outputs should be increased and undesirable outputs should be

decreased in order to improve efficiency. However, the undesirable outputs should be increased

rather than decreased in the traditional DEA assumption, but they do not conform to the

isotonicity characteristic results in the inaccurate efficiency estimates. Charnes et al. (1985)

treated the undesirable outputs as inputs so that the bad outputs can be reduced. Seiford and Zhu

(2002) believed that treating the undesirable outputs as inputs does not reflect the true production

process. Hence, Seiford and Zhu (2002) proposed an approach to treat undesirable input/outputs

in the VRS envelopment. This approach follows the "classification invariance' concept in Ali

and Seiford (1990) to deal with the problem of undesirable outputs. Following the Seiford and

Zhu (2002) undesirable model, the matrix can be presented as follows:

$$\begin{bmatrix} Y \\ -X \end{bmatrix} = \begin{bmatrix} Y^g \\ Y^b \\ -X \end{bmatrix}.$$

The terms Y^g and Y^b represent the corresponding desirable and undesirable outputs and X

represents the input. It is clear that we desire to increase the desirable outputs (Y^g) and to

decrease the undesirable outputs (Y^b) to improve efficiency. Thus, we multiply each undesirable

output by (-1) and then find a proper value w to convert negative data to positive

($\bar{y}_j^b = -y_j^b + w > 0$) data and maintain the invariant to the data. Employing the previous

notations, the model is:

$$\max : \theta$$

$$s.t. \quad \sum_{j=1}^{n} z_j y_j^g \geq \theta y_0^g$$

$$\sum_{j=1}^{n} z_j \bar{y}_j^b \geq \theta y_0^b$$

$$\sum_{j=1}^{n} z_j x_j \leq x_0$$

$$\sum_{j=1}^{n} z_j = 1$$

$$z_j \geq 0, \quad j = 1, \cdots, n$$

Here, θ is the score of the DMU, y_j^g and y_j^b correspondingly represent the j-th desirable and

undesirable outputs, x_j is the j-th input, and z_j is the weight of the j-th DMU.

Data Collection and the Chosen Outputs and Inputs

Data Collection

Taiwan is divided into 23 different districts and mainly into four regions named Northern,

Central, Southern, and Eastern. The Northern region has Taipei City, Keelung City, Hsinchu

City, Taipei County, Taoyuan County, Hsinchu County, and Ilan County, the Central region has

the 6 districts of Miaoli County, Taichung County, Chunghwa County, Nantou County, and

Yunlin County, the Southern region includes the 8 districts of Kaohsiung City, Tainan City,

Chiayi City, Chiayi County, Tainan County, Kaohsiung County, Pintung county, and Penghu

County, while the Eastern region includes the 2 counties of Hualien and Taitung. The data

sources for this study consist of 23 counties or cities for the period from 2002 to 2005 as released

by the Ministry of Economic Affairs of the R.O.C. The pertinent definitions of the variables, as

well as the original data and explanations of the data, are described in Table 1.

The Chosen Outputs and Inputs

A. Economic Efficiency

The major indicators used to measure Economic Efficiency include GDP (Fare et al 1995;

Martic and Savic, 2001; Timmer and Los, 2005), Industry output (Charnes et al, 1989), and its

side benefits (Maudos et al, 2000; Percoco, 2004). This research uses the sales income of each

registered company at the Ministry of Finance in each division as output variables (EY1). Due to

global warming and the rise of environmental protection, environmental pollution needs to be

considered when measuring the output of economic efficiency. Arcelus and Arocena (2005) used

the control of carbon dioxide amount as an output item, while Fare et al. (2004) took carbon

dioxide and three other green gases as undesirable output. The major indicators that Taiwan's

region uses for air pollution include dust volume, sulfur dioxide, ozone, and thickness of RSP.

Sulfur dioxide and ozone are mainly produced during industry production by petroleum used in

power products, factory pots, and flare gas for auto and motor transportation. The more economic development grows, the higher the pollution increases. This research uses the thickness of sulfur dioxide and ozone detected in districts by the Environmental Protection Administration by as pollution output (EY2) index and takes it as the undesirable output in scale.

Among the inputs of economic efficiency, assets and labor are the main indicators of economic activities (Maudos et al, 2000; Martic and Savic, 2001; Percoco, 2004). This research will implement the assets of the companies registered at the Ministry of Economic Affairs as the asset input (EXI), while the labor input (EX2) is made up of statistics on 15 years old and above income labor and the number of people and non-income indoor labor who work 15 hours or more in every district gathered by the Directorate-General of Budget, Accounting, Statistics, Executive Yuan. In addition, the dimension of the land might affect the road scale, population density, and number of buildings, and they are identified as input variables in most research studies (Hughes and Edwards, 2000; Martic and Savic, 2001; Ma and Goo, 2005). According to the land dimension announced by the Ministry of Administration, the land dimension has adopted the Urban Development Plan Region as its main land input variables (EX3), by considering the incapability of commercial activity in mountains, rivers, and valleys.

B. Government Efficiency

On the evaluation on government efficiency, the research of Sun (2002), Hughes and

Edwards (2002), and Afonso and Fernandes (2006) took government expenses as the

government efficiency input indicator. This article herein is based on annual income sources

(which include incoming financial sources, federal subsidy, and loans) that are announced by the

Ministry of Statistics as the Government Efficiency index (GX1).

Public construction (Percoco, 2004; Afonso and Fernsndes, 2006) and citizens' living

environment are the main output performances for government. The criteria to evaluate living

environment quality includes security (Sun, 2002), education, medication (Afonso and Aubyn,

2005), social welfare (Afonso and Fernandes, 2006), and so on. Not only does this index indicate

the regional habitation living quality, it also reflects the quality of its commercial environment.

This research uses the percentage of social welfare staff among total population in each district

to observe the government's performance in practicing social works among total population

(GY1), 15 years old and above who receive a higher education rate (GY2) as education

performance, and the population of medical practicing staff to evaluate the resources of medical

support index.

To increase the convenience of civil activities, the urban plan usually sets up space for

public commendation, which is divided and based upon population, use of land, traffic

conditions, and potential future development to ensure a good urban life condition. Therefore,

using public commendation land dimension for over 10,000 people (GY4) shows the

government's contribution in public commendation performance. The output index for public

security is evaluated by crimes committed, thefts, and violent crime detection rate (GY5), and

takes crime detection rate as the undesirable output.

Table 1. Variable Descriptions

Variables	Term	Description
Asset	EX1	Current Companies' Registered Assets (NT$ million)
Labor	EX2	Working Population (Thousand)
Land	EX3	Urban Plan Dimension
Economics Output	EY1	Sales Income (NT$ million)
Pollution	EY2	Thickness of Sulfur Dioxide and Ozone (ppb) in Air
Government Output	GX1	Annual Output (NT$ million)
Social Work	GY1	Social Welfare Workers Among Total Population (%)
Education	GY2	Education Rate of 15 Year Olds & Above in Population (%)
Public Commendation	GY3	Land Dimension for Urban Plan on Public Space / 10,000 People (ha.)
Medical	GY4	Population of Medical Staff Over All the Population (%)
Public Security	GY5	Crime, Theft, Violent-Crime Detection Rate (%)

Table 2 lists various indicators for statistical description. In Table 2, we naturally find

the most thriving economic activities are in Taipei City and Taipei County. Here, assets, working

population, and commercial sales income all reach a very high rate, but the two with their high

density of commercial activities sacrifice the living space of their citizens. The low economic

activity areas include Penghu County and Taitung County. Due to their relatively lower

population, Chiayi County and Tainan County receive more social welfare or medical resources.

The less industrialized these areas are, the more the local government can promote tourism and

also create more recreational space for the local citizens.

Table 2. Descriptive Statistics of Variables in this Study (2002-2005)

		EX1	EX2	EX3	EY1	EY2	GX1	GY1	GY2	GY3	GY4	GY5
2002	Mean	675,245	411	196	1,071,600	28	28,699	6	23	16	0.008	66
	Std.Dev.	1,669,030	356	241	1,886,560	7	29,236	5	9	6	0.003	12
	Max.	8,164,310	1,562	1,209	8,886,940	38	145,159	21	48	27	0.015	88
	Min.	4,109	32	11	18,353	0	6,357	1	10	8	0.004	46
2003	Mean	702,040	416	196	1,188,800	29	32,008	7	25	16	0.008	68
	Std.Dev.	1,731,190	360	241	2,123,020	7	31,966	5	9	6	0.003	11
	Max.	8,454,980	1,578	1,209	10,015,800	39	149,100	19	48	27	0.015	85
	Min.	4,127	33	10	17,956	0	6,898	1	11	8	0.004	50
2004	Mean	724,668	426	196	1,390,070	31	35,470	7	26	16	0.008	66
	Std.Dev.	1,768,850	370	241	2,467,590	8	34,502	4	9	6	0.003	12
	Max.	8,633,830	1,628	1,210	11,708,500	40	160,405	20	50	27	0.015	86
	Min.	4,159	34	10	19,613	0	7,389	1	12	8	0.005	44
2005	Mean	753,297	432	196	1,491,190	30	35,858	7	27	16	0.009	66
	Std.Dev.	1,827,660	377	241	2,747,980	7	34,873	4	9	6	0.003	13
	Max.	8,921,530	1,664	1,210	13,126,300	38	158,151	16	52	27	0.016	87
	Min.	4,010	34	10	21,784	0	6,841	1	13	8	0.005	48

Empirical Results

Efficiency Analysis

This research employs the computer program DEA Excel Solver to estimate Seiford and

Zhu's (2002) undesirable models. Table 3 presents the results for years 2002-2005.

From Table 3, in 2002 the average economic efficiency value is 0.913 and the average government efficiency value is 0.901. In 2003 the average economic efficiency value is 0.910 and the average government efficiency value is 0.913. In 2004 the average economic efficiency value is 0.908 and the average government efficiency value is 0.905. In 2005 the average economic efficiency value is 0.859 and the average government efficiency value is 0.889. The measurement results yielded by economic efficiency and government efficiency have no apparent difference. Furthermore, economic and government efficiencies show that they gradually decline annually.

For economic efficiency, Taipei City, Taichung City, Tainan City, Chiayi City, Taitung County, Hualian County, and Penghu County are always on the frontier of DEA. Taichung County, Tainan County, Chiayi County, Yilan County, and Hsinchu City take second place. Nantou County, Miaoli County, Kaohsiung City, Taipei County, and Taoyuan County rank the worst level.

In government efficiency, the efficiency scores of Taipei City, Taichung City, Tainan City, Chiayi City, Taitung County, Hualian County, and Penghu County are all 1 in the DEA estimation, thus ranked #1. Keelung City places 11th in 2002 and 2003, but progresses the best in government efficiency among all areas after 2004. Pintung County, Yunlin County, Kaohuiung County, Taipei County, and Taoyuan County have the worst government efficiency of all areas.

The Quadrant

In order to have a better understanding of the relationship between economic efficiency and government efficiency for each county or city, we use the quadrant to graphically show the position of each county or city.

We divide the quadrant with government efficiency as the vertical axis and economic efficiency scores as the horizontal axis. In this research we plot the quadrant according to the efficiency scores under Seiford and Zhu's (2002) undesirable models. Thus, the vertical axis offers the average government efficiency scores, which means the county or city located to the right side of the vertical axis possesses a higher government efficiency on average in the county or city. The horizontal axis presents the average economic efficiency scores, which means the county or city located above the horizontal axis possesses a higher economic efficiency on average in the county or city. Quadrant I represents higher economic efficiency and higher government efficiency. Quadrant II represents higher economic efficiency and lower government efficiency. Quadrant III represents lower economic efficiency and lower government efficiency. Quadrant IV represents lower economic efficiency and higher government efficiency (see Figure 1).

Table 3. Economic Efficiency and Government Efficiency

	2002				2003				2004				2005				Average			
	Econ. Eff.		Gov. Eff.		Econ. Eff.		Gov. Eff.		Econ. Eff.		Gov. Eff.		Econ. Eff.		Gov. Eff.		Econ. Eff.		Gov. Eff.	
	Score	R	Score	R	Score	R	Score	R	Score	R	Score	R	Score	R	Score	R	Score	R	Score	R
Taipei County	0.809	22	0.701	23	0.761	23	0.698	23	0.745	23	0.676	23	0.715	22	0.703	22	0.758	23	0.695	23
Yilan County	0.912	11	0.888	12	0.900	13	0.929	12	0.931	10	0.920	12	0.911	11	0.911	11	0.914	11	0.912	12
Taoyuan County	0.787	23	0.824	19	0.785	22	0.834	19	0.774	22	0.812	19	0.695	23	0.743	21	0.761	22	0.803	19
Hsinchu County	0.910	12	0.923	10	0.995	9	1.000	1	0.861	14	0.860	17	0.816	18	0.787	19	0.895	13	0.892	14
Miaoli County	0.822	20	0.875	15	0.805	21	0.922	14	0.838	20	1.000	1	0.838	16	0.955	10	0.826	21	0.938	10
Taichung County	0.943	10	0.975	9	0.935	11	0.975	9	0.896	12	0.859	18	0.848	15	0.846	16	0.906	12	0.914	11
Changhua County	0.867	14	0.853	16	0.854	16	0.884	16	0.842	18	0.871	15	0.849	14	0.878	12	0.853	16	0.871	16
Nantou County	0.835	19	0.836	17	0.830	19	0.913	15	0.837	21	0.893	13	0.814	20	0.827	17	0.829	20	0.867	17
Yunlin County	0.855	18	0.763	21	0.808	20	0.732	22	0.841	19	0.791	21	0.834	17	0.796	18	0.835	19	0.770	21
Chiayi County	0.960	9	0.884	13	0.946	10	0.924	13	0.964	9	0.938	11	0.966	9	0.857	14	0.959	9	0.901	13
Tainan County	1.000	1	0.881	14	1.000	1	0.871	17	0.999	8	0.876	14	0.972	8	0.870	13	0.993	8	0.875	15
Kaohsiung County	0.860	16	0.810	20	0.860	15	0.803	20	0.859	15	0.806	20	0.815	19	0.777	20	0.849	17	0.799	20
Pintung County	0.861	15	0.747	22	0.839	17	0.751	21	0.844	17	0.710	22	0.890	12	0.671	23	0.859	15	0.720	22
Taitung County	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Hualien County	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Penghu County	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Keelung City	0.859	17	0.922	11	0.864	14	0.953	11	0.859	16	1.000	1	0.862	13	1.000	1	0.861	14	0.969	9
Hsinchu City	0.893	13	1.000	1	0.917	12	0.956	10	0.913	11	0.943	10	0.955	10	0.985	9	0.920	10	0.971	8
Taichung City	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Chiayi City	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Tainan City	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Taipei City	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Kaohsiung City	0.821	21	0.831	18	0.839	18	0.847	18	0.869	13	0.868	16	0.814	21	0.849	15	0.836	18	0.849	18
Mean	0.913		0.901		0.910		0.913		0.908		0.905		0.895		0.889		0.907		0.902	
Std.Dev.	0.076		0.094		0.085		0.095		0.082		0.098		0.096		0.108		0.082		0.095	
Maximum	1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
Minimum	0.787		0.701		0.761		0.698		0.745		0.676		0.695		0.671		0.758		0.695	

Government

Efficiency

II   I

Economic

Efficiency
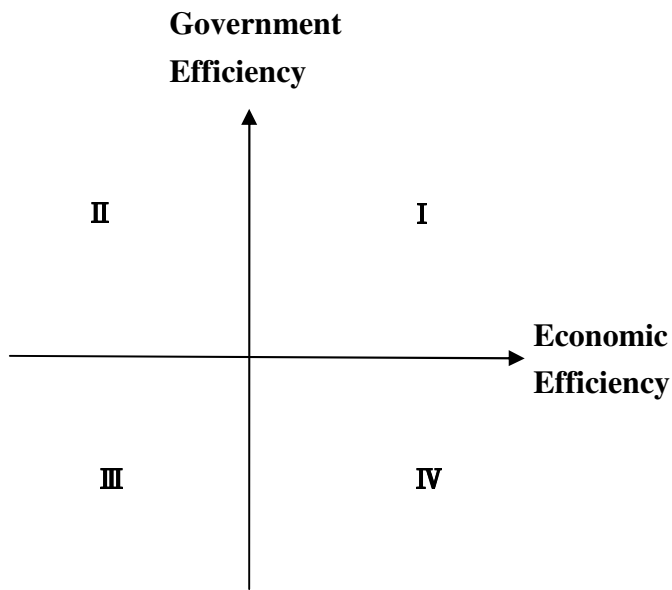
III   IV

Figure 1. The quadrant

From Figure 2, we find that there are 8 counties or cities, 11 counties or cities, 10 counties or cities, and 9 counties or cities in Quadrant I in 2002, 2003, 2004, and 2005, respectively. There are 2 counties or cities, 1 county or city, 1county or city, and 2 counties or cities in Quadrant II in 2002, 2003, 2004, and 2005, respectively. There are 10 counties or cities, 7 counties or cities, 10 counties or cities, and 10 counties or cities in Quadrant III in 2002, 2003, 2004, and 2005, respectively. There are 1 county or city, 4 counties or cities, 2 counties or cities, and 3 counties or cities in Quadrant III in 2002, 2003, 2004, and 2005, respectively.

The Distribution of 23 Counties or Cities

We choose those counties or cities which remained in the same quadrant for four years as the representatives of Quadrants I, II, III, and IV (see Table 4).

2002   2004

2003   2005
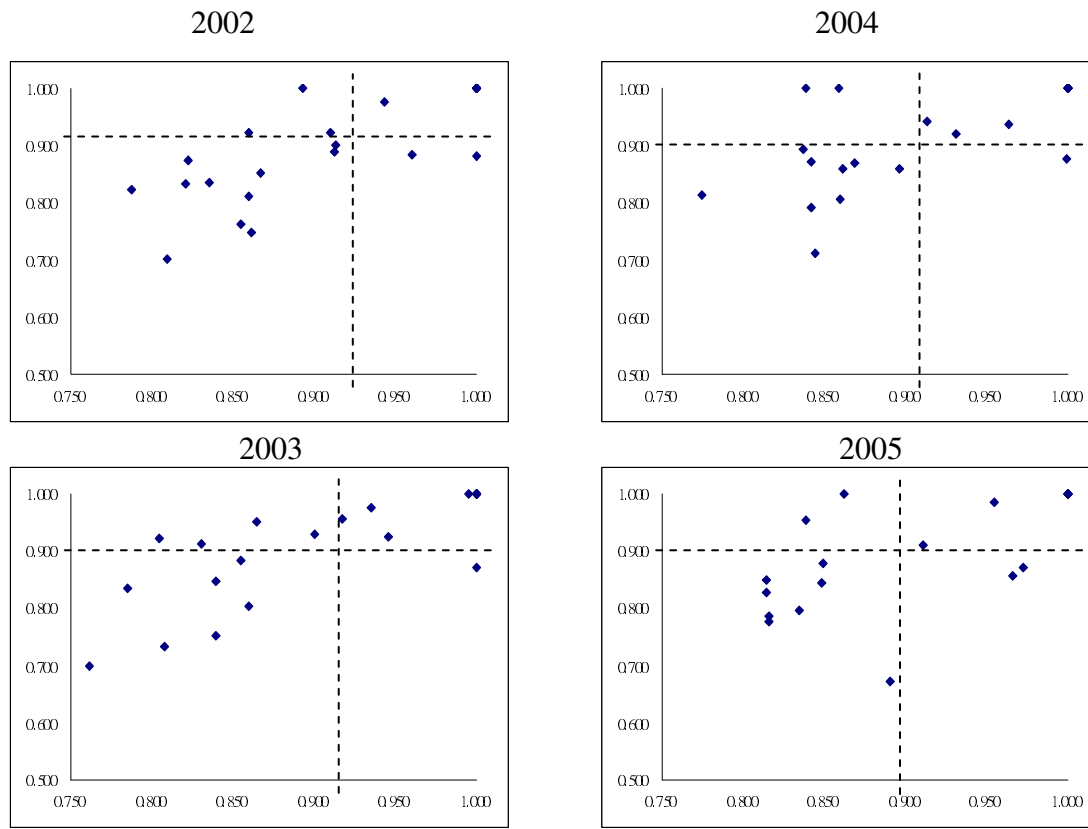
Figure 2 Economic Efficiency and Government Efficiency
Distribution Map (2002-2005)

1. Quadrant I**:** These counties or cities are operating efficiently and have high economic

efficiency and high government efficiency compared to others. We see that most of the counties

or cities in this area are those with a mature commercial development or well-known as leaders

in the tourism industry. The representative counties or cities include Taipei City, Hsinchu City,

Taitung City, Chiayi City, Tainan City, Yilan County, Taitung County, Hualian County, and

Penghu County.

2. Quadrant II: These counties or cities have higher economic efficiency and lower

government efficiency. If they properly adjust government performance, then they may also

upgrade to compete with those counties or cities in Quadrant I. The representatives of Quadrant

II are Chiayi County and Tainan County.

3. Quadrant III: These counties or cities are operating inefficiently and have lower

economic efficiency and lower government efficiency. The representative counties or cities are

Taipei County, Taoyuan County, Hsinchu County, Changhua County, Nantou County, Yunlin

County, Kaohsiung County, Pintung County, and Kaohsiung city. These counties or cities should

adjust government management and change their operations to improve their performance.

4. Quadrant IV: These counties or cities have lower economic efficiency and higher

government efficiency. The representatives of Quadrant IV are Keelung City, Miaoli County, and

Taichung County.

From all of the above, we conclude that the counties or cities in Quadrant I perform the best

in each year while counties or cities in Quadrant III perform the poorest. The counties or cities in

Quadrants II and IV show not many differences between them in some years.

Correlation Between Economic Efficiency and Government Efficiency

It is crucial to test if there is a high correlation between economic efficiency and

government efficiency. Here, we adopt the Pearson Correlation Coefficients Test, and the results

are listed in Table 5. From Table 5, we can see that economic efficiency and government

Table 4. The Distribution of Economic Efficiency
and Government Efficiency in Quadrants

	Higher Economic Efficiency	Lower Economic Efficiency
Higher Government Efficiency	Taipei City Hsinchu City Taitung City Chiayi City	Keelung City Miaoli County Taichung County
Lower Government Efficiency	Chiayi County Tainan County	Taipei County Yunlin County Taoyuan County Kaohsiung County Hsinchu County Pintung County Changhua County Kaohsiung City Nantou County

efficiency are highly correlated with each other. In 2002 the economic and government efficiency

correlation coefficients are 0.789. In 2003 the two efficiency correlation coefficients are 0.800. In

2004 the two efficiency correlation coefficients are 0.742. In 2005 the two efficiency correlation

coefficients are 0.763. Thus, there exists a significantly positive correlation between economic

efficiency and government efficiency. This result is consistent with the result in Chen and Lee

(2005).

Table 5. Pearson Correlation Coefficients

		Econ. Eff.				
		2002	2003	2004	2005	Average
Gov. Eff.	2002	0.789 **				
	2003		0.800 **			
	2004			0.742 **		
	2005				0.763 **	
	Average					0.785 **

** Denotes statistically significant at 5% level

From the above analyses, we know that higher economic efficiency will be able to bring about higher economical development, which simultaneously will be able to bring more sources of wealth to the government and result in higher government efficiency. In other words, government efficiency and economic efficiency complement one another and are able to create areas that can be more prosperous.

Conclusion

Most studies in the existing literature have discussed government and economic efficiencies separately, but they do not take them into account together. In this study we adopt the Seiford and Zhu (2002) undesirable modeling to discuss government and economic efficiencies together for 23 different districts in Taiwan and carry on the correlation analysis to government and economic efficiencies. The conclusions of this paper are as follows.

1. The regions with the most thriving economic activities are Taipei City and Taipei County, while low economic activity areas include Penghu County, Taitung County, Chiayi County, and Tainan County.

2. Economic efficiency and government efficiency have no apparent difference. They   also show that economic and government efficiencies gradually decline annually

3. Taipei City, Hsinchu City, Taitung City, Chiayi City, Tainan City, Yilan County, Taitung County, Hualian County, and Penghu country have high economic efficiency and high

government efficiency compared to others. Most of the counties or cities are those with mature commercial development or well-known as leaders in tourism.

4. Taipei County, Taoyuan County, Hsinchu County, Changhua County, Nantou County, Yunlin County, Kaohsiung County, Pintung County, and Kaohsiung city have lower economic efficiency and lower government efficiency.

5. Chiayi County and Tainan County have higher economic efficiency and lower government efficiency. Keelung City, Miaoli County, and Taichung County have lower economic efficiency and higher government efficiency

6. There is a positive relationship between economic efficiency and government efficiency. Thus, higher economic efficiency is able to bring higher economical development, resulting in higher government efficiency. This result is consistent with Chen and Lee (2005).

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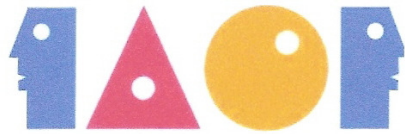
THE APPLICATION OF FUZZY LINGUISTIC SCALE ON INTERNET

QUESTIONNAIRE SURVEY

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Abstract

The growing number of respondents with access to the internet introduces a new data collection alternative that is likely to become increasingly important in the future. The purpose of this paper is to develop the process of a fuzzy linguistic scale to solve the linguistic scale transformation problems generated by the traditional quantitative methods based on the Likert scale and semantic scale, and to reduce the difficulties of answering the fuzzy questionnaire. Therefore, the problem of dilution of measuring results due to the traditional linguistic value in which every scale interval is equal can be solved by using the fuzzy linguistic scale.

Keywords: Fuzzy Linguistic Scale, Linguistic modeling, Cognitive Sciences, Internet
          Questionnaire.

Introduction

The questionnaire always plays a significant part in social science studies. While promising, internet surveys also face a variety of challenges in security of confidential information, and in mastery of new and rapidly changing technologies. It also is useful in collecting and analyzing data and in making sure if the assumption is correct (Kim & Lee, 2009). A questionnaire normally comes with statements or questions, but in all cases the subject is responding to some specific purposes. A question or statement can be worded in many ways, and the same is true for the response. One of the most popularly used responses is a combination of statements and gradation of the statement in the form of scales such as the Likert scale. Every item usually is stated in the form of a statement in which the respondents have to choose a response from a scale of 1 to 5. To construct an ordinal scale standard, researchers, for their own convenience, often adopt the Likert Scale (LS) and the semantic differential scale (SDS) on the application of marketing research. However, in empirical studies, these two scales usually are assumed as intervals. In most cases, it is quite difficult to describe adequately the human of a nonlinear system by mathematical models, especially when the structure of the system is unknown. Although LS and SDS have precision and applicability, there still are limitations. For instance, a person's real likes or dislikes could not always be expressed precisely, due to complexity of human thinking logic under different situations. It also is hard to convey a person's linguistic expression clearly and concisely. On one hand, traditional quantitative methods that try to express fuzzy linguistic terms in precise scale technically would generate deviation easily in true meaning of linguistic terms to be conveyed. On the other hand, the traditional quantitative method, which is based on the assumption of equal distance within a

measuring scale, often is ignored intentionally or unintentionally.

However, the studies conducted by Bradley, Katti, & Coons (1962) and Bradley (2006) suggest that the distance within the measuring scale usually is not set equally. Studies conducted by scholars domestically and internationally also show that an equal-distance scale unavoidably produces an incorrect estimate of factors. The use of fuzzy set theory, proposed and developed by Zadeh (1993), has given very good results modeling the qualitative aspects in linguistic terms.

Literature

Fuzzy Questionnaire Styles

In many social science studies, the purpose usually is to analyze concepts or attitudes of human beings. In this type of study, answers provided are not strictly "true" or "false," due to some uncertainties of human behavior. Boolean Logic (Fuzzy Logic), on the contrary, takes into account the complexity of human thinking and uncertainties of human behavior.

It would be best to display traits of the study by explicitly accurate values. But it is energy and time consuming to evaluate accurate values. Researchers also should consider analysis cost. Providing questionnaire takers with consecutive scale area will enable researchers to collect data more easily. For instance, Wang et al. (2006), Westenberg et al. (2007) and Robalino *et al.* (*2007)* apply the concept of Fuzzy membership function and Fuzzy statistics to construct consecutive area questionnaires. Hwang (1993) and Abdullah et al. (2004) also offers method to test fuzzy statistic and makes comparisons with traditional questionnaire designs. Matt et al. (2003), and Cassone & Ben-Arieh (2005), by combining fuzzy theory, design various types of fuzzy questionnaires and make comparisons with traditional questionnaires. On the application side, Hwang (1993) applied fuzzy theory on math teaching process evaluations. Westenberg et al. (2007) applied fuzzy theory in defining product investment combinations. Deng & Pei (2007)

used fuzzy theory to analyze service quality assessment. Lien & Chen (2005) applied fuzzy linguistic scale approach and discrete choice theory for building the housing consumption choice behavior model in a household. However, for the general public, it's hard to draw lines to express attitudes and opinions. As Zadeh (1993) said using values to accurately decide relating and influential disciplines is not an easy task in many situations. A practical way is to establish a reference system. For instance, traditional questionnaires request test takers to write down "levels of attitude" on the scale to enable researchers to establish membership functions. This way, however, will increase the level of complexity of data collecting and calculations. It is not the most practical method in this aspect.

Fuzzy Linguistic Scale

To ask questionnaire takers to express their attitudes verbally is the easiest and the most direct method. But, researchers must be able to transform verbal expressions into values to expedite statistical analysis. In fuzzy theory studies, researchers often use fuzzy values to measure linguistic terms. Chen and Hwang (1992) offer a method of applying fuzzy theory to convert fuzzy numbers into crisp numbers.

This method effectively improves the shortages of traditional measuring tools. The difficulties faced by questionnaire takers when filling out questionnaires is reduced because fuzzy data can be expressed in linguistic terms. The only shortcoming is that the linguistic scale is decided subjectively by Chen and Hwang. There are many studies based on Chen and Hwang's linguistic scale. But most researchers directly apply Chen and Hwang's linguistic scale and linguistic conversion values. Chen and Hwang did not provide a solid explanation of their research process and scale construction; besides, the studied subjects are foreigners. Thus, researchers should notice the difference in subject background, timing, and culture. Deviations

will occur when the method is applied directly without considering the difference. Based on the above reasons, we provide a both practical and realistic fuzzy linguistic scale to construct processes to eliminate the problems embedded in Chen and Hwang's method.

The Process

In our research, we build a process of fuzzy linguistic scale according to unequal scale intervals, different individuals, and disregard the inflated.

Step 1: Design a fuzzy linguistic scale questionnaire

Step 1.1 Decide the number of terms used

The verbal terms used in our scales are in the universe $X=\{x_1, x_2, \ldots, x_m\}$; m is the number of terms used.

Step 1.2 Decide the styles of linguistic combination

According to linguistic terms, there will be $\dfrac{(m-1) \times m}{2}$ types of combination.

Step 2: Convey the scale questionnaire

Step 2.1 Analyzing the types of the questionnaire takers' answers

After the answers of the key questionnaires are obtained, analyze the types of the scales used by questionnaire takers according to overall scales shown. Design and distribute linguistic questionnaires after the types of scales that contain minimum linguistic terms are obtained.

Step 2.2 Establish membership function belonged to individual test-taker

Define the linguistic terms variables (k) in questionnaires according to each individual's (i) answers. Also, in an interval scale (0-1), subjectively determine the scope of linguistic terms by using triangle fuzzy number A=(c, a, b, d; w)$_{LR}$. Suppose the membership function of A is

$$\mu_{A_{i_k}}(x) = \begin{bmatrix} w\langle x - c_{ik} \mid a_{ik} - c_{ik} \rangle, & c_{ik} \leq x \leq a_{ki} \\ w & , a_{ik} \leq x \leq b_{ki} \\ w\langle x - d_{ik} \mid b_{ik} - d_{ik} \rangle, & b_{ik} \leq x \leq d_{ki} \\ 0 & , others \, 。 \end{bmatrix} \qquad (1)$$

Since,

$$L(x) = w\langle x - c_{ik} \mid a_{ik} - c_{ik} \rangle, \quad c_{ik} \leq x \leq a_{ki} \qquad (2)$$

$$R(x) = w\langle x - d_{ik} \mid b_{ik} - d_{ik} \rangle, \quad b_{ik} \leq x \leq d_{ik} \qquad (3)$$

Step 3: Integrate various types of linguistic scales

Integrating various types of linguistic variables should be done after the questionnaire taker's linguistic terms variable k is transformed into A_{ik}, for different questionnaire takers i have different recognition and experience. Kacprzyk et al. (1992), Ishikawa et al. (1993) and Hsu & Chen (1996) proposed the formula of Fuzzy Delphi method to aggregate group opinions. But this paper considers the participants to be many, and moreover the linguistic cognition is different, it therefore uses the mean value to carry on the opinion integration, avoiding various linguistic cognition scopes as too dispersing. Suppose the membership function of A is $A_k = (c_k,$

$a_k, b_k, d_k)_{LR}$ 　　　　　　(4)

$$c_k = \frac{\sum\limits_{i=1}^{n} c_{ik}}{n}, \qquad (5)$$

$$a_k = \frac{\sum\limits_{i=1}^{n} a_{ik}}{n} \qquad (6)$$

$$b_k = \frac{\sum\limits_{i=1}^{n} b_{ik}}{n} \qquad (7)$$

$$d_k = \frac{\sum\limits_{i=1}^{n} d_{ik}}{n}. \qquad (8)$$

Step 4: Converting Fuzzy Number to Crisp Score

In the past, many scholars proposed the methods of defuzziness (Chen & Hwang, 1992; Chen & Hsieh, 1998). At this stage, we adopted Chen & Hsieh's (1998) method of defuzziness. They proposed graded mean integration representation for a generalized fuzzy number. Now we describe graded mean integration representation as follows:

Suppose L^{-1} and R^{-1} are inverse functions of functions L and R, respectively, and the graded mean h level value of generalized fuzzy number A=(c, a, b, d; w)$_{LR}$ is h[L-1(h) + R-1(h)]/2 as Figure 1. Then the graded mean integration representation of *A* is

$$P(A) = \left. \int_0^w h \left\langle L^{-1}(h) + R^{-1}(h) \middle| 2 \right\rangle \middle/ \int_0^w h\,dh \right. \tag{9}$$

Therefore, the formula (2) and (3) is modified as below:

$$L^{-1}(x) = c + (a - c)h / w, \quad 0 \le h \le w \tag{10}$$

$$R^{-1}(x) = d - (d - b)h / w, \quad 0 \le h \le w \tag{11}$$

Thus,

$$\frac{L^{-1}(h) + R^{-1}(h)}{2} = \frac{c + d + (a - c - d + b)h / w}{2} \tag{12}$$

By formula (9), the graded mean integration representation of A is (Suppose A is a trapezoidal fuzzy number). Since,

$$P(A) = \left. \int_0^w h \left\langle L^{-1}(h) + R^{-1}(h) \middle| 2 \right\rangle \middle/ \int_0^w h\,dh \right. = \frac{c + 2a + 2b + d}{6} \tag{13}$$

A generalized triangular fuzzy number is a special case of generalized trapezoidal fuzzy number when *b=a*. Then, replacing *b* by *a* in formula (13), the graded mean integration representation of A becomes

$$P(A) = \left. \int_0^w h \left\langle L^{-1}(h) + R^{-1}(h) \middle| 2 \right\rangle \middle/ \int_0^w h\,dh \right. = \frac{c + 4a + d}{6} \tag{14}$$

According to this method, convert fuzzy numbers of linguistic terms to crisp scores. Then,

after process reorganization, you can obtain the various types of linguistic terms' translate table.
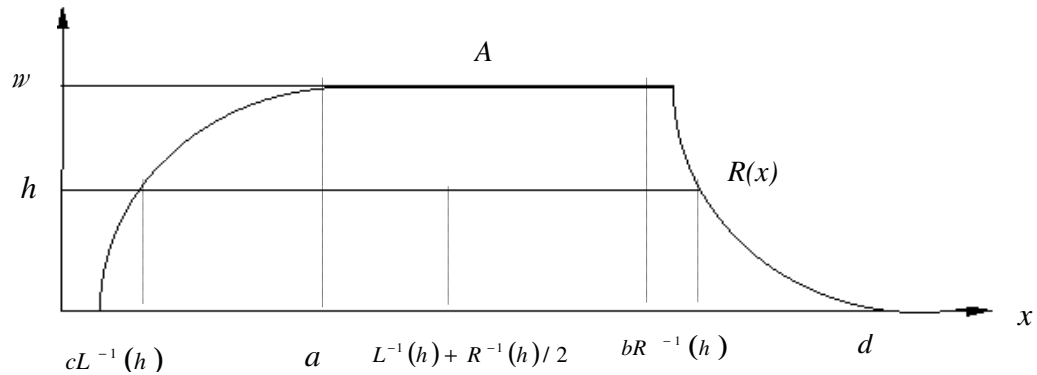

Figure 1 The graded mean integration of a generalized fuzzy number A=(c, a, b, d; w)$_{LR}$

Case Study

Sampling Method and Sample Structure

The sample is including nine online communities in Taiwan, including Kimo, CPB, Sony music etc. who were contacted and asked to participate in the study. Data were collected between October and December 2008 via the web for Internet users using a standardized questionnaire. First, a questionnaire of online helping behavior is handed to a online communities' users. Second, after the first questionnaire is completed, a second questionnaire containing linguistic scale is handed to the online communities' users.

Usually, answering a fuzzy linguistic questionnaire is not complicated. For this reason and because not many samples will be needed, we design questionnaires for this study based on representative samples. The method is that some random samples belonging to eight different linguistic scale combinations are collected and investigated to derive at least 15 effective samples for each linguistic scale.

Constructing Fuzzy Linguistic Scale

Based on consumer profit-segmentation variables, we first decide linguistic terms and

expressed as X = (strongly agree, agree, normal, disagree, strongly disagree) five linguistic terms. Next, forsake single linguistic scale and design ten combinations of linguistic scales, shown as Table 1.

Table 1 The combinations of fuzzy linguistic scale

Types	I	II	III	IV	V	VI	VII	VIII	IX	X
Strongly Agree	Yes	Yes		Yes			Yes			
Agree	Yes	Yes	Yes	Yes	Yes		Yes	Yes		
Normal	Yes	Yes	Yes	Yes	Yes	Yes		*Yes*	Yes	
Disagree	Yes	Yes	Yes		Yes	Yes			Yes	Yes
Strongly Disagree	Yes		Yes			Yes				Yes

Eliminate five questionnaires considered invalid out of the 130 questionnaires collected. Sort remaining 125 questionnaires into different types. Based on the combinations of fuzzy

Integrating Various Types of Linguistic Scales.

According to the above steps, we get the conversion scales as figure 2.

Figure 2 Various types of linguistic scales (Type -)
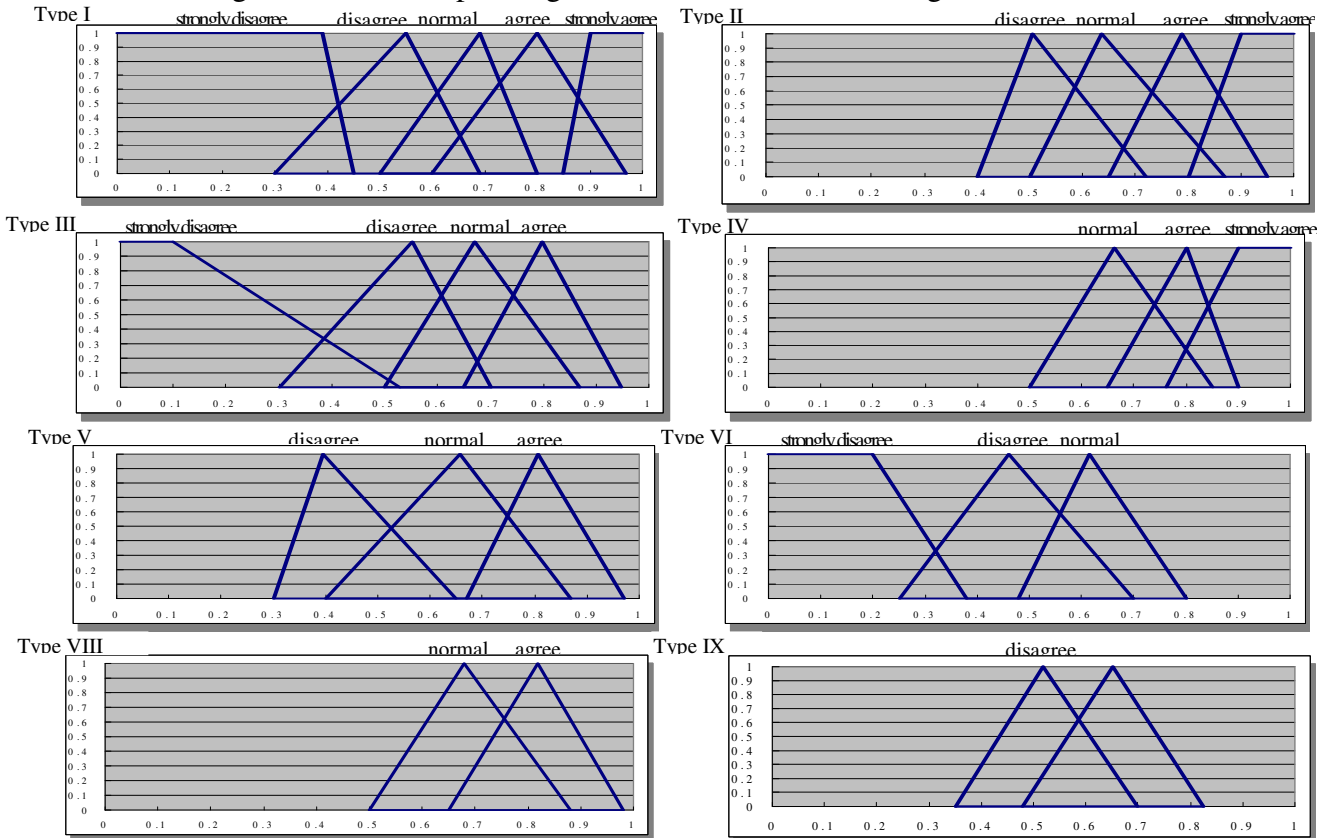
individual logical thinking, effectively eliminating errors generated by a single conversion set.

linguistic scales, eliminate two types (VII and X) that no one used in our study. Design eight

different types of linguistic scale combinations. This method considers the difference in

Though there are only 12 and 13 questionnaires categorized into type V and IX, it is sufficient to

do linguistic scale analysis.

From Figure 2, the results are described as follows: First, thorough empirical

investigation obtained linguistic variables, various types of linguistic fuzzy numbers scale are

completely different, and presented the asymmetry. Namely, different linguistic types that the

fuzzy numbers present different values for the same linguistic terms. Second, from types 1 to 5,

we find that the general public tends to have consistent opinions regarding a linguistic term's

more positive expression, namely, in "agree" and "very agree" on, participant's fuzzy number

chart width is narrow; namely, no matter whether the statement is the same, all had a close fuzzy

number graph. Finally, the fuzzy cognition of linguistic terms possesses "on the Double-sided

Property". Namely, the fuzzy numbers of linguistic terms have an overlap phenomenon; for

example, the fuzzy numbers of "normal", "agree," and "strongly agree" possess the same

converting crisp scores under α-cuts$=0.1$ in type *Converting Fuzzy Numbers to Crisp Scores*

Then, according to the formula (13) and (14), convert each fuzzy number of Figure 1 to

crisp scores. From Table 2 and Figure 3, we quickly can obtain various type of linguistic terms'

crisp scores.

The question of equal distance of scales

From comparison in Table 2, it's obvious that traditional questionnaires presuming equal

distance between scales assume everyone has same recognition levels when these levels are

transformed into scales such as "5, 4, 3, 2, 1." However, our study indicates that not everyone

has the same recognition levels. For instance, in type I, the transformed numbers are 0.89, 0.74, 0.59, 0.41, and 0.23, respectively.

Table 2 The various types of linguistic terms' crisp scores and Likert's score

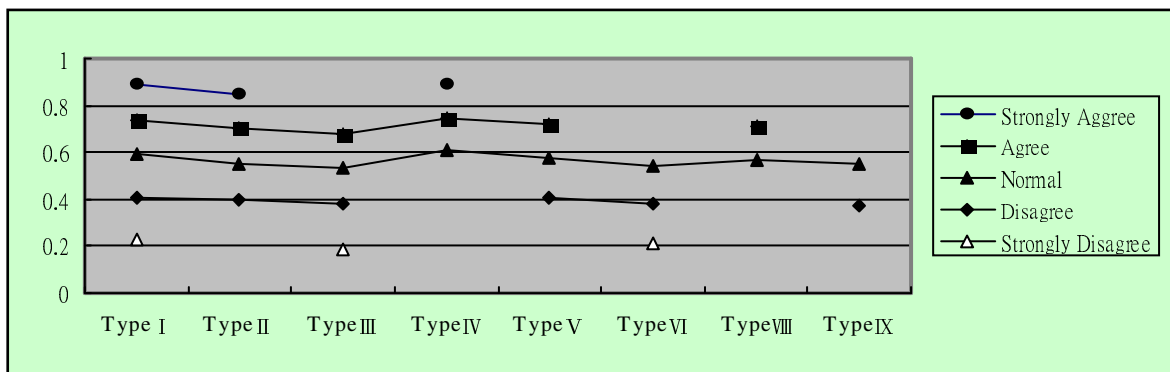| Types	Likert's score	I	II	III	IV	V	VI	VII	VIII	IX	X
Strongly Agree	5	0.89	0.85		0.89			****			
Agree	4	0.74	0.70	0.68	0.75	0.72		****	0.71		
Normal	3	0.59	0.55	0.53	0.61	0.58	0.54		0.57	0.55	
Disagree	2	0.41	0.40	0.38		0.41	0.38			0.37	****
Strongly Disagree	1	0.23		0.19			0.21				****

Figure 3 The types of linguistic terms' crisp scores and Likert's score

Comparison and Analysis

The questionnaire of single transformed value

When taking into account individuals' different logical thinking, recognition levels will be different as to a single linguistic term. Take "Agree" for example: traditional questionnaire is on scale 4; on the other hand, the transformed values under Fuzzy Linguistic Scale are 0.74, 0.70, 0.68, 0.75, 0.72, and 0.71.

Linguistic devaluation and inflation

Table 2 and Figure 3 show that we also have considered the phenomenon of linguistic devaluation and inflation in human logical thinking. When using measurements containing lesser scales, questionnaire takers tend to choose the "middle scale" and they would consider the width of the scale when answering questionnaires. The phenomenon of linguistic devaluation and inflation occurs frequently in the largest scale and the smallest scale sequentially.

The problem of dilution of measuring results

From Figure 3, the curve constituted by "average scale" values fluctuates most dynamically. In traditional scales, assuming equal distance between scales, test takers tend to choose scales closer to the middle one. Dilution of measuring results usually occurs. On the contrary, Fuzzy Linguistic Scale is not equally distanced. It eliminates the problem presented by traditional questionnaires by giving different linguistic terms and fuzzy values.

Conclusions

The Internet questionnaire method will become one of the major data collection methods in the future research. According to this study, linguistic bias exists between the internet questionnaire method and traditional method. We have the following conclusions for reference: First, through a questionnaire, questionnaire takers are able to recognize the scope of linguistic variables. The designed fuzzy linguistic conversion scale is able to solve the problem of subjectively set membership function. The traditional type of questionnaire assumes distances between scales are equal. Deviations will occur and the results obtained sometimes will be diluted. Second, using this fuzzy linguistic conversion scale, we have taken into account the problems of linguistic devaluation and inflation in human expression. This enables researchers not only to deal with different recognition styles, but also to notice differences in individuals by

providing different linguistic variable combinations for research purposes. The phenomenon that questionnaire takers tend to choose scales close to the middle will underestimate the variable correlation and thus lead to improper decision making. Third, the result shows that the general public tends to have a very close degree of recognition in answering questionnaires. There is only a slight ramification in recognition among test takers. However, the closer the chosen scales are to the middle, the fuzzier the linguistic terms are. Finally, however, the coverage of the internet questionnaire method was different according to the participants' characteristics. These differences may have a negative affect on survey results by the characteristics of respondents. Therefore, the accuracy of the internet questionnaire method should be further studied and also should be utilized fuzzy linguistic scale for internet survey results.

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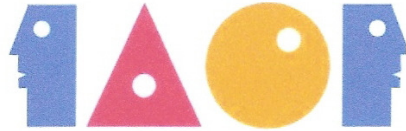
LINKAGE COMMUNITY BASED INNOVATION AND SPEED TO MARKET: THE MEDIATING ROLE OF NEW PRODUCT DEVELOPMENT PROCESS

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Abstract

The notion that firms can improve their innovativeness by tapping customers for knowledge has become prominent in new product development studies. Specifically, we argue that link user innovation and commercialization. Using the SEM analysis result to show that, this research proposes the impacts of members participant the willingness on the stages of idea generation and concepts and testing and launching are significant. This research also found the impacts of the three stages of new product development showed significant influence on new product speed to market. Finally, a complete model is developed for empirical testing. It seems to be a promising source of innovation capabilities for new product development.

Keywords: Community Based Innovation, New Product Development, Speed to Market.

Introduction

New product development plays an important role in a firm's growth and development. Traditionally, new product development processes and the marketing of new products took place within the firm boundaries, but several factors have led to the erosion of closed innovation. Clayton Christensen (2003) indicates that a company that listens to its customers and provides what they want still may lose out to the competition — because a cheaper, not-as-good but good-enough competitor comes in and gains market share. Therefore, many researchers and practitioners consider user participation in the development of new product is essential to the success of new product (Mäkipää et al., 2005, p.19; Füller et al., 2007, p. 62; Fang, 2008, p. 91). Community based innovations aggregate the efforts of individuals to create something that serves a shared need, and explicitly includes the participation of customers. These efforts are supported by formal or informal community partnerships that lower overhead, coordinate behavior, and spread risks in order to create value that, oftentimes, otherwise would be unavailable to the market. Since online communities offer a promising environment for creating innovation, they offer an interesting context for further empirical studies of this topic (Mäkipää et al., 2005; Füller et al., 2007; Ahonen et al., 2007). Such virtual interest communities are based upon shared enthusiasm for an issue or an activity. They possess and exchange knowledge concerning specific product domains and often are virtual meeting places for innovative users to discuss opportunities for new products and ideas for product improvement. While data about customers are readily available through existing customer knowledge. To be useful, managers need to transform data into customer information and to integrate the information throughout the firm to develop customer knowledge. It is the customer knowledge competence based on internal firm processes that generate and integrate specific customer information, which enables firms to

develop customer-specific strategies. Thus, the remainder of this article proceeds as follows: First, a theoretical framework is advanced to explore the nature of community based innovation on new product development and speed to market. Second, this paper takes an inductive approach and develops a model to understand participation in product-development communities. The main research links user innovation and commercialization. Finally, we discuss the theoretical and empirical implications, as well as limitations and future research directions.

Research Conceptual Framework and Method

Research Conceptual Framework and Hypotheses

Figure 1 presents the proposed model, referred to as the community based innovation (CBI) model. The research model for this study was designed to enables the researcher to examine the antecedents of CBI in online communities, and then how firms can interact best with such groups to get valuable input for new product development and may result in effects on new product speed to market. The main research can remedy what literatures have not dealt with: linking user innovation and commercialization.
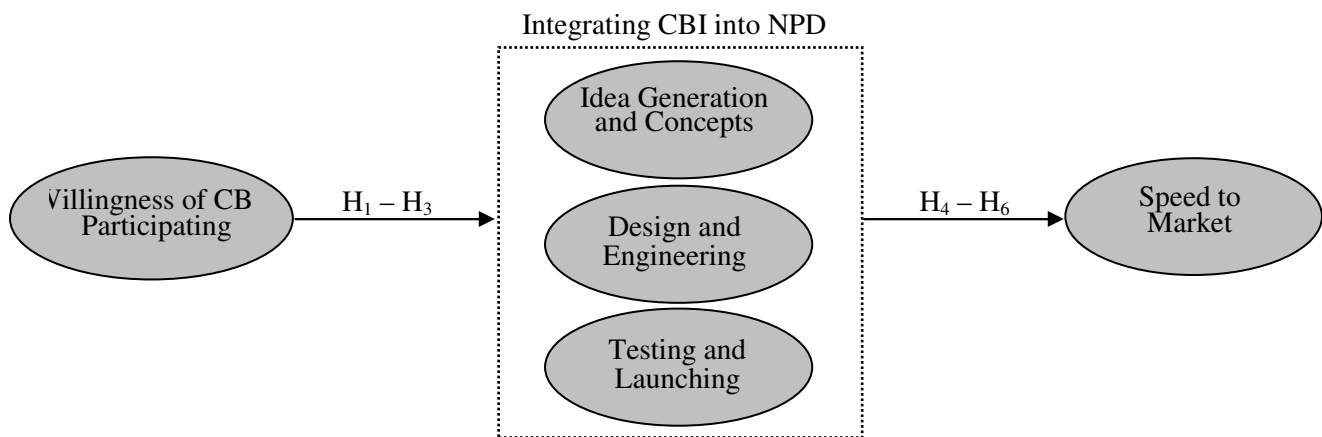

Figure 1 Research Model and Hypotheses

Reliability and Validity of Measures

Internal consistency was assessed by computing Cronbach's alpha, and the alpha coefficients for each construct of this study are presented in Table 1. As shown in Table 1, Cronbach's alpha for all items was found to be greater than 0.70, in accordance with Nunnally's standard (Nunnally, 1967). Following Anderson and Gerbing (1998), we also conducted confirmatory factor analysis to further establish the reliability and discriminant validity of the multi-item scales.

Survey Administration

The sample is 143 participants from five online communities of firms operating in Taiwan, namely Microsoft, Working House, Inventec Corporation, Hometec Technology Inc., and Asustek Computer Inc., that were contacted and asked to participate in the study. A banner with a hyperlink connecting to our online survey was posted on the homepage of MY3Q (*http://www.my3q.com/home2/209/yim952008/18339.phtml*) from March 19 to May 31, 2008, and members with knowledge sharing experience were invited to complete this survey. The surveys began with an introductory statement that asked respondents to give their own responses, and assured them of confidentiality. The exclusion of 18 invalid questionnaires resulted in a total of 143 complete and valid ones for data analysis. Table 2 lists the demographic information of the respondents. This was followed by the measures and a request for demographic information. The sample consisted of 125 respondents, including 59 with the educational background of university and 53 service industry workers in Taiwan. The male/female ratio of the sample was 42.4 percent and 57.6 percent, respectively. In the sample, about 50 percent were in their twenties and 35 percent were in their thirties, and just fewer than 70 percent of respondents were single. The largest group of respondents, 42.4 percent, worked in the service industry.

Table 1 Summary of Measurement Scales

Construct/items	Factor loading	t-value	Construct Reliability	Cronbach's α
The Willingness of CBI			0.741	0.781
CBI1	0.831**	20.844		
CBI2	0.889**	21.447		
CBI3	0.811**	19.684		
CBI4	0.789**	19.100		
Idea generation and concepts			0.742	0.911
IGC1	0.742**	17.231		
IGC2	0.768**	18.659		
Design and engineering			0.870	0.925
DE1	0.870**	17.221		
DE2	0.891**	18.936		
Testing and launching			0.825	0.903
TL1	0.825**	19.987		
TL2	0.819**	18.145		
Speed to Market			0.825	0.903
STM1	0.831**	18.890		
STM2	0.814**	18.209		
STM3	0.807**	18.113		

Note: (** significant at the .001 level)

Table 2 Demographics (n=125)

Measure	Items	Nr.	Percent	Measure	Items	Nr.	Percent
Gender	Male	53	42.4%	Education	High school or below	21	16.8%
	Female	72	57.6%		College/ University	59	47.2%
Age	19-23	23	18.4%		Graduate school or above	45	36.0%
	24-28	41	32.8%	Primary occupation	Self-Employed	22	17.6%
	29-35	27	21.6%		Government	17	13.6%
	36-42	18	14.4%		Information Technology	15	12.0%
	42 or above	16	12.8%		Manufacturing	7	5.6%
Marital status	Single	85	68.0%		Service Industry	53	42.4%
	Married	40	32.0%		Student	11	8.8%

Questionnaire Data Analysis

Data analysis utilized a two-step approach, as recommended by Anderson & Gerbing (1998). The ten constructs were allowed to covary freely in the CFA model. Model estimation was done using the maximum likelihood approach, with the item correlation matrix as the input. Table 3 presents the results of the CFA analysis.

Table 3 Correlations and AVE

Construct	Mean	Standard Deviation	Construct				
			CBI	IGC	DE	TL	STM
CBI	3.896	0.761	**0.798**				
IGC	3.675	0.834	0.548**	**0.813**			
DE	3.406	0.857	0.322**	0.379**	**0.769**		
TL	3.735	0.832	0.192**	0.280**	0.131*	**0.905**	
STM	3.978	0.782	0.365**	0.413**	0.398**	0.374**	**0.897**

Diagonal elements are the square root of the average variance extracted (AVE).   CBI:The Willingness of CBI
IGC:Idea generation and   DE: Design and engineering   TL: Testing and Launching   STM: Speed to Market
    concepts

These results suggest that discriminate validity was achieved. Therefore we conclude that the scales should have sufficient construct validity.

Empirical Study

Questionnaire Data Analysis

AMOS 7.0 was used for testing the model and hypotheses shown in Figure 2. For the current CFA model, covariance structure analysis testing of the proposed model (see Figure 3) resulted in a chi-square statistic of 25.98 (df=11, p<0.01). Although the chi-square value was significant, this statistic is sensitive to sample size and model complexity; as such, χ^2/df was 2.36 (χ^2 =25.98; df=11), NNFI was 0.94, and CFI was 0.92, AGFI was 0.93, RMR was 0.002 (<0.05), the RMSEA was 0.009 (<0.05), indicating satisfactory model fit.

Figure 2 illustrates the estimated coefficients and their significance for the structural model. Five of the six paths exhibited a P-value less than 0.05, while the remaining two were not significant at the 0.05 level of significance. The impacts of members participant the willingness of CBI on the stages of idea generation and concepts (β=0.41, t=5.24), and testing and launching (β=0.39, t=5.03) are significant. Therefore, H_1 and H_3 can be accepted. However, members participant the willingness of CBI has no significant impact on the stage of design and engineering (β=0.07, t=0.89), and thus H_2 cannot be accepted. The impacts of the stages of idea generation and concepts exhibited a strong positive effect on new product speed to market (β=0.37, t=4.89), and testing and launching (β=0.54, t=7.49) are significant, and the stage of design and engineering showed significant influence on new product speed to market (β=0.07, t=0.59). Consequently, H_4, H_5 and H_6 were supported empirically.
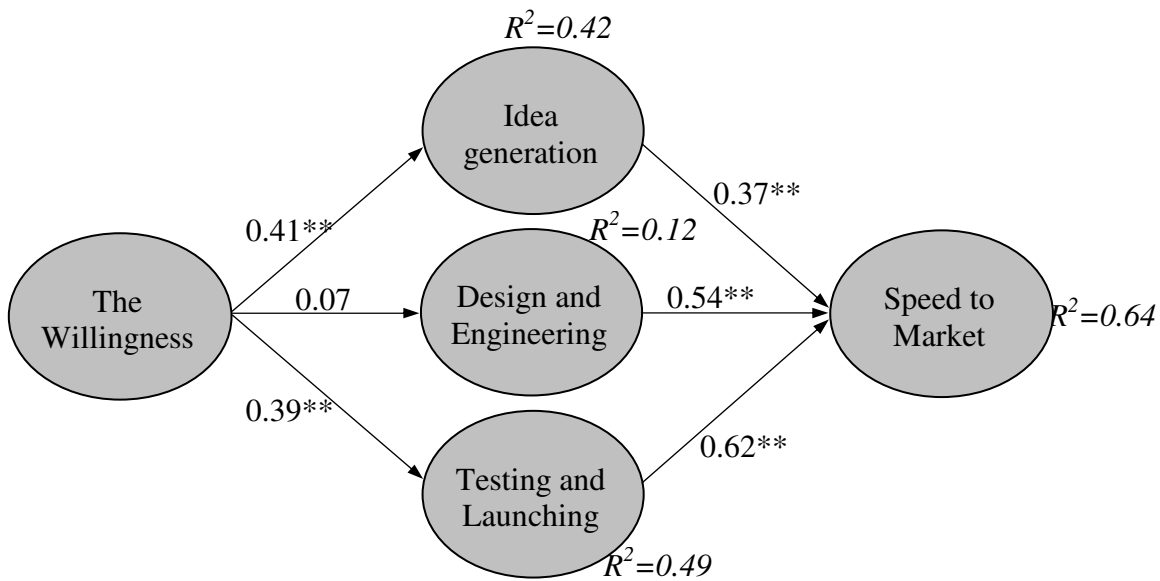

Figure 2 Results of Hypotheses Tests
*p <.05   ** p <.01

Results

Finally, the explanatory power of the research model also is shown in Figure 3. The R^2 values show that the items' members participant the willingness of CBI account for 42 percent of the variance of the idea generation and concepts stage, 12 percent of variance of the design and engineering stage, and 49 percent of the testing and launching stage. And The R^2 values show that the items' the idea generation and concepts stage, the design and engineering stage and the testing and launching stage account for 64 percent of the variance of new product speed to market.

Discussion and Implications

Summary of Results

The contribution of this work is to develop a model that highlights the role of new product development process as mediators between interaction with customers and speed to the market. We have developed an interpretation of the model that highlights the importance of formal organization for successful userer innovation seen from the point of view of established innovating firms. The findings of this work are as follows. First, the research model was designed to examine the antecedents of CBI in online communities, and then how firms can interact best with them to get valuable input for new product development and speed to market. Second, the threat of competitors getting access to information that should be kept secret and the need to address a sufficient number of participants from predefined market segments – especially important for the testing and launching stages – require more careful consideration. Finally, Speed to Market is a potentially misguided pursuit. Leading companies are investing to achieve mastery of the product development life cycle. Achieving speed to market is one way companies are leveraging their improved product development processes for competitive advantage. Speed, however, is just one dimension -- quality, efficiency and capacity are others -- of this optimization. The

research found that in new product development's three stages, besides promotes the member to participate in the new product development ideals generation and concepts stage has the help regarding speed to market, the research also found that the third and second stage has a more significant influence with the speed to market. Namely, members participates CBI in the Design, Engineering, Testing and Launching of new product development process has the very helpful regarding new product on speed to market. Namely regarding the development and design suggestions of product prototypes, because the participant need itself has the high specialized knowledge, but is not the common user rests on its use experience to be able to ford into. In the testing and launching stage, consumers can become acquainted with the new product and give their feedback on virtual presentations and test simulations. These ideas were ranked internally as very attractive by using assessment scales including the dimensions "market potential," "degree of newness," and "technical feasibility." The presentation of entire product specifications or finished prototypes by community members has not been seen yet. Such contributions will require further modifications for the identification of communities, e.g., the personal contact in closed communities of professional designers and experts, and for improved incentive systems, e.g., patent sharing. However, the general principles of CBI also can also be considered in this study.

Implications for Research and Practice

Online communities have gained increasing importance in scholarly and practitioner writings on the management of innovation. This is because networks are seen as the locus of innovation. The open innovation model is different. Opposite to the traditional model, the online community as a form of open innovation based project, targets to undefined objectives, with the possibility of changing and evolving objectives. Open innovation models also apply to the

commercialization phase, and companies may spin out already commercialized technologies in which more value can be realized elsewhere, or acquire already commercialized product lines or businesses that can provide immediate sources of new growth for the company. Traditionally, many companies have relied on their internal R&D organizations to fuel innovation, but they now can augment these efforts by engaging online communities that care about their products to identify and capture innovations. Many of today's most innovative companies have adopted a collaborative innovation strategy, one that taps the creativity, ingenuity, and knowledge of their employees, customers, vendors, partners, suppliers, analysts. Global competition and an accelerated business cycle make it imperative for companies to enlist their external communities to collect and evaluate ideas efficiently and transform them into innovation.

In attracting such efforts, the fun-factor and intrinsic stimuli proved to be more important than monetary incentives to motivate the participants to carry out the presented development tasks. In this study, an average of 80 percent of the participants signaled their willingness to support the innovating companies again in future initiatives for NPD. Several interactions over a certain period of time may lead to a culture of trust and commitment, and the consumer thus becomes a virtual co-innovator with strong ties to the company and the new product. The four-step NPD procedure can be interpreted as a first course of interaction between users and the innovating company. Thereby, companies can establish a "community of innovation" around their products in development. Looking forward, when companies use online communities for innovation to a greater extent, a competition for the most qualified users and a market for sophisticated solutions will arise.

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QUALITY COST IMPROVEMENT MODELS CONSIDERING FUZZY GOALS

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Abstract

Decreasing quality cost in the production process is an important issue for an operations manager in the competitive environment. Traditionally, quality cost includes four main parts, namely prevention cost, appraisal cost, internal failure cost, and external failure cost. The improvement of quality cost in general is desirably performed by achieving more than one goal. These goals possibly conflict with each other, and their levels may be difficult to determine. In order to deal with this problem, this paper proposes a fuzzy goal programming (FGP) approach to determine the settings of the associated decisive variables so as to achieve the desirability. The approach is applicable to resolve multi-objective optimization problems, involving multiple conflicting goals with imprecise information. In addition, different preemptive priorities of the goals can be considered in the formulation based on the different importance of each goal, and the optimal solutions can make the total achievement degrees of all goals maximal. A numerical example is used to demonstrate the applicability of this approach.

Keywords: Fuzzy Goal Programming; Quality Costs; Decision Making; Fuzzy Sets

Introduction

Quality costs can be considered as a means for an operations manager to evaluate quality

levels in the operation activities. Several studies have investigated quality cost problems, such as

Oliver and Qu (1999), Halevy and Naveh (2000), and Tkaczyk and Jagla (2001). For the

measurements of quality cost, Giakatis and Rooney (2000) proposed a new method to identify

and measure quality costs. In addition, Tansey et al. (2001) developed new quality scales to

measure quality costs and used statistical analysis to identify the scale's construct validity,

dimensionality and reliability.

Many authors used different quality cost structures to develop process design/control

models. Bernardo et al. (2001) and Lin and Nam (1999) used Taguchi loss functions to address

process design problems. Jiang and Tsui (2000) developed an average quality cost criterion to

evaluate the performance of statistical process control. Based on internal and external failure

costs, Tang et al. (2003) studied the process control policies and inventory holding time. And

Feiring et al. (1998) suggested a Markov chain model to estimate total failure costs by individual

parts. However, the studies based on quality cost structure to develop quality cost improvement

model are lack.

Traditionally, quality costs include four fundamental cost components: prevention cost,

appraisal cost, internal failure cost, and external failure cost. Prevention cost and appraisal cost

are considered as controllable variables for achieving the desired levels of the response variables, i.e., internal failure and external failure costs. Feigenbaum (1974) claimed that as appraisal cost rise, failure costs tend to fall. This is because more failures are discovered at the earlier stage. Ittner (1996) indicated that effective prevention investments could reduce both appraisal and failure costs. Several empirical studies have investigated the relationships among quality cost components. Chauvel and Andre (1985) developed the relationship between the total quality cost and prevention and appraisal costs based on correlation analysis. Ittner (1996) and Carr and Ponemon (1994) applied various statistical techniques to perform hypothesis tests for the relationship between quality cost components and the improved quality level based on past data and experience. Krishnamoorthi (1989) applied regression analysis to fit statistical function models for representing the relations of controllable variables and response variables in terms of four quality cost components.

For improving quality costs, the use of quantitative relationship models is useful. However, quality cost models in general are developed based on imprecise cost data (Freeman, 1995; Porter and Rayner, 1992). In addition, from the decision-making viewpoints, several goals are desirably achieved in the planning stage. The goals may conflict with each other. In order to deal with these problems, this study proposes a fuzzy goal programming approach to determine the optimal settings of controllable variables and also maximally satisfy the operations

manager's desirability. This model allows managers to consider different importance among various goals, as well as to consider the fuzziness of each goal.

The remainder of the paper is organized as follows. Section 2 provides a review of quality cost and various models of quality cost behavior. Fuzzy goal programming model is formulated in Section 3. Based on the existing quality cost functions (Krishnamoorthi, 1989), a numerical example is used to demonstrate the proposed model in Section 4. Finally, the conclusion is presented in Section 5.

A Review of Quality Costs

It is widely recognized that a quality cost system includes all costs associated with making, finding, repairing, and avoiding defects (Plunkett and Dale, 1988). These costs have been classified into two categories: controllable and response variables. Controllable variables have two different types: prevention cost and appraisal cost. Several studies indicated that each investment in prevention provides a learning opportunity to decrease the future costs of defectives. It is analogous to a capital investment that provides benefits over multiple periods (Fine, 1986; Marcellus and Dada, 1991). Prevention cost usually includes employee education, quality planning, supplier quality assurance, and so on. Appraisal cost is the expenditure incurred due to the assessment of the products quality to determine their conformance to customers'

requirements. The costs include inspection labor and material costs as well as the cost of maintenance test equipment.

Response variables are those required to examine and correct products or services that do not conform to customers' specifications. These costs can be classified into two subcategories: internal failure and external failure costs. Internal failure cost occurs prior to the shipment of products. Examples are reworking and scrapping costs. Managers often underestimate internal failure costs or ignore hidden costs incurred within their firms, such as excessive inventory levels held to accommodate poor quality (Bowman, 1994; Ittner, 1994), schedule changes and downtime increase because of quality-related problems (Nandakumar et al., 1993), and the disruptions in operations due to out-of-conformance products (Marcellus and Dada, 1991; Deming, 1982). External failure cost occurs after the shipment of products. These costs include warranty cost and complaint investigation (Feigenbaum, 1974). Juran and Gryna (1988) and Goodstadt and Marti (1990) called external failure costs as intangible quality costs, including the loss of customer goodwill, customer dissatisfaction costs, and future lost sales.

Typically in quality cost models, the relationship between quality levels and costs is conveyed graphically (Plunkett and Dale, 1988). The traditional quality cost models portray an optimal level of quality at the point where the increase of the marginal cost of prevention and appraisal activities equals the reduction of the marginal benefit from internal and external failure

costs. Besides, a continuous improvement model (or called dynamic model) argues that the only optimal point emerges when zero-defects occur, considering that putting enough efforts into prevention will lead to no defects produced in the operations so as to have the advantages of zero failure costs and obviating any need for appraisal. Empirical studies by Chauvel and Andre (1985) and Krishnamoorthi (1989) supported the traditional models. Ittner (1996) and Burgess (1996) suggested that the traditional model could be an accurate static representation of quality cost system. Accordingly, this study employs the traditional models to develop a fuzzy goal programming model for the quality improvements.

Satisfying external customers' requirements is the most important challenge for a business unit. Therefore, in general the goal for decreasing external failure costs is more significant than the others. For reflecting different importance among the goals, this paper applies a preemptive priority structure for achieving operations managers' desirability.

Model Formulation

Let x_j be the jth controllable item of quality cost variable, $j = 1, \ldots, $ n, and y_i be the response variable i to describe the relationship with controllable quality cost items, i.e. $y_i = f_i(x_1, \ldots, x_n)$, $i = 1, \ldots,$ m. Response variables are considered as the goals for determining the optimal inputs to achieve the desirable levels of the goals. A goal

programming model for quality cost improvement can be formulated as follows:

Find $x_1, \ldots, x_n$ which

maximize the achievements of $(y_1, \ldots, y_m)$,

subject to $y_i = f_i(x_1, \ldots, x_n)$ and $\varepsilon_j \leq x_j \leq \eta_j$, $j = 1, \ldots, n$, $\qquad\qquad\qquad$ (1)

where ε_j is the minimum amount needed on the controllable item j for ensuring the process

stability, and η_j is the maximum amount that can support the controllable item j due to the

budgetary limitation.

Owing to the imprecise nature of quality costs and the consideration of more than one

improvement goal, a fuzzy goal programming (FGP) model is developed in this study. The FGP

can allow an operations manager to set up a goal linguistically and to determine the priority

among the goals. The objective is to maximize the overall achievement degree for all goals. The

managers first establish the aspiration level for each goal by a linguistic term, for example

"approximately 50%". Let $y_i^{\min}$ represent the aspiration level and $y_i^{\max}$ be the maximally

allowable level of the goal y_i. Let the vector **x** denote the controllable quality cost items, i.e., **x**

= $(x_1, \ldots, x_n)$. The managers would be completely satisfied with the input (**x**) at which

$y_i(\mathbf{x}) \leq y_i^{\min}$, while the managers would be completely dissatisfied, if $y_i(\mathbf{x}) \geq y_i^{\max}$. Accordingly,

the achievement degree can be formulated linearly as

$$\mu_i(\mathbf{x}) = \begin{cases} 1 & if \quad y_i(\mathbf{x}) \le y_i^{\min}, \\ \dfrac{y_i^{\max} - y_i(\mathbf{x})}{y_i^{\max} - y_i^{\min}} & if \quad y_i^{\min} \le y_i(\mathbf{x}) \le y_i^{\max}, \\ 0 & if \quad y_i(\mathbf{x}) \ge y_i^{\max}. \end{cases} \qquad (2)$$

where $\mu_i(\mathbf{x})$ is the achievement degree of the ith goal at $\mathbf{x}$, and can be viewed as the membership function of the ith goal.

The fuzzy optimization scheme has been proven to be useful in modeling decision-making problems involving human perception (Zimmermann, 1978; Lee and Wen, 1997). In order to resolve a fuzzy optimization problem, in general it is reformed as an equivalent crisp problem. Its objective function can be expressed as a weighted additive model, i.e., $z = \sum_{i=1}^{m} w_i \mu_i(\mathbf{x})$, where w_i denotes the weight (the relative importance) of the ith fuzzy goal with $\sum_{i=1}^{m} w_i = 1$ (Tiwari et al., 1987; Hannan, 1981). A major limitation of applying the weighted additive model is that the model may produce undesirable solutions when the weights are changed, as illustrated in Chen and Tsai (2001). Instead, the model proposed in this paper takes into account that the goal with relatively high importance has a higher achievement degree than the others, i.e., $\mu_i(x) \ge \mu_k(x)$, where the ith goal is more important than the kth one. Thus the objective can be formulated as a simple additive function, which is suitable for showing the overall achievement degree associated with multiple goals (Tiwari et al., 1987). The FGP model can be expressed as

Maximize $\sum_{i=1}^{m} \mu_i(\mathrm{x})$ (3)

subject to   membership functions $\mu_i(\mathrm{x})$, $i = 1,\ldots,m$,

system constraints, i.e., the allowable range of each controllable quality cost item, and

preemptive priorities of the goals, i.e., $\mu_i(\mathrm{x}) \geq \mu_k(\mathrm{x})$ $i \neq k$, $i, k = 1,\ldots,m$.

An Illustrative Example

The inputs of the FGP model are controllable quality cost items. They can

be the items in the prevention cost category, e.g., training, preventive

maintenance, quality engineering and so on, or the appraisal cost category, e.g.,

inspection, quality audits, lab tests, and so on. For simplicity, without the loss

of generality, we adopt two aggregated costs as quality cost input variables,

proposed by Krishnamoorthi (1989), for illustration. Based on an empirical

study for industries, two quality cost relation functions are constructed as

$$y_1 = \frac{5.9}{x_1} + \frac{298}{x_2} \text{ and}$$ (4)

$$y_2 = \frac{121}{x_1} + 0.213x_2,$$ (5)

where x_1, x_2, y_1, and y_2 denote prevention cost, appraisal cost, external failure cost and

internal failure cost, respectively, which are expressed as percentages of the total quality cost.

Equation (4) expresses external failure cost (y_1) as a function of prevention (x_1) and appraisal

(x_2), indicating that y_1 is inversely related to x_1 and x_2. The large coefficient of $1/x_2$ implies that most of the decrease in y_1 could be achieved from x_2. This means that the input of prevention cost will have few impacts, while appraisal cost must be increased to reduce most of external failure cost. Equation (5) indicates that internal failure cost is reduced much more than external failure cost by an increase in prevention cost. Note that the increase in appraisal cost tends to increase the internal failure cost, although the amount is little.

Suppose that an operations manager faces with the above quality cost relationships, and external failure cost in Equation (4), internal failure cost in Equation (5), and controllable costs are desirably minimized. They are defined as three goals, i.e., y_1, y_2, and $y_3 = x_1 + x_2$. Obviously, these goals are conflicting and cannot be achieved simultaneously. Therefore, the priority order is set as y_1, y_2, and y_3. The achievement of the three goals can make the total quality cost minimal, considering the determined priorities. Assume that the total quality cost is 10% of the sales revenue, i.e., \$100,000. The present prevention cost, appraisal cost and failure cost as percentages of the total quality cost are 10%, 25% and 65%, respectively. Actually, this allocation is often quoted as the norm for non-quality-enlightened organizations (Oakland, 1993).

This quality improvement problem involves three conflicting goals and will be resolved by maximizing the overall achievement degree of goals. First, suppose the minimum amounts,

$5,000 and $12,000, should be invested on the purposes of prevention and appraisal, respectively, to ensure process stability. In other words, 5 percent expenses on prevention ($\varepsilon_1 = 5\%$) and 12 percent expenses on appraisal ($\varepsilon_2 = 12\%$) are necessary. However, the expenses cannot be greater than $15,000 and $30,000 (i.e., $\eta_1 = 15\%$, $\eta_2 = 30\%$), respectively, because of the budgetary limitation. For implementing FGP, the aspiration level and maximally allowable level of each goal y_i (i.e., $y_i^{\min}$ and $y_i^{\max}$) should be determined beforehand. Although these two levels can be determined subjectively, the model may produce an infeasible solution region, if the levels seriously violate the system restrictions. To avoid this problem, we optimize each individual goal to obtain the corresponding maximal achievement degree under the system restrictions, and also determine the lowest achievement degree of each goal by using the input variable solutions produced in optimizing the other goals. Thus the two levels of y_i can be found as follows: (10.33, 26.01) for y_1, (10.62, 26.76) for y_2, and (17, 45) for y_3. Using the above ranges, the associated membership functions, formulated as Equation (2), can be built up.

Based on the preemptive priority structure of the goals, their membership function relationships in FGP can be represented as $\mu_1(x) \geq \mu_2(x)$, and $\mu_2(x) \geq \mu_3(x)$. Finally, a crisp optimization model can be formulated as follows,

Maximize $\quad \mu_1(x) + \mu_2(x) + \mu_3(x)$

subject to
$$
\begin{cases}
\mu_1(\mathrm{x}) \leq \dfrac{26.01 - (5.9/x_1 + 298/x_2)}{26.01 - 10.33} \\[3mm]
\mu_2(\mathrm{x}) \leq \dfrac{26.76 - (121/x_1 + 0.213 \cdot x_2)}{26.76 - 10.62} \\[3mm]
\mu_3(\mathrm{x}) \leq \dfrac{45 - (x_1 + x_2)}{45 - 17} \\[3mm]
\mu_1(\mathrm{x}) \geq \mu_2(\mathrm{x}); \mu_2(\mathrm{x}) \geq \mu_3(\mathrm{x}) \\[2mm]
0 \leq \mu_1(\mathrm{x}) \leq 1; 0 \leq \mu_2(\mathrm{x}) \leq 1 \\[2mm]
0 < 5 \leq x_1 \leq 15 < 100; 0 < 12 \leq x_2 \leq 30 < 100
\end{cases}
\tag{6}
$$

We solve the above nonlinear programming problem using a computer software package, namely GINO. The best compromise solutions of prevention and appraisal are 13.18 and 22.63 percents, respectively. This indicates that the optimum policy for minimizing quality cost needs to increase the prevention percentage from the present 10% to 13.18% (i.e., $13,180), while appraisal expense should be decreased to 22.63% from 25%. The achievement degrees of three goals are μ_1=0.79, μ_2=0.79 and μ_3=0.33. The value of each goal is y_1=13.62, y_2=14, and y_3=35.81. This policy can be expected to result in a 36.57 percent reduction of total quality cost.

As mentioned before, external failure cost is more important than the others. Suppose operations managers desire to raise its achievement degree (i.e., μ_1) in order to make external failure cost decreased. However, the increase of μ_1 should have influences on the other quality costs. For investigating the influences of different achievement degrees μ_1 on the other quality costs, several different degrees (μ_1=0.8, 0.85, 0.9, 0.95) are used. Figures 1 to 3 at the end of this paper depict the changes of total quality cost, prevention cost and appraisal cost when different

degrees of μ_1 are desired. The results show that the changes of total quality cost, prevention cost

and appraisal cost when different degrees of μ_1 are desired. The larger the achievement degree

of μ_1, the higher total quality cost is. This is because prevention cost and appraisal cost also

increase. The figures indicate that prevention cost can only be increased to $15,000 when

μ_1=0.85, due to budgetary limitation, while appraisal cost is continuously increased to reduce

most of external failure cost.

Concluding Remarks

Quantitative relationship functions among the quality cost components are useful for

quality improvement decisions. An operations manager often desires to achieve more than one

goal for the improvements. From the practices, multiple goals may conflict with each other, and

the goal levels are not easy to be determined exactly. This study proposes a fuzzy goal

programming model to formulate the quality improvement problems involving conflicting goals.

The model allows managers to establish the aspiration level and maximally allowable level of

each goal, which can be formulated as a membership function to express the achievement degree

of the goal. In addition, it allows managers to specify the preemptive priority of all goals. Based

on the existing statistical functions of quality cost, an example is used to illustrate the feasibility

of the proposed model.

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%

68
66
64
62
60

0.8   0.85   0.9   0.95

Total quality cost

Achievement degree of external failure costs
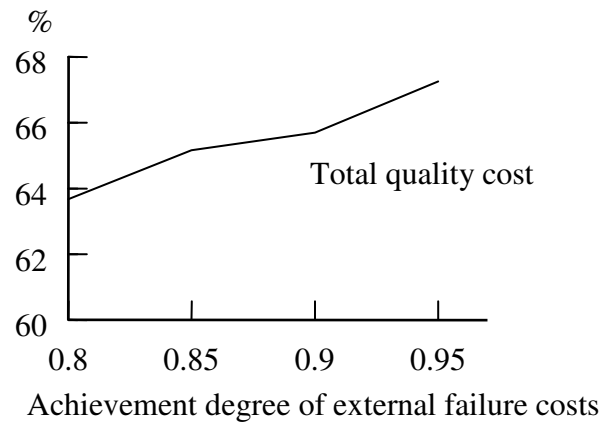
Figure 1. The changes of total quality cost with different achievement degrees of external failure cost

%

15

14

13

0.8   0.85   0.9   0.95

Prevention cost

Achievement degree of external failure costs
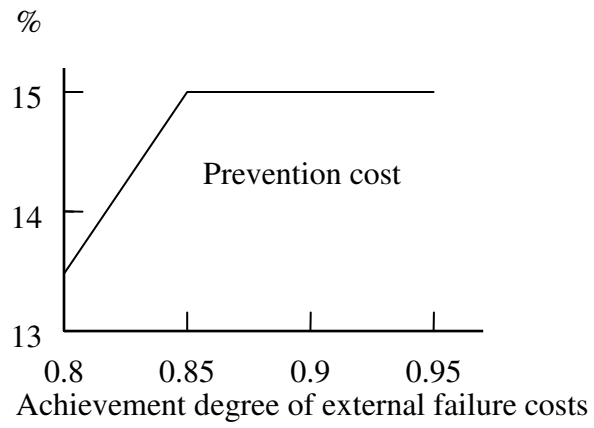
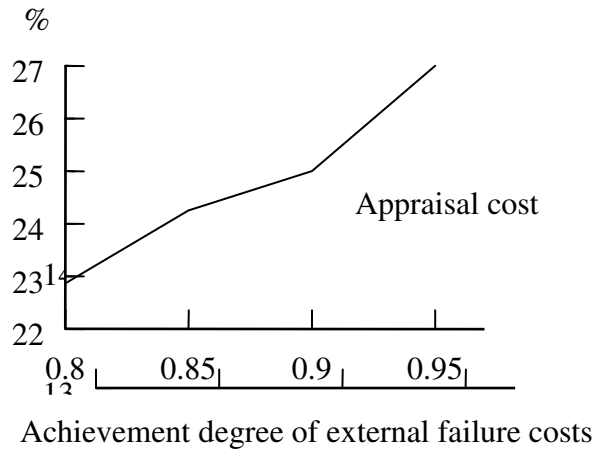Figure 2. The changes of prevention cost with different achievement degrees of external

failure cost

Figure 3. The changes of appraisal cost with different achievement degrees of external failure cost

INNOVATION CAPABILITY AND PERFORMANCE IN TAIWANESE SCIENCE PARKS: EXPLORING THE MODERATING EFFECTS OF INDUSTRIAL CLUSTERS FABRIC

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Abstract

This paper examines the impact of the innovation capability on business performance. Through empirical study, it revealed that the innovation capability has a significant positive effect on business performance. Value chain cluster in the fabric of industrial clusters has a moderating effect on the innovation capability and performance of businesses. Since science parks promoted business performance, construction of more industrial clusters should be a future trend.

Keywords: Innovation Capability, Industrial Clusters, Science Park, Performance

Introduction

Science's and technology's international competition is day by day intense with the advent of its rapid development and the arrival of globalized time. Governments around the world share a general consensus on seeking the country economic progress and the comprehensive national strength enhancement based on science and technology development. Facing the global intense economic competition challenge, the economy of Taiwan has also entered a new era of reliance on advancements in science and technology to promote development. To attract the foreign country high-tech enterprises' investments and technology transfer, the government must provide an industrial cluster space to achieve economies of scale to reduce infrastructure costs such as staff training, factory, and land while also enjoying the cluster economic benefits in the dissemination of technological innovations. According to the 2007-2008 Global Competitiveness Report published by the 2009 World Economic Forum (WEF), Taiwan has again taken first place worldwide in the "state of cluster development" index. The comparison total score 5.7 points (perfect score 7 points) shows an increase of 0.18 points from 5.52 points the previous year and indicates its outstanding industrial cluster. The international competitiveness of Taiwan's industrial clusters has continuously improved. It placed second on this index from 2001 to 2003 and third from 2003 to 2004, climbed again to the second place from 2004 to 2005 and stayed on from 2005 to 2006 and finally earned the first

place in the world from 2006 to 2007 which continued occupying the leading position from 2007 to 2008, making this the most superiority project among the indices for Taiwan's competitiveness.

On the other hand, under the progress of the economy unceasingly, industries in Taiwan have gradually advanced from being manufacturing-oriented to investment-oriented. The innovative capabilities and advantages have already been considered an important link to the investment development in industrial technology policies. Innovation can strengthen the flexibility of organizations and adaptive faculty towards the environment (Geroski, 1995). Undeniably, effectively developing an excellent innovation capability is already one significant issue which could not be evaded for enterprises for adapting to globalization and the highly dynamic competitive market environment, making this an important research subjects in the academia (Shane and Ulrich, 2004).

Afuah (2002) theory viewpoint revealed that although the innovation be introduced and applied to new products and processes but more important is the manufacturer must connect the innovation with exterior market to achieve a favorable achievement. According to James (2002) research, innovation activities have evident regional differences and their effects in various regions are also diverse which results from the dissimilarities in methods and weights attached to their composite elements. Thus, this study examines the impact of the maturity of the innovation

capability and industrial clusters on the operation efficiency of firms in Taiwan's science parks.

Findings from this study can be utilized by countries worldwide when planning for industrial

clusters in science parks and offers recommendations concerning the operations of firms located

in science parks.

<div align="center">Literature Review and Hypothesis</div>

<div align="center">*Innovation Capability*</div>

Regardless of from which point of view innovation is looked at, if firms intend to

innovate and improve their innovation performance, they must have innovation capability. Adler

and Shenbar (1990) defined innovation capability as the ability to develop and respond and

identified its four dimensions: (1) ability to develop new products that meet market needs; (2)

ability to apply appropriate process technologies to producing these new products; (3) ability to

develop and adopt these new products and process technologies to satisfy future needs; and (4)

ability to respond to related technology activities and unexpected activities created by

competitors. From this definition, it can be observed that the aim of innovation capability is to

apply a set of appropriate process technologies to producing new products that meet market

needs and at the same time, to be able to respond to unexpected technology activities and

competitive conditions. In other words, innovation capability not only resolves present problems

on products and processes of enterprises, but must also be able to respond to changes in the external environment.

Guan and Ma (2003) proposed that innovation capability is a special asset of a firm. This ability to quickly introduce new products and adopt new processes is very important for firms to compete. They classified innovation capability into seven dimensions: learning, research and development, manufacturing, marketing, organizational, resources exploiting, and strategic. In line with this, Yam et al., (2004) suggested the concept of technological innovation capabilities (TICs). They believed TICs are a kind of special assets or resources that include technology, products, processes, knowledge, experience, and organization. Drucker (2006) suggested developing a superior innovation capability as an important market strategy. That is, firms transform competitive threats derived from changes in the environment into profits in the face of highly uncertain market environments. The study of Tidd and Bessant (2009) concluded that firms with a high degree of innovation capability are on average twice as profitable as other firms.

Various researchers have offered different views on the categories of innovation capability. Moore (2004) distinguished innovation capability into disruptive, applicative, product, process, marketing, structural, and business model capabilities as he connected these with the market development life cycle. In a study on high-tech firms in Taiwan, Chuang (2005)

categorized technological innovation as product and process innovations and administrative innovation as staff innovation, marketing innovation, and organization structure innovation. Tsai et al. (2001) believed innovation capability must be the administrative innovation of business activities such as planning, organization, employment, leadership, and control and technological innovation of products, processes and facilities obtained by firms from the outside and produced within. Lin et al. (2004) proposed that aside from the technical aspect of products and processes, innovation must also refer to changes or breakthroughs in administrative procedures and management methods. Although there are many types of innovation capability, since the statistical analysis of this study focuses on convergence, the study employed technology innovation and management innovation, two innovation capabilities with more direct correlation with business decisions of firms, as dimensions.

Industrial Clusters

The term 'industrial cluster' refers to the firms and institutions in close proximity to each other in a particular field and area maintaining an interactive relationship, influencing and supporting each other, where production efficiency is achieved and externalities are created through a fine division of labor. From this, small firms are also able to achieve economies of scale in production as enjoyed by large firms and at the same time, these production networks

encourage mutual learning and collaborative innovation and form more flexible production

systems (Porter, 1998; Rosenfeld, 1997; Swann and Prevezer, 1996).

Discussion on clusters can be traced back to the concept of 'cluster economy'

extended by Marshall (1890). It emphasized that external economies and economies of scale

produced from the proximity of firms within an area reduce production and transaction costs

through the sharing of infrastructures, technology labor, and resources. Thus, external economies

and reduction of transaction costs are main factors of industrial clustering. Aside from these

economic reasons, lots of literature also stressed on the importance of social and culture factors.

Clusters are formed when actors or communities possessing innovation and management

capabilities exchange uncodified knowledge which results from the need to frequently interact

face-to-face in order to solve technology and management problems during industrial

development in an environment where collaborative relationships among firms; local firms

having common development goals, common views, values, norms, and support; and social

structures supporting local industry development termed as institutional thickness (Storper and

Salais, 1997; Saxanian, 1994) exist. Some scholars also believed clusters result from the

coincidence of several events. Once specialized clusters are formed, external economies of scale

are generated while promoting or maintaining the sources of external economies like the labor

market, specialized suppliers, and technology spillovers (Boschma and Lambooy, 1999; Cooke et al., 1998).

Furman et al. (2002) indicated that industrial clusters are most advantageous for industrial innovation. The competitive pressures and market opportunities experienced by geographically proximate firms within the cluster are more visible and the rapid flow of information and human resources is beneficial to introducing industry knowledge spillovers and strengthening the advantage of industrial innovation. Moreover, within regional clusters, firms can benefit from agglomeration economies and spillover effects stimulated, for example, through labor force training or mobility, paid access to market information, collaborative relationships with nearby research institutions, or the exchange of tacit knowledge (Shapira, 2008).

With regards to measuring the effects of industrial clusters, Anderson (1994) outlined three types of industrial clusters while various other scholars have also proposed similar views in recent years. This study summarized them as follows. The first category of industrial clusters is buyer-supplier relationships. This industrial cluster is characterized by collaborative vertical relationships of upstream suppliers and downstream buyers. It is a value chain cluster (e.g., Anderson, 1994; Porter, 1998; Feser and Bergman, 1999; Brenner, 2005) comprised of suppliers of materials, related industries, places, and customers. Under the second category, competitor and collaborator relationships, industrial clusters are formed from firms producing identical or

similar products and services. Here, relationships exist because competitors frequently share

information concerning products and production processes to innovate opportunities in the

market (e.g., Anderson, 1994; Porter, 1998; Feser and Bergman, 2000; Kim, 2003). The third

type refers to shared-resource relationships. Here, industrial clusters are referred to as social

entities composed of firms within a region where various resources such as technology,

knowledge, stock of product, infrastructure, and place are shared (e.g., Anderson, 1994; Porter,

1998; Rosenfeld, 2002; Morosini, 2004). From these, this study focused on three categories for

evaluating industrial clusters, namely: value chain clusters, coopetition clusters, and shared-

resource clusters.

Business Performance

Traditional performance assessment systems often stress on the "outcome" and not on

the "process," easily overlooking conflicts caused by changes in the external environment.

Key factors for business success are not grasped, firms thus failing to achieve the ultimate goal

of performance assessment and losing its significance in management. Thus, the concept of

balanced scorecard has been increasingly employed for performance assessment. The balanced

scorecard (BSC) is both a performance framework and a management methodology. It was

developed by Robert Kaplan and David Norton after an extensive research project in 1990

(Voelker et al., 2001). The BSC is essentially a customized performance measurement system

that goes beyond conventional accounting and is based on organizational strategy. Kaplan and

Norton (1996) performed a study on future performance assessment system in all kinds of

industry by gathering the opinions from researchers and workers. Eventually, they came up with

the framework of balanced scorecard. This is a suite of new methodologies measuring firms'

short- and long-term achievements and a tool that can be used for planning strategies and

management decisions to measure performance in order to meet the demand of performance

measurement and management and improve weaknesses caused by traditional performance

assessment.

Traditional accounting-based performance measures evaluate business performance from

a financial viewpoint. However, in addition to a financial perspective, the balanced scorecard

also incorporated three other perspectives: customers, business processes, and growth and

learning. Aside from measuring tangible and intangible assets, the balanced scorecard also

evaluates whether strategies are effective. The four perspectives are described in detail as

follows:

(1) Financial Perspective

The financial perspective typically considers analysis of certain lagging indicators,

usually financial ratios and data that report on past performance. These include return on equity,

return on assets, net income, revenue, and cash flow information. Consideration of this information has been a long-standing tradition in management of a firm (Bible et al., 2006).

(2) Customer Perspective

Businesses must first distinguish among markets and customers and measure their performance in these areas. Indicators include market share ratio, customer satisfaction, continuation of customers, acquirement of customers, and profitability of customers. The balanced scorecard can assist firms in clearly identifying these indicators, seeking measuring standards, and exerting control over these.

(3) Internal Business Process Perspective

Management needs to control essential internal processes to provide value and attract their customers in the target market. Kaplan and Norton (1996) considered that management at this perspective must establish the firm's important internal processes which through improvements in internal procedures, assist them in creating customer value and reach the financial returns expected by shareholders. Indicators include innovation process, operation process, and customer service process.

(4) Learning and Growth Perspective

Kaplan and Norton (1996) believed that the learning and growth perspective identifies infrastructure that must be built to create long-term growth and improvement of innovative

companies. The balanced scorecard proposes that focus should not be only on investing in new products and new facilities; organizations must also invest in people, systems, and processes. Basing on experience with the BSC, Kaplan and Norton (1996) categorized this perspective into three aspects: ability of employees, ability of information systems, and incentive, authority, and fitness.

The Relationship between Innovation Capability and Industrial Clusters on Business Performance

This study primarily examined the degree of innovation capability in firms and its impact on business performance in regional innovation systems and industrial clusters. First, on the matter of innovation capability and business performance, Garcia-Morales et al. (2007) pointed out that technological organization with greater organizational innovation capability achieves a better response from the environment, obtaining more easily the capabilities needed to increase organizational performance and consolidate a sustainable competitive advantage. Moreover, many systematic researches seem to reveal a positive relationship between innovation and performance in businesses (Zangwill, 1992; Garcia-Morales et al., 2007; Koellinger, 2008). From the above findings, the following hypothesis can be derived.

Hypothesis 1: Innovation Capability has a positive effect on Business Performance.
> *H1-1: Innovation Capability has a positive effect on Performance of Financial Perspective.*
> *H1-2: Innovation Capability has a positive effect on Performance of Customer Perspective.*

*H1-3: Innovation Capability has a positive effect on Performance of Internal Business
Process Perspective.*

*H1-4: Innovation Capability has a positive effect on Performance of Learning and
Growth Perspective.*

On the aspect of industrial clusters and business performance, Morosini (2004) believed that if firms located in advanced country regions can be effective in promoting cooperation, this has a significant performance-enhancing effect on their performance. Moreover, he also viewed the cluster's underlying social fabric has a potential for innovation and knowledge creation and at the same time, elements such as competitive factors, geographic closeness, and degree of knowledge integration within industrial regions produce a positive impact on the economic performance of industrial clusters. Lai et al. (2005) argued that innovative activity comes from direct contact with a variety of sources (e.g. suppliers, customers, competitors, and providers of different kinds of services). Industrial clusters that accumulate high levels of innovative success have assembled information that facilitates the next round of innovation, since the ability to innovate successfully would be a function of the technological levels already achieved. From the above findings, the following hypothesis can be derived.

*Hypothesis 2: Industrial Clusters have a significant moderating effect between Innovation
Capability and Business Performance.*

*H2-1: Value Chain Clusters have a significant moderating effect between Innovation
Capability and Business Performance.*

*H2-2: Coopetition Clusters have a significant moderating effect between Innovation
Capability and Business Performance.*

H2-3: Shared-Resource Clusters have a significant moderating effect between Innovation Capability and Business Performance.

Method

Sample and Data Collection

Questionnaires were distributed to firms located in large science park in Taiwan, while sampling was performed on the top managers from these firms. Taiwan has three science parks presently including Hsinchu Science Park, Central Taiwan Science Park, and Southern Taiwan Science Park, and the Hsinchu Science Park is the biggest. In the sampling design, this study sampled the top 300 firms located in the Hsinchu science parks in Taiwan. Companies were first contacted by phone in July 2008 to obtain their willingness to participate in the study. Upon confirmation, questionnaires were then distributed by post. A total of 86 questionnaires were collected until the end of December 2008, 82 of which were valid, giving a response rate of 27.3%.

Measurement Scales

This study constructed the questionnaire based on previous research on innovation capability, industrial clusters, and business performance and modified for adaptation to the context. SPSS17.0 was employed to conduct tests on the hypotheses. The questionnaire of this study was tested with a high reliability and validity, as shown in Table 1.

To ensure that the survey design has a high degree of reliability and validity, this study conducted reliability, validity, and factor analysis tests. This study employed construct validity and criterion validity to evaluate the validity of the questionnaire. Zaltman and Burger (1975) and Kerlinger and Lee (2000) proposed a method of selecting factor dimensions using principal components analysis. Factors selected must conform to these conditions: (1) factor loadings must be greater than 0.5; (2) rotation sums of squared loadings must be more than 50%; and (3) Kaiser-Meyer-Olkin measure of sampling adequacy must be greater than 0.7. When these conditions have been met, the test is considered stable. It can be seen on Table 1 that the validity value of this study exceeded that of the standard value. In measuring reliability, Nunnally (1978) proposed Cronbach's α coefficient as a measure of reliability; α coefficient greater than 0.7 is high reliability while less than 0.35 is low reliability. From Table 1, it can be seen that the composite reliability values are larger than 0.7, showing that this study has high reliability.

Table 1: Summary of validity and reliability analysis

	Construct Validity		Criterion validity	Reliability
	KMO[a]	Rotation Sums of Squared Loadings	Factor Loading	
Innovation Capability	0.929[***]	83.34%	0.689~0.892	0.937
Industrial Clusters	0.823[***]	75.88%	0.606~0.875	0.901
Business Performance	0.919[***]	81.79%	0.651~0.883	0.926

Note: a. Kaiser-Meyer-Olkin (KMO) is measure of sampling adequacy.
    b. *** denote significance at the 0.1% level.

Data Analysis and Results

Innovation Capability and Business Performance

Table 2 shows the results of multiple regression analyses. It can be seen here that the innovation capability of sample firms has a positive effect on business performance. Within this, technology innovation capability and management innovation capability have a positive impact on performance perspectives such as financial, customer, internal business process, and learning and growth. Thus, Hypothesis 1 is confirmed.

Table 2: Multiple regression results of Business Performance on Innovation Capability

| | Business Performance | | | |
	Financial	Customer	Internal Business Process	Learning and Growth
Innovation Capability				
Technology Innovation	0.346***	0.339***	0.248***	0.203**
Management Innovation	0.193**	0.274***	0.362***	0.307***
Adj. R^2	0.247	0.261	0.258	0.183
F	21.732***	24.963***	23.877***	16.379***

Notes: 1. ** and *** denote respectively significance at the 0.5% and 0.1% level.
2. The regression coefficients in the table are standardized.

Moderating Role of Industrial Clusters

To address changes in the impact of innovation capability, industrial clusters, and regional innovation systems on business performance due to firm age and size, this study employed a firm's history and number of employees as control variables proposed by several researchers (Li and Atuahene-Gima, 2001; Bharadwaj and Menon, 2000) to examine the moderating effect of industrial clusters and regional innovation systems.

Before conducting moderating effect analysis, this research considered the question of collinearity between these independent variables which possibly have significant correlations between them. Therefore, before hierarchy regression analysis is performed, this research separately subtracts each arithmetic mean from the factors of the innovation capability and the industrial clusters and contains the interaction items between them. The scholar, Neter et al. (1996), suggested the collinearity examination by Variance Inflation Factors and the path of the VIF. If the VIF value is greater than 10, collinearity exists in the model. Otherwise, non-collinearity exists.

Table 3 shows the results of hierarchical regression analyses. Several models are estimated in this set of analyses. Model 1 includes control variables only. Model 2 reports the direct effects of innovation capability on business performance. Model 3 tests the moderating effects of industrial clusters. Model 4 tests the moderating effects of both industrial clusters and interaction items. In addition, each VIF values of the Model 4 on Table 3 were discovered smaller than 10 and demonstrated non-collinearity on this level of hierarchy regression.

From the Model 4 in Table 3, it can be seen that the interaction items of innovation capability and value chain clusters has a positive moderating effect (β=0.262, p<0.05) on business performance. In other words, if firms have a high degree of innovation capability and highly

concentrated value chain clusters within the industry, then these can be effective on the firms' performance. Thus, Hypothesis 2 offers partial support (Hypothesis 2-1 is confirmed).

Table 3: Hierarchical regression results of Business Performance on Innovation Capability and Industrial Clusters

	Model 1	Model 2	Model 3	Model 4	Model 4 VIF
Control variables					
Company's History	0.083	0.037	-0.006	-0.019	1.126
Number of Employees	0.176*	0.125	0.117	0.036	1.364
Independent variables					
Innovation Capability(IC)		0.273**	0.251**	0.232**	2.683
Moderating Variables					
Value Chain Clusters			0.262**	0.243**	1.974
Coopetition Clusters			0.086	0.088	1.962
Shared-Resource Clusters			0.113	0.073	1.941
IC×Value Chain Clusters				0.281**	2.342
IC×Coopetition Clusters				-0.102	2.069
IC×Shared-Resource Clusters				-0.007	1.866
R^2	0.167	0.268	0.341	0.422	
F	18.428***	22.573***	17.139***	12.313***	
ΔR^2	0.167	0.101	0.073	0.082	
ΔF	18.428***	12.316***	7.449**	7.725**	

Notes: 1. *, ** and *** denote respectively significance at the 0.1%, 0.5% and 0.01% levels, respectively.
2. The regression coefficients in the table are standardized.

Discussion, Implications and Limitations

The concepts of industrial clusters emphasize that through the close social networked systems composed of actors from various firms, internal and external resources and information are easily obtained, diffused, and gathered to build innovation and other capabilities in firms (Morosini, 2004; Asheim, 2007). Empirical results show a positive relationship existing between innovation capability and business performance, corresponding to arguments of a number of

researchers (e.g., Zangwill, 1992; Garcia-Morales et al., 2007; Koellinger, 2008). Further analysis shows that when innovation capability is distinguished between technological and management innovations and when balanced scorecard is used to measure performance, the technological and management innovation capabilities of the sample firms have a significant positive relationship on such performance perspectives as financial, customer, internal business process, and learning and growth. This demonstrates that if firms can focus on each aspect of innovation capability, improvements on performance of firms are evident.

On the moderating effect of industrial clusters, this study observed that the interaction of innovation capability and value chain clusters has a positive moderating effect on business performance. This result echoes the finding of Morosini (2004) that individual firms having high innovation capability and clustered in a specific geographical region create a social fabric where a high degree of cooperative effectiveness within vertical value chains leads to significant improvements in business performance. However, the interaction of innovation capability with coopetition clusters and shared-resource clusters did not demonstrate a significant level. From these results, it can be inferred that the social fabric of firms in the science parks has only achieved integration among vertical value chains. In another word, the compositive relation of the industrial clusters are constructed from the industrial value chain between the entire upstream and downstream members. It has not yet evolved to that of horizontal coopetition fabric and of

shared-resource clusters spanning a wide range of interactive dimensions. Therefore, the relationships of the industrial clusters in Taiwanese science parks demonstrate that they have not evolved the coopetition effectiveness by each other competitor and collaborator. As well as the common network relationship of the sharing resources, achieve the overall operating scale economy. These findings can be employed by future government organizations regarding the administration of regional industry policies which should emphasize coopetition effects to replace zero-sum effects among firms, and at the same time, strengthen effectiveness of resource-sharing among industries so that the whole industry and national economy become more robust.

A limitation of this study is the focus on Hsinchu science parks in Taiwan only for its research sample. This sample is not enough for an overall representation. Therefore, it is suggested that future research widen its scope, for example, Taiwanese all science parks to study the samples. This study employed only industrial clusters as moderating variables for examining innovation capability and business performance. Future research can include more concepts such as regional innovation systems, organizational learning effectiveness, and knowledge-sharing mechanisms as moderating variables to allow for a more comprehensive study. Moreover, may also aim at the moderating effects of the innovation system and industrial clusters fabric and carry on the further comparative research analysis.

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THE INFLUENCES OF THE FINANCIAL CRISIS ON THE CONSUMPTION OF HAIRDRESSING IN TAIWAN

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Abstract

By applying statistical methods, this study explored the consumption changes in hairdressing of the general public in Taiwan. Gray correlation was applied to analyze the consumption changes of the general public in Taiwan and calculate the change order of the items of consumption of hairdressing. The result proved that most people in Taiwan didn't believe the financial crisis would influence their habit of consumption of hairdressing. However, part of the consumers believed their considerations of consumption would be influenced.

Through an overall analysis on consumption, it was found that the order of willingness to consume in the hairdressing services differed according to where people live, which included Northern Taiwan, Central Taiwan, Southern Taiwan, and Eastern Taiwan. People in the Northern and Central Taiwan would first reduce their consumption of the item "Enjoying other services provided by hair salons", while people in the Southern and Eastern Taiwan would first consider to reduce the consumption of "Haircut", followed by "Hair dyeing" and "Shampoo".

Keywords: Gray Association Analysis, Consumption of Hairdressing

Research Motivations and Purposes

Since the global financial crisis broke out, the situation of anywhere influenced by it has been terrible. The consumption has been low for almost two years. The service industry has faced serious challenges because of consumers' conservative attitude. The hairdressing business has been popular in Taiwan, providing small customized services. It is invertible that this business has been influenced by consumers' conservative attitude during this financial crisis. Therefore, this study tried to further explore if hairdressing consumers have changed their behaviors of consumption of hairdressing, and find out the order of willingness to consume in the services through grey relation analysis.

Literature Review

Once, beauty was the equivalent of luxury. But nowadays, it is interpreted differently. Kuo, Min-Hua and Chung Li-Wei (2007) indicated in their study that beauty-related products are not influenced by economy, while it is exactly the contrary for luxury goods. Their research result matched foreign scholars'. There is indeed a significant and positive relationship between the investments in beauty of women in Taiwan and their personal income. Therefore, from the result of that research, we can be more assured that people's investments in themselves can benefit their careers. And beauty-related products have transformed into necessities. To be more precise, beauty-related products can be considered as investment goods. Besides satisfying people's own desire for beauty, their income is also increased indirectly by these products (Kuo and Chung, 2007).

The Factors of Choosing Salons Considered by Hairdressing Consumers

According to the study by Hsiao-Wen Kuo's (2006), consumers with higher income, motorcycles, and higher level of involvement in products would be more willing to consume in

hairdressing in a farther place. Secondly, people with higher income go to general places for consumption of hairdressing less frequently, while visiting high-class hair salons more frequently than chain salons. Thirdly, people of higher age more frequently change their hair styles. Fourthly, younger people with higher level of involvement in products spend more money in hairdressing (Kuo, 2006).

Ya-Hui Chen (2003) indicated in her study that consumers' choices of hair salons are influenced by corporate image and service quality. Their intention of consumption differs according to their income, age, education background, and satisfaction (Chen, 2003). According to the study by Chih-Lang Lai (2003), the reasons why hairdressing consumers switch to different hair salons because of their previous experiences of consumption and information searched before/after switch (Lai, 2003). This study similarly reflected the degree of consumers' concern about quality of services provided by hairdressing salons and customer satisfaction. In addition, retrieval of information on reputation of other salons' services would influence consumers' decisions on switching to another salon.

According to the study by An-Tien Hsieh and Wen-Ting Chang (2004), the degree of consumers' involvement may have certain effect on price sensitivity. There are four dimensions of association between consumers' involvement and price sensitivity: consumers' participation, construction of relationship, information exchange, and intervention. The result of the study indicated that the first three dimensions are not related to price sensitivity while the intervention dimension is. Consumers' participation includes preparation for purchase, communication with companies during process of purchase, intervention, or feedbacks to enterprises after purchase. Under the same conditions, the industries with the property of higher involvement, such as the hair salon industry, compared with the industries with the property of lower involvement, such as

the restaurant industry, have lower price sensitivity. When consumers become aware of values of services through involvement, their understanding of the result from increasing price sensitivity would be enhanced. In addition, according to the scholar's study, by improving consumers' satisfaction, their tolerance of price would be improved as well. This way, their price sensitivity would be reduced (Hsieh and Chang, 2004).

The Influences of the Changes in Consumption Environment and
Consumption Behaviors on the Service Industry

The Changes in Consumption Environment in Taiwan.

In the consumption environment in Taiwan, with the advancement of technology and diversified development of consumers' life styles, consumption behaviors are no longer simply related to buying products because of their preference, but making purchases through actually touch and experience to create personal tastes. Consumers with strong self-awareness and merchants with sharp eyes can sense the trend of change. The development of the new consumption trend has changed consumers' traditional viewpoints on consumption. And with the evolution of technology, different challenges have emerged. In order to find out how, in the future, to seize the first opportunity in the market with new ways of thinking and sensitivities, leaders of industries shall think over this issue carefully, and understand the new trend of modern consumption with the properties of rapidness, changeability, and briefness.

Based on the development trend of consumption environment, if beauty salons still operate following the traditional service model of pursuing the leading position in technology or brand image, it would be edged out by consumers in the future due to their desire for a change to something new. Therefore, how to integrate internet marketing and use e-business to develop new customer sources has become the impact and challenge operators in this industry must face. Because most operators in the hairdressing business in Taiwan are skilled workers unfamiliar

with the IT field, in the future, they should become managers instead of skilled workers, separating skills from management, in order to stand out in the age of variety by using the right specialties in the right fields.

The Influence of the Global Financial Crisis on the Service Industry

The Impacts the Service Industry Faces.

The 2009 first-season survey report on industrial and commercial business management statuses released by the Department of Statistics, Ministry of Affairs in Taiwan shows that the operating income of "other services industries" in the first season of 2009 is 31.1 billion NT dollars, which has decreased by 9.23% compared with the first season of 2008. This means the economic recession continues. Although the operation income of the hairdressing and beauty industry is 11 billion NT dollars and that of the car maintenance and car care is 10.4 billion NT dollars, as the first and the second highest among industries, their growth rates are negative, with shortage of 20.72% and 0.64%, respectively (Taiwan Department of Statistics, 2009). According to the statistics, with the low consumption caused by the financial crisis, the situations of negative growth in service industries are very serious. Especially in the beauty and hairdressing industries, the operation income has decrease by over 20%. In the labor and technology intensive market, they are badly wounded.

The Influences of the Financial Crisis on Consumers' Behaviors.

The financial crisis has caused global damage. The influences are even more serious for Taiwan, a country with about 64% of GDP are from export trading businesses. To analyze from the aspect of consumers' behaviors, these external environment changes have caused consumers to change in cognition, emotion, attitude, motivation, and learning. Because no one can predict when the recession will be over, plus the reduction of disposable income while necessities of life

can not be reduced, in order to save money from expenses, consumers have become smarter and more rational with changed consumption habits. All these changes are reflected in their decisions. The most obvious phenomenon is "reduction of consumption", which means money has to be sent on important goods. The purchases of non-necessities and luxury goods can be delayed, in order to mitigate the issue of reduced income. In sum, after the impact of the financial tsunami, consumers' behaviors have become more practical and conservative, in hopes of making the best use of limited resources. Thus, most of the issues consumers care about focus on how to spend less money to obtain the highest benefits.

The Theory of Grey Relation Analysis.

Grey relation analysis is one of the methods in the grey theories. It is a measurement method used to analyze the degree of relations between discrete data series. The background in which the theory was invented is the systems in our surroundings, such as a social system, an economic system, etc. There are relations between systems, such as triggering relations, conditioning relations, etc. The existence of these relations keeps the balance of sub-systems. Some of the relations are known, some are not or just partly known. Therefore, how to discover them and make use them is the key to the analysis on the systems. In view of this, the grey system theory proposes the concept of applying "grey relation" analysis on each sub-system. It attempts to determine the relations between sub-systems (or factors) in the systems with numbers. The meaning of grey relation is that, in the development process of a system, if the postures of two factors' changes are identical, which means the degree of simultaneously change is high, and then these two factors are highly related. On the contrary, the relation between them is rather weak. Therefore, "grey relation analysis" provides a quantitative measure for the

posture of the system's development change. It is very useful for dynamic process analysis (Lin, 2004; Kung and Wen, 2007).

Grey Association.

Grey association is a measurement method commonly used in grey relation analyses to describe the degree of relations between series. Considering the series xi = (xi(1), xi(2)…….., xi (m)) ∈X, i=1,2,…,n, where xi(k) represents any element in the series, in the factor set P(X) in the grey relation space, the grey relation coefficients must be defined before determining the degrees of grey relations. For local grey relation measurement, only $x_0(k)$ ∈X is used as reference series, while other series x_i is comparative series. Then the grey relation coefficient between $x_0(k)$ and x_i (k) is:

$$\gamma(x_0(k), x_i(k)) = \frac{\Delta_{min} + \zeta \Delta_{max}}{\Delta_{0i}(k) + \zeta \Delta_{max}} \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where $\zeta \in (0,1)$ is the distinguished coefficient, $\Delta_{0i}(k) = |x_0(K) - x_i(K)|$ is the absolute difference between $x_0(k)$ and $x_i(k)$, and

$$\Delta_{min} = \min_{\forall i} \min_{\forall k} \Delta_{0i}(K) = \min_{\forall i} \min_{\forall k} |x_0(K) - x_i(K)| \dots\dots\dots\dots\dots\dots\dots\dots\dots.(2)$$

$$\Delta_{max} = \max_{\forall i} \max_{\forall k} \Delta_{0i}(K) = \max_{\forall i} \max_{\forall k} |x_0(K) - x_i(K)| \dots\dots\dots\dots\dots\dots\dots\dots..(3)$$

(1) For overall grey relation measurement, any one of the series xi, i=1,2,……n will become the reference series in turn while others are comparative series. Then the grey relation coefficient between $x_i(K)$ and $x_j(K)$ is:

$$\gamma(xi(K), xj(K)) = \frac{\Delta_{min} + \zeta \Delta_{max}}{\Delta_{ij}(K) + \zeta \Delta_{max}} \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4)$$

Where $\Delta_{ij}(K) = |x_i(K) - x_j(K)|$ is the absolute difference between xi(K) and xj(K). And

$$\Delta_{\min} = \frac{\min}{\forall i, \forall j} \frac{\min}{\forall k} \Delta_{ij}(K) = \frac{\min}{\forall i, \forall j} \frac{\min}{\forall k} \left| x_i(K) - x_j(K) \right| \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

$$\Delta_{\min} = \frac{\max}{\forall i, \forall j} \frac{\max}{\forall k} \Delta_{ij}(K) = \frac{\max}{\forall i, \forall j} \frac{\max}{\forall k} \left| x_i(K) - x_j(K) \right| \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

After grey relation coefficients are determined, through the following formulas, the measured values of grey relation between x_0 and x_i or x_i and x_j can be obtained:

$$\gamma(x_0, x_i) = \sum_{k=1}^{m} \beta_K \gamma(x_0(k), x_i(K)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

$$\gamma(x_i, x_j) = \sum_{k=1}^{m} \beta_K \gamma(x_i(k), x_j(K)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where β_k is the weight, and $\sum_{k=1}^{m} \beta_K = 1$. Under normal circumstances, different weights are given according to the degree of factors' actual importance to the system. If not specified, equal weights are used to calculate grey relations.

After the measured values of grey relations between each factor, the order of the grey relation series of the major factors which may influence the issue on hand can be determined by the values of grey relations of influential factors. Then from the values of grey relations, the degrees of importance for influential factors are clearly presented. In addition, in the process of calculating grey relation coefficients, distinguished coefficient ζ is a parameter which can be adjusted according to actual situations. The purpose is to adjust the comparative relation between Δ_{ij}, the values to be measured, and $\Delta_{\max}$, the background value. Although the value of distinguished coefficient ζ would influence the value of grey relation coefficients, it doesn't change the order of grey relation series. Under normal circumstances, the value of distinguished coefficient ζ is set to 0.5. Generally speaking, the focus of analyses on issues is merely on the order of grey relations between series, which is called the relational series. The final order can

help understand the major factors which influence the issues on hand and can be used as a reference for decision making (Deng, 1989; Lin, 2005).

Research Design

Questionnaires were planned and designed for this study. A consumption survey was conducted with the consumers from four regions, including northern, central, southern, and eastern Taiwan. Then demographic variables were analyzed with statistic methods to find out important features of the consumers. At last, by analyzing the questionnaires with statistic methods, values of the degrees of identification were obtained. Grey relation analysis was applied to obtain the order of important factors. Through the order of factors, the actual statuses of consumers' behavior change were obtained.

Applying Grey Relation Analysis to the Influences of Financial Crisis
on Consumption of Hairdressing

Questionnaire Survey of Consumption of Hairdressing and Analysis of the Survey

A survey was conducted for this study on the regular services the hairdressing industry usually provides, such as shampoo, hair dyeing, permanent, haircut, hair design, other services, and sale of hairdressing products, hoping to find out through questionnaires, under the influences of the financial crisis, if consumers have changed their habits in consumption, if they have stopped consumption, if they have reduced their consumption of hairdressing, the model of reduction of consumption if available, if the frequencies of their consumption of all the items have been reduced or just part of them, and the frequencies of which items have been reduced first.

In order to explore consumers' habit changes in consumption of hairdressing in Taiwan, the research subjects in this study were categorized into four groups according to where they lived, including northern, central, southern, and eastern Taiwan. The chosen subjects were

consumers who had visited some middle or small sized chain salons in these four regions during the period from March to November of 2009. Random sampling was applied for this questionnaire survey. 100 questionnaires were distributed in each region. The numbers of questionnaires retrieved were 84 in Northern Taiwan, 96 in Southern Taiwan, 100 in Central Taiwan, and 73 in Eastern Taiwan. A total of 353 questionnaires were retrieved. The overall response rate was 88%.

The Statuses of Consumption of Hairdressing for the Consumers in the Four Regions of Taiwan

A five-point scale was applied to the questions in the questionnaires (1 = totally agree, 2 = agree, 3 = partly agree, 4 = a little agree, and 5 = disagree). The percentage of people who selected an option was used as the degree of intensity of that option.

(1) The result of the survey of southern hairdressing consumers' consumption behaviors is listed below in Table 1.

From the summary of the findings above, it is found the condition of people stopping their consumption of hairdressing was not serious in Southern Taiwan. The statistics show that only less than 13% of people have stopped their consumption in hairdressing, while 30%~56% of people have not been influenced by the financial crisis.

(2) The result of the survey of central hairdressing consumers' consumption behaviors is listed below in Table 2.

Table 1. The Influences of the Financial Crisis on the Southern Hairdressing Consumers

No.	Hairdressing Consumption Items	Percentages of reducing or stopping consumption under the influences	Percentages of consumption which was not influenced.
1	Hair Design	13%-36%	30%-51%
2	Haircut	7%-33%	34%-53%
3	Hair Dyeing	13%-39%	33%-44%
4	Permanent	10%-27%	40%-56%
5	Shampoo	9%-30%	28%-47%
6	Enjoying other services provided by hair salons	10%-34%	29%-52%
7	Purchasing hairdressing-related product	13%-33%	30%-54%

Table 2. The Influences of the Financial Crisis on the Central Hairdressing Consumers

No.	Hairdressing Consumption Items	Percentages of reducing or stopping consumption under the influences	Percentages of consumption which was not influenced.
1	Hair Design	11%-14%	69%-73%
2	Haircut	4%-13%	75%-81%
3	Hair Dyeing	11%-13%	69%-78%
4	Permanent	6%-12%	74%-85%
5	Shampoo	10%-29%	55%-65%
6	Enjoying other services provided by hair salons	1%-12%	65%-83%
7	Purchasing hairdressing-related product	1%-8%	73%-89%

From the summary of the findings above, it is found that 55%~89% of the people in Central Taiwan have not changed their hairdressing consumption habits. It is obvious that the consumption capacity of people in Central Taiwan was high.

(3) The result of the survey of northern hairdressing consumers' consumption behaviors is listed below in Table 3. From the summary of the findings above, it is found that the financial crisis had no significant influences on the respondents in North Taiwan. Only the largest influence was on their consumption of hairdressing-related products.

Table 3. The Influences of the Financial Crisis on the Northern Hairdressing Consumers

No.	Hairdressing Consumption Items	Percentages of reducing or stopping consumption under the influences	Percentages of consumption which was not influenced.
1	Hair Design	6%-39%	17%-30%
2	Haircut	7%-34%	16%-30%
3	Hair Dyeing	3%-37%	16%-26%
4	Permanent	3%-36%	13%-30%
5	Shampoo	6%-34%	9%-28%
6	Enjoying other services provided by hair salons	4%-28%	10%-29%
7	Purchasing hairdressing-related product	3%-45%	10%-21%

The result of the survey of eastern hairdressing consumers' consumption behaviors is listed below.

From the summary of the findings above, it is found that the percentage of the respondents who believed that they were not influenced by the financial crisis was a little bit higher than that of the respondents who believed that they were influenced.

Table 4. The Influences of the Financial Crisis on the Eastern Hairdressing Consumers

No.	Hairdressing Consumption Items	Percentages of reducing or stopping consumption under the influences	Percentages of consumption which was not influenced.
1	Hair Design	1%-34%	1%-59%
2	Haircut	5%-23%	33%-48%
3	Hair Dyeing	10%-37%	32%-47%
4	Permanent	10%-31%	29%-43%
5	Shampoo	15%-50%	15%-29%
6	Enjoying other services provided by hair salons	12%-46%	18%-36%
7	Purchasing hairdressing-related product	12%-36%	14%-37%

Summarizing the consumption of hairdressing in all four regions:

The analysis result of the data from the four regions in Taiwan shows that most of the respondents did not agree the financial crisis would influence their consumption of hairdressing-related services.

Analysis on Consumers with Demographic Variables

This study summarized and analyzed the consumers' occupation, income, gender, and age by applying statistic methods to the basic data of the people randomly selected, using the demographic variables.

(1) Analysis on Occupation

According to the summary of the statistics data of the variable "occupation", the consumer groups were a little bit different in different regions in Taiwan. In Northern Taiwan and Eastern Taiwan, the consumers were mainly housewives, followed by commercial and industrial personnel. In Central Taiwan and Southern Taiwan, the consumers were mainly commercial and industrial personnel, followed by military personnel or public servants and

housewives, respectively. As for the third important group, it was retired personnel in Northern Taiwan and students in all other three groups.

Table 5. The Order of Importance of the Consumers In the Four Regions In Taiwan

Region	The Most Important Group	The Second Important Group	The Third Important Group
Northern Taiwan	Housewife	Commercial or industrial personnel	Retired personnel
Central Taiwan	Commercial or industrial personnel	Military personnel or public servant	Student
Southern Taiwan	Commercial or industrial personnel	Housewife	Student
Eastern Taiwan	Housewife	Commercial or industrial personnel	Student

(2) Analysis on Income

Table 6. The Income Status of the Consumers in the Four Regions in Taiwan

Region	The Most Important Group	The Second Important Group
Northern Taiwan	30000-60000 dollars	20000-30000 dollars
Central Taiwan	20000-30000 dollars	Dependent on families
Southern Taiwan	Under 20000 dollars	20000-30000 dollars
Eastern Taiwan	Dependent on families	20000-30000 dollars

Currency: NTD

According to the summary of the income statuses in the four regions in Taiwan, the consumers in Northern Taiwan had rather high income with over 40% of consumers having

income over 30000 NT dollars. The second largest group was those with income of 20000~30000 dollars. In Central Taiwan, most of the consumers (32%) were dependent on their families. The second largest group was those with income of 20000~30000 dollars, followed by those with no income at all and those of income over 30000 NT dollars. In Southern Taiwan, most of the consumers were of income under 20000 NT dollars. The second largest group was those with income of 20000~30000 dollars. Overall, the major customers of middle or small sized salons in Taiwan were mainly those with income of 20000~30000 NT dollars.

(3) Analysis on Gender

Table 7. Ratios of Consumers' Gender

Region	Male	Female
Northern Taiwan	23%	77%
Central Taiwan	22%	78%
Southern Taiwan	19%	81%
Eastern Taiwan	10%	90%

According to the statistics above, females were the major consumers of hairdressing in all four regions in Taiwan. And in Eastern Taiwan, the percentage of male hairdressing consumers was significantly lower than that in the other regions.

(4) Analysis on Age

Table 8. The Age Groups of Major Consumers

Region	The Most Important Group	The Second Important Group	The Third Important Group
Northern Taiwan	26-45 years old	18-25 years old	45-55 years old

Central Taiwan	26-45 years old	45-55 years old	18-25 years old
Southern Taiwan	26-45 years old	18-25 years old	45-55 years old
Eastern Taiwan	26-45 years old	45-55 years old	18-25 years old

According to the data above, 37~59% of hairdressing consumers in Taiwan were 26~45 years old. Except for Northern Taiwan, in all the other regions, the second largest consumer groups were all those of age 45~55.

The Changes in Hairdressing Consumers' Behaviors under the Influences of the Financial Crisis

Grey relation analysis was applied to analyze the ratio of agreement with the items of consumption in the four regions in Taiwan, with equal weights and default setting (0.5) of the distinguished coefficient ζ.

Let X1 be the series of degree of agreement with "reducing consumption in haircut".

Let X2 be the series of degree of agreement with "reducing consumption in hair dyeing".

Let X3 be the series of degree of agreement with "reducing consumption in permanent".

Let X4 be the series of degree of agreement with "reducing consumption in shampoo".

Let X5 be the series of degree of agreement with "reducing consumption in enjoying other services provided by hair salons".

Let X6 be the series of degree of agreement with "reducing consumption in purchasing hairdressing-related product".

Let K1 be totally agree, K2 be agree, K3 be partly agree, K4 = be a little agree, and K5 be disagree.

(1) Grey Relation Analysis on Consumption of Hairdressing in Northern Taiwan

Table 9. Grey Relation Coefficients and Grey Relational Grades for Northern Taiwan

Grey Relation Coefficient	K 1	K 2	K 3	K 4	K 5	Relational grade
r(x 0, x 1)	0.8983	0.5354	0.3985	0.7910	0.6709	0.6588
r(x 0, x 2)	1.0000	0.6092	0.3759	0.6709	0.7067	0.6725
r(x 0, x 3)	0.8983	0.4380	0.4454	0.7260	0.8154	0.6646
r(x 0, x 4)	0.8983	0.4240	0.5248	0.6709	0.7260	0.6488
r(x 0, x 5)	0.8983	0.5248	0.3813	0.7260	0.8154	0.6692
r(x 0, x 6)	1.0000	0.4690	0.4454	0.6543	0.7681	0.6674

The grey relational grades were calculated and ordered

r(x 0, x 2) = 0.6725 > r(x 0, x 5) = 0.6692 > r(x 0, x 6) = 0.6674 > r(x 0, x 3) = 0.6646 >

r(x 0, x 1) = 0.6588 > r(x 0, x 4) = 0.6488

The analysis result:

Hair dyeing > Enjoying other services provided by hair salons > Purchasing hairdressing-related

product > Permanent > Haircut > Shampoo

(2) Grey Relation Analysis on Consumption of Hairdressing in Central Taiwan

Table 10. Grey Relation Coefficients and Grey Relational Grades for Central Taiwan

Grey Relation Coefficient	K 1	K 2	K 3	K 4	K 5	Relational grade
r(x 0, x 1)	0.8491	0.4545	0.7377	0.5294	0.4639	0.6069
r(x 0, x 2)	0.7895	0.4054	0.7895	0.5172	0.5294	0.6062
r(x 0, x 3)	0.7377	0.3846	0.6164	0.6338	0.6164	0.5978
r(x 0, x 4)	0.7377	0.4054	0.6716	0.6164	0.5556	0.5973
r(x 0, x 5)	1.0000	0.4054	0.7377	0.4054	0.6716	0.6440
r(x 0, x 6)	0.9574	0.4054	0.7377	0.4455	0.6164	0.6325

The grey relational grades were calculated and ordered

r(x 0, x 5) = 0.6440 > r(x 0, x 6) = 0.6325 > r(x 0, x 1) = 0.6069 > r(x 0, x 2) = 0.6062 >

r(x 0, x 3) = 0.5978 > r(x 0, x 4) = 0.5973

The analysis result:

Enjoying other services provided by hair salons > Purchasing hairdressing-related product >

Haircut > Hair dyeing > Permanent > Shampoo

(3)   Grey Relation Analysis on Consumption of Hairdressing in Southern Taiwan

Table 11. Grey Relation Coefficients and Grey Relational Grades for Southern Taiwan

Grey Relation Coefficient	K 1	K 2	K 3	K 4	K 5	Relational grade
r(x 0, x 1)	1.0000	0.5269	0.6364	0.6712	0.7778	0.7225
r(x 0, x 2)	0.8596	0.6203	0.6203	0.7538	0.6712	0.7050
r(x 0, x 3)	0.7778	0.6203	0.6203	0.7538	0.7101	0.6965
r(x 0, x 4)	0.8596	0.5904	0.6364	0.6712	0.7538	0.7023
r(x 0, x 5)	0.7101	0.7538	0.5904	0.6364	0.7778	0.6937
r(x 0, x 6)	0.7538	0.6712	0.7101	0.5904	0.7538	0.6959

The grey relational grades were calculated and ordered

r(x 0, x 1) = 0.7225 > r(x 0, x 2) = 0.7050 > r(x 0, x 4) = 0.7023 > r(x 0, x 3) = 0.6965 >

r(x 0, x 6) = 0.6959 > r(x 0, x 5) = 0.6937

The analysis result:

Haircut > Hair dyeing > Shampoo > Permanent > Purchasing hairdressing-related product >

Enjoying other services provided by hair salons

(4) Grey Relation Analysis on Consumption of Hairdressing in Eastern Taiwan

Table 12. *Grey relation coefficients and grey relational grades for Eastern Taiwan*

Grey Relation Coefficient	K 1	K 2	K 3	K 4	K 5	Relational grade
r(x 0, x 1)	1.0000	0.5949	0.5402	0.5054	0.8246	0.6930
r(x 0, x 2)	0.8545	0.6104	0.5402	0.5402	0.8246	0.6740
r(x 0, x 3)	0.7705	0.5529	0.5529	0.6104	0.8246	0.6623
r(x 0, x 4)	0.8545	0.4747	0.5663	0.8545	0.6267	0.6754
r(x 0, x 5)	0.8868	0.5054	0.5949	0.6267	0.7231	0.6674
r(x 0, x 6)	0.8246	0.5054	0.6104	0.6267	0.7460	0.6626

The grey relational grades were calculated and ordered

$r(x_0, x_1) = 0.6930 > r(x_0, x_4) = 0.6754 > r(x_0, x_2) = 0.6740 > r(x_0, x_5) = 0.6674 >$

$r(x_0, x_6) = 0.6626 > r(x_0, x_3) = 0.6623$

The analysis result:

Haircut > Shampoo > Hair dyeing > Enjoying other services provided by hair salons >

Purchasing hairdressing-related product > Permanent

The summary of the above results of grey relation analyses:

(1) Hairdressing services ordered by consumers willingness to reduce consumption of them in

Northern Taiwan

Hair dyeing > Enjoying other services provided by hair salons > Purchasing hairdressing-related

product > Permanent > Haircut > Shampoo

(2) Hairdressing services ordered by consumers willingness to reduce consumption of them in

Central Taiwan

Enjoying other services provided by hair salons > Purchasing hairdressing-related product >

Haircut > Hair dyeing > Permanent > Shampoo

(3) Hairdressing services ordered by consumers willingness to reduce consumption of them in

Southern Taiwan

Haircut > Hair dyeing > Shampoo > Permanent > Purchasing hairdressing-related product >

Enjoying other services provided by hair salons

(4) Hairdressing services ordered by consumers willingness to reduce consumption of them in

Eastern Taiwan

Haircut > Shampoo > Hair dyeing > Enjoying other services provided by hair salons >

Purchasing hairdressing-related product > Permanent

Conclusions and Suggestions

After a series of questionnaire surveys and statistical analyses, it is found that, generally speaking, most people in Taiwan, no matter which region they lived, believed the global financial crisis would not influence their habit of consumption of hairdressing. Of course, still a part of them believed their consumption frequencies or amounts would be reduced. Therefore, through grey relation analysis, the orders to reduce consumption of the hairdressing services were found.

Overall consumption analyses were performed on hair salons' general services for this study. The result shows that, for people from four different regions in Taiwan, the orders to reduce consumption of the hairdressing services were different. People in Northern and Central Taiwan would consider to reduce consumption of "enjoying other services provided by hair salons", while people in Southern and Eastern Taiwan would reduce consumption of "haircut" first, and then "hair dyeing and shampoo".

From the aspect of marketing, how to develop new strategies according to the factors above to make a salon's features stand out is something salon operators must think about during the economic recession. Hair salons in Northern and Central Taiwan should use "additional services" to attract customers, such as providing massage for scalp with shampoo for a cheaper bundle package price, or adding a TV in salon for customers to watch while being serviced plus a cup of expensive drink, to make them feel the service they've received is more valuable than its price, so that they would deter from giving up "enjoying other services provided by hair salons". As for salons in Eastern and Southern Taiwan, "fast haircut with low price" would be attractive. For example, the William Beauty Salon near Carrefour draw customers into the salon with 100-dollar fast haircut and then try to sell them more services after they get in.

The financial crisis has influenced many industries, especially the financial industry, the construction industry, and the manufacturing industry. Therefore, some civil industries and service industries have been facing difficulties of reducing income. But it is proved that this doesn't necessarily lead to a dead end despite the influences. Take the hairdressing business in this study for example, the survey result shows that hairdressing has already become a part of people's lives in Taiwan. Hairdressing is like a necessity. People still spend money on it but the amount spent is lower. The result of this study can be used as reference for hairdressing business operators to plan their marketing, so that they can develop strategies corresponding to the different demands in different regions and create their own advantages in the recession.

Research Limitation

The research subjects of this study were consumers who had visited some middle or small sized chain salons. People who did not consume weren't included, and therefore consumption information on this kind of people wasn't considered in this study. Thus, the conclusions of this study can provide operators only the viewpoints of those who still consume.

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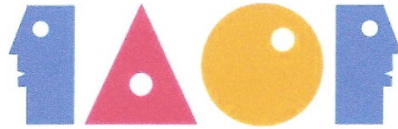
BOARD COMPOSITION AND CORPORATE VALUE IN TAIWAN HIGH-TECHNOLOGY FIRMS

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Abstract

Traditional accounting performance measures (return of equity, earnings per share) only reflect short-term performance and are unable to express an enterprise's long-term value. The sample of this study includes Taiwan listed firms from 1998 to 2008 and the ordinary least squares (OLS) method to test our hypothesis. The empirical results show that independent directors' proportion is positively related to Economic valued added (EVA) and that this variable plays an active role in value creation in high-tech firms. However, independent directors' proportion exhibits an insignificant relationship to Market value added (MVA).

Keywords: Board of Directors, Independent Director, Economic Value Added,   Market Value Added, High-technology

Introduction

Traditional accounting indexes measure performances such as return on assets (Bailey &

Helfat, 2003), earnings per share (Neumann & Voetmann, 2005), return on equity (Peng, 2004),

free cash flow (Neumann & Voetmann, 2005), return on stock price (Allgood & Farrell, 2003),

and stock price (Shen & Cannella, 2003). Such measurements are generated from financial

statements that follow the generally accepted accounting principles (GAAP), requiring

conservatism. Kaur & Narang (2008) concluded that traditional measures do not reflect the real

value of shareholders' wealth and thus EVA needs to be measured scientifically to obtain a real

idea about shareholders value.

Jensen & Meckling (1976) pointed out that one or many clients employ another agent and

empower them with decision-making power. However the client (owner) has not been

unanimous with the agent position for pursuing the principle that individual interests will create a

conflict of interests. Therefore, the client will limit agent behaviors to protect owner's rights.

Previous literature has focused on the relationship between board composition and firm

value, measuring performance with Tobin's Q (Beiner et al., 2006; Hu et al., 2009), book value

(Shen et al., 2006), and market to value book (Beiner et al., 2006) . This paper examines whether

the board of directors plays a critical role in creating a firm's value in the high-tech industry of

Taiwan with the hope of offering some insights for enterprises and government.

Literature Review

This study used EVA to evaluate economic value and to assess resource allocating

efficiency (Stewart, 1991). Austin (2005) pointed to EVA as a benchmark and basis for pricing

and other strategies. Pohlen & Coleman (2005) also pointed to EVA to assess the operating and

supply chain. Compared to the above solutions, Kaur & Pal (2008) suggested that some

companies adopt the EVA technique to measure shareholder value.

Parrino et al., (2002) also pointed out that independent directors are the most important

organizational policymakers, with professional knowledge that serves as the objective in the

policymaker role. Petra (2005) showed that independent directors enhance the board, supervise

an administrator, and guarantee that the administrator makes the best decision for shareholder's

interests. Therefore, the higher independent directors' proportion has better performance.

This study used EVA to evaluate economic value, and reacted Market value added (MVA)

to calculate the enterprise's market value. This paper concludes that independent directors'

proportion improves the corporate mechanism and improves firms' performance, Therefore its

proportion has significant positive relationship with EVA and MVA.

H1: Independent directors' proportion has a significantly *positive relationship with EVA.*

H2: Independent directors' proportion has a significant*ly positive relationship with Market value*

   added.

Compared to the above-mentioned inferences, the increase of EVA and MVA derives from the

increase of independent directors' proportion. Therefore, EVA and MVA have a significant

positive relationship with independent directors' proportion.

H3: Economic value added has a significant positive relationship with independent directors'

proportion.

H4: Market value added has a significant positive relationship with independent directors'

proportion.

Methodology

The sample of this study comes from the TEJ database (Taiwan) and includes

listed firms in Taiwan high-technology firms from 1998 to 2008(N=1308). We used the ordinary

least squares (OLS) method. The proxy variables are as follows: EVA_t is the economic valued

added measured in Appendix A. Market value added (MVA_t) is at time t measured in the

difference between market value of equity and book value of equity. $INDEP_t$ is the proportion of

independent directors (more detailed in Appendix B) at time t measured in independent

director's numbers divided by total directors. $INSOWN_t$ is the ratio of inside directors'

shareholding at time t measured in its' stock hold numbers divided by outstanding common

stocks. $DEBT_t$ is the proportion of long-term debt at time t measured in long term debt divided

by total asset×100%. $BLOCK_t$ is the block shareholders (more detailed in Appendix B) in

enterprises at time t measured in a dummy variable. If there are block shareholders in the company, its value is 1 and 0 is the contrary. GW_t is sales growth measured as the difference between at time t sales and at time t-1 sales divided by at time t-1 sales. $INST_t$ is the institution shareholding ratio at time t measured in government, bank, company, mutual-fund, foreign bank, foreign company, foreign mutual-fund, fund institution shareholder stocks divided by outstanding common stocks. $CAPEXP_t$ is capital investment at time t measured in net fixed assets plus deprecation expense.

Results

Descriptive Statistics

From Table 1, EVA1 (unadjusted) is the highest and EVA2 (join adjusted items) is the lowest. MVA shows that high-technology firms in Taiwan are 902798(NT dollars). The difference between independent directors' proportion is very great (the minimum is 11% and the maximum is 60%). The director's shareholding ratio is 22.78% and the institutional investor holds 29.89%. Therefore, the institutional investor possesses powerful management influence in high-technology firms. The proportion of long-term debt at 6.97% shows it to be financial conservative. Sales growth at 16.49% also shows that high-technology firms in Taiwan are doing well.

Empirical Test

Empirical results from Table 2 show that independent directors' proportion exhibits a significant positive relationship with EVA, supporting hypothesis 1 because independent directors are important policymakers in organizations. Abundant professional knowledge and personal duty shows a low relation to an enterprise. The higher independent directors' proportion impels the director to effectively supervise administrators to improve and ensure stockholders' equity or create greater value. This is also in agreement with Parrino et al., (2002). However, the independent director proportion has insignificant positive relationship with MVA. Hypothesis 2 is rejected, because investors have doubts about independent directors' ability to supervise hi-tech industry managers in Taiwan, which apparently does not influence stock price.

Table 3 shows that EVA and MVA have a significant positive relationship with independent directors' proportion in the OLS model, revealing that enterprise's value increases when independent directors' proportions increases, thus supporting hypothesis 3 & 4.

Other variables (Table 2), the inside directors' shareholding ratio positively relates to EVA but only have a significant relationship with EVA1. This is because the inside director holding ratio increases and the board of directors supervise the administrator to prevent the administrator from damaging the enterprise's value, thereby improving performance.

Block shareholders in enterprises show a significant positive relationship between EVA2

and EVA3 because they effectively supervise the management. However, an institution's investor

holding ratio shows an insignificant relationship with EVA. This paper is unable point out its

relationships. The proportion of long-term debt has a significant negative relationship with

EVA2. Sales growth has a significant positive relationship with EVA1 because the rate of

increase shows enterprise's value creation. Capital expenditure has a significant positive

relationship with EVA1and EVA2 because it raises enterprise value while investing in capital

expenditure.

On the other hand, the institution stockholding ratio has a significant positive relationship

with MVA, showing that institutional investors have higher independence and professional

knowledge to supervise the enterprise's executive more closely and create enterprise value. Sales

growth has a significant positive relationship with MVA because it is favored by investors and it

promotes stock price. However , inside director's stockholding ratio、long-term debt、the block

stockholder、and capital expenditure have an insignificant relationship with MVA.

Compared to the above solutions (from Table 3), the proportion of long-term debt and

block stockholders has a significant negative relationship with independent director proportion

because it increases independent directors' proportion in the hi-tech industry. This improves

supervisory strength of the board of directors and prevents managers' from excessively

expanding credit to cause a financial crisis. This paper does not examine why block stockholders

have a significant negative relationship with independent directors, thus we cannot clearly point

out this relationship. Institution investor stockholding ratio、 director stockholding ratio、 sales

growth and capital expenditure also have an insignificant relationship with independent directors'

proportion. Therefore, these variables have no effect on independent directors' proportion.

Conclusion

Previous literature has used traditional indexes to measure firm value; however this

method only calculates short-term performance. This may lead the administrator to manipulate

short-term performance and sacrifice long-term interests, making it impossible to reflect true

value. EVA creates enterprise value This research measured performance using economic value

added (unadjusted、 adjusted、 economic depreciation) and market valued added. Empirical

results show that independent directors' proportion increases EVA, because the independent

director has supervisory power over the administration and prevents fraud to ensure stockholder's

equities or creates greater value in the high-tech industry of Taiwan. On the other hand, this

research concludes that inside directors' proportion has a significant positive relationship with

EVA, because it plays a professional role to supervise administrators in the Taiwan hi-tech

industry.

Table 1: Descriptive Statistics for Variables

(N = 1308)

Variable	Min	Max	Average	S. dev.
EVA1	-979184	642,383	74,007	150,428
EVA2	-1,571,112	444,119	-42733	208,426
EVA3	-1,560,538	605,590	-9685	218,174
MVA	-3,246,790	7,112,788	902,798	1,474,028
INDEP	11.11%	60.00%	30.55%	9.66%
INSOWN	0%	71.74%	22.78%	12.54 %
DEBT	0%	41.81%	6.97%	8.70%
GW	-82.46%	235.92%	16.49%	32.99%
INST	0%	100.%	29.89%	19.89%
CAPEXP	0.9032	5.0846	1.0792	8.0698

Table 2 Regressions of Independent Directors' Proportion with EVA、MVA

(N=1308)

Independent variable

	Intercept	INDEP	INSOWN	DEBT	BLOCK	GW	INST	CAP	adj-R^2
A	5.113***	.256***	.006**	.004	.061	.003**	.002	.005**	0.214
B	5.360***	.246***	.005	-.008*	.235**	.000	.002	.21**	0.215
C	5.369***	273***	.005	-.007	.208**	.000	.002	.004	0.237
D	4.268***	.125	0.01	-0.02	.117	2.357***	1.136***	0.05	0.327

*:$p<0.1$ 、 **: $p<0.05$ 、 ***: $P<0.01$

Notes: 1.We used VIF to test linearity between variables. The values are all lower than 2, showing lack of linearity.

2.Panel A: Dependent variable is EVA1；Panel B: Dependent variable is EVA2；Panel

C: Dependent variable is EVA3；Panel D: Dependent variable is MVA

3. Model:

$$EVA_t = \alpha_0 + \alpha_1 INDEP_t + \alpha_2 INSOWN_t + \alpha_3 DEBT_t + \alpha_4 BLOCK_t + \alpha_5 GW_t + \alpha_6 INST_t + \alpha_7 CAPEXP_t + \varepsilon_t$$

$$MVA_t = \alpha_0 + \alpha_1 INDEP_t + \alpha_2 INSOWN_t + \alpha_3 DEBT_t + \alpha_4 BLOCK_t + \alpha_5 GW_t + \alpha_6 INST_t + \alpha_7 CAPEXP_t + \varepsilon_t$$

Table 3: Regressions of EVA、MVA with independent directors' proportion
(N=1308)

		Independent variable							
A	Intercept	EVA1	INSOW	DEBT	BLOCK	GW	INST	CAPEXP	adj-R^2
	1.222***	0.148***	.003	-.005*	.000	.001	-.001	.001	0.290
B	Intercept	EVA2	INSOW	DEBT	BLOCK	GW	INST	CAPEXP	adj-R^2
	1.133***	0.132***	.003	-.005*	-.005*	.001	-.001	.001	0.312
C	Intercept	EVA3	INSOW	DEBT	BLOCK	GW	INST	CAPEXP	adj-R^2
	1.246***	0.154***	0.003	-0.005	0.005	0.001	-0.001	0.001	0.307
D	Intercept	MVA	INSOW	DEBT	BLOCK	GW	INST	CAPEXP	adj-R^2
	1.057***	1.135***	0.022	-0.877**	-0.932**	0.025	0.018	0.036	0.322

*:p-value<0.1 、 **: p-value<0.05 、 ***: P-value<0.01

Notes: 1 We used VIF to test linearity between variables. The values are all lower than 2,
showing lack of linearity.

2. Dependent variable is independent directors' Proportion

3. Model:

$$INDEP_t = \alpha_0 + \alpha_1 EVA_t + \alpha_2 INSOWN_t + \alpha_3 DEBT_t + \alpha_4 BLOCK_t + \alpha_5 GW_t + \alpha_6 INST_t + \alpha_7 CAPEXP_t + \varepsilon_t$$

$$INDEP_t = \alpha_0 + \alpha_1 MVA_t + \alpha_2 INSOWN_t + \alpha_3 DEBT_t + \alpha_4 BLOCK_t + \alpha_5 GW_t + \alpha_6 INST_t + \alpha_7 CAPEXP_t + \varepsilon_t$$

Compared to the above reference, the proportion of long term debt has a significantly

negative relationship with independent directors' proportion because independent directors'

proportion has more power to control the capital structure. This prevents the manager from

expanding financing that leads to a financial crisis. According to the above solutions, this

research focuses on the high-tech industry. This research cannot conclude why block

stockholders have a significantly negative relationship with independent directors. The authors

suggest that other variables, such as management quality and independent directors' experiences

or education be added in future studies.

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Appendix A

This research defines the EVA (Steward, 1991) model in three ways as follows:

1. EVA1: (unadjusted EVA) = NOPAT-(WACC×IC)

   NOPAT = Pretax operating income (1-cash tax rate)
   Invest capital(IC) = asset- non bear debt- short term securities investment - construction
         in process

2. EVA2: adjusted EVA (join adjusted items) = NOPAT- (WACC×IC)

   NOPAT = pretax operating income (1-cash tax rate) + adjustment items
   Invest capital(IC) = asset - non bear debt - short term securities investment-construction
         in process + adjusted items

3. EVA3: adjusted EVA (join economic deprecation adjusted items) = NOPAT-(WACC×IC)

NOPAT = pretax operating income (1-cash tax rate) + adjustment items $\pm$ economic deprecation adjusted items

Invest capital= asset- non bear debt - short term securities investment - construction in process + adjusted items

In addition:

1. Weight average capital cost (WACC) =

$$\frac{Interest..\exp ense}{debt} \times \frac{debt}{capital} \times (1 - tax\%) + equity.\cos t \times \frac{equity}{capital}$$

2. Equity cost is measured by capital asset price model and calculated by $R_f + \beta(R_m - R_f)$, R_f is the risk free(fixed deposit interest rate in one year). β is risk Coefficient. R_m is return of market (portfolio).

3. No bear debt = account payable + account notes + accrued expense + pre-earned revenue + other account payable + account tax payable + other current liabilities

4. Adjust items＝un-amortization research expense(5 years, Straight-line method)) + un-amortization marketing expense(5 years, Straight-line method)) + allowance for account receivable + allowance for loss on inventory + allowance for loss on short term investment securities.

5. Economic deprecation adjusted items is measured by funds method as it is better

Appendix B

1. The independent director is not the manager and only holds 1% ownership, directly or indirectly. He has no stake in the company and does not control ownership.

2. Block stockholders are defined by the Securities Trade Act (No.22) in Taiwan, in which the shareholder who holds 10% of outstanding common stock

3. According to Descriptive Statistics, CAPEXP is 100 million (NTS dollars) of one unit.
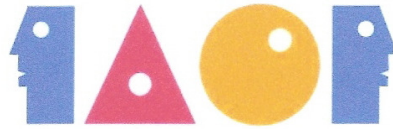
RESEARCH AND DEVELOPMENT ON THE APPLICATION OF TRIZ INNOVATIVE PRINCIPLES TO BALANCED SAILBOAT PATENT

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Abstract

In these times of advanced technology and fierce competition, an enterprise must research and develop a market-monopoly product if wanting to possess a particular competitive advantage. This is the basis for an enterprise to keep sustainable management. Therefore, the concept of "Innovation" will certainly become one of essential conditions for an enterprise to keep sustainable management. In this Research, we try to apply the concept of Contradiction Matrix to balanced sailboat. It is hoped with the help of this tool that an enterprise can have a principle to follow in product innovation, research and development. If encountering a relative problem in the future, an enterprise can use "Innovation" method to solve the problem. In this way, the enterprise can not only remove unfavorable factors blocking its development, but also cultivate capability of solving problems in the whole course, and then create brilliant achievements.

Keywords: TRIZ, Inventive, Contradictory, Matrix

Introduction

In the 21 centuries with advanced technology and fierce competition, an enterprise must make full use of its internal resources to engage in innovation and invention and create values for customers and whole society if wanting to establish a particular competitive advantage. Thus, "Innovation" will certainly become one of essential conditions for an enterprise to keep management advantages persistently.

With continuous importance attached to innovation industry, more and more people are devoted to research on innovation and invention. But innovation is a kind of instinctive mental process and innovative procedure is a kind of unscientific program, so it is not a task that everyone is competent for. If with an assistant tool, an enterprise can shorten the time of developing new products and make developing process more smooth and innovative process scientific. In this Research, we try to use TRIZ as innovative tool. It is hoped that this set of systematic process can be offered to enterprises or product developers for reference and assist them to solve problems by innovative methods when they encounter bottlenecks in invention. In this way, an enterprise can not only remove obstacles, but also cultivate capability of solving problems in the whole course, obtain learning effect by all-round consideration, become familiar with and internalize these methods and raise professional capability of organizational members.

In this Research, we try to apply the concept of Contradiction Matrix to innovation and

invention of balanced sailboat. It is hoped with the help of this tool that an enterprise can have a

principle to follow in product innovation and invention and a product developer can develop a

new product rapidly and scientifically.

Major themes in this Research are as below.

Ⅰ.Using 40 Innovative Principles of TRIZ for innovation and invention

Ⅱ.Using 39 Engineering Parameters of TRIZ for fit of product attributes

Ⅲ.Using Contradiction Matrix for analysis

Ⅳ.Illustrating feasibility of Innovative Principles corresponding to Single Engineering

Characteristic (lack of contradiction message)

TRIZ Innovative Principles

To engage in innovative methods, the need to use methods to facilitate the output of

innovative ideas, the commonly used methods are these methods，such as Brain Storming, Solo

Brain Storming, Gallery Method and Delphi Method.(Liu Zhicheng, 2003). Recently TRIZ is

often applied to product improvement, research and development. Quality Function

Development Method can assist enterprises to research and develop competitive products

meeting customers' demands. It is considered in this Research that systematized thinking ways

of TRIZ can be more capable of assisting originators with research and development, so TRIZ

innovative methods are adopted.

Significance of TRIZ

TRIZ, a Russian abbreviation for Teoriya Reshniya Izobretatelskikh Zadatch, means

Theory of Inventive Problem Solving. TRIZ is an innovative method of concluding concrete

connotation of novel thoughts and problem improvement of all the innovators and inventors in

the world, enabling innovation to be considered in systematized ways, breaking through

limitation of individual inertial thinking and guiding product innovation to a correct direction.

TRIZ is a Tool of Resolving Contradictory Problems

Technical Contradiction

If two different parameters in a system conflict with each other, a technical contradiction

exists in this system. At the time of encountering a technical contradiction, we usually use

Contradiction Matrix to solve the problem. This is a two-dimension matrix, in which rows

represents improving parameters, columns stands for worsening parameters and the fields

corresponding to these two contradicted parameters are the inventive principles suggested for use

by TRIZ. In this article, Solution Mapping 5 Stage (Shulyak & Steven Rodman, 2002) is used for

analysis on present status, Contradiction Matrix and inventive principles. Stage 1 is to find out

the factors needing for improvement. Stage 2 is to contrast the factors needing for improvement

with Contradiction Matrix parameters. Stage 3 is to list possible directions of solving problems.

Stage 4 is to confirm if directions of solving problems appear with contradictions. Stage 5 is to

compare parameters with each other and find out possible inventive principles. Contradiction

Matrix is as shown in Table 1.

Table 1.Contradiction Matrix

Deteriorative characteristics / Improved characteristics	1 weight of moving object		9 speed		21 power		39 productivity
1 weight of moving object							
9 speed							
21 power							
39 productivity							

40 Inventive (Innovative) Principles

40 Inventive Principles are the best way to resolving system contradictions. If

contradiction characteristics of a system are confirmed, suitable Innovative Principles can be

found in Contradiction Table to resolve contradictions. Concepts of 40 Innovative Principles are

as shown in Table 2.

Rules of Selecting TRIZ Innovative Principles

Using 40 Principles One by One

The simplest method is to browse TRIZ 40 Principles one by one, take them as hints of

inspiring innovation directly without regard for engineering parameters and contradictory

Table 2. 40 Principles of the Invention

1.Segmentation	2. Separation	3.Local quality	4.Asymmetry
❶ dismantling of an object into several independent parts (make an object easy to disassemble (increase the level of division or partition	❶ extracted from an object components or properties of unpleasant ❷ extracted only the parts or attributes required.	❶ An object by the same composition structure transformation into different compositions ❷ To make an object in its restrictions, every conceivable part of the components most appropriate action. ❸ To make every part of an object can achieve different and useful function.	❶ To an object by the symmetric structure to asymmetric structures. ❷ If an asymmetric structure of the original object, then change its degree of asymmetry.
5. Combination	6. Multifunctional	7. Nested structure	8. Antigravity
❶To merge the same or similar objects, or a collection of the same or similar components to achieve the same operation. ❷The same or continuous operation iwill be integrated in time.	❶ An object or structure will have various functions, in order to eliminate the rest of demand	❶ Objects can be placed inside another object ❷ One object to another object through the holes.	❶ To compensate for the weight of an object, that can be connected to the object of lifting force. ❷To compensate for the weight of an object that can be interact with the buoyancy of air power or water provided by the environment.
9. Prior counteraction	10. Prior Action	11. In advance to prevent	12. Equipotentiality
❶ If necessary, they should consider the reaction in advance. ❷ In an object in advance to give a pressure (Tension) force to counter the other	❶ Be prepared in advance, so that Objects can be roles timely and in the appropriate place. ❷ To complete all the action in advance	❶ To compensate for the low reliability of the object can be pre-emptive measures.	❶ To change the status of the work can reduce the object is lifted or reduce the number of times.

pressure (Tension) force of existence and known.	or at least the completion of part of the action.		
13. Reversion ❶ The way often used to solve specific problems is thinking in the reverse. ❷ To a movable object is fixed, put a fixed object to can be moved. ❸ The object or process will be upside down.	14. Camber ❶ The use of curve or surface to replace the straight-line components in order to replace the cube sphere. ❷ The use of roller, ball or spiral. ❸ The linear motion into a roll, using centrifugal force.	15. Dynamic ❶ So that characteristics of the object or the external environment in various stages of operation in order to achieve optimal performance automatic adjustments. ❷ Put an object into several parts and there are relative motion capabilities. ❸ If an object or process is rigid or non-deflection, and turn it into a movable, or may be deflection.	16. The role of inadequate or excessive ❶ If you can not easily be 100% of the expected results, then use the same method, consider using a little less the amount of one or more may be easier to resolve.
17. Transition to the new space ❶ Move an object into two-dimensional or three-dimensional space. ❷ In order to replace the single-layer multi-layer. ❸ Projected image to the neighboring region or the other side of the object.	18. Mechanical Vibration ❶ To object to vibrate. ❷ Increase the frequency of vibration. ❸ The use of resonant objects. ❹ Replaced by mechanical vibrations using a piezoelectric vibration, combined with supersonic vibration, and electromagnetic fields.	19. Periodic Action ❶ The use of the continuity of the movement to replace the periodic movement. ❷ If you already have is periodic motion, then the change in amplitude or frequency. ❸ Using pulse pause between the time to reach a different movement.	20. The usefulness of continuous movement ❶ Uninterrupted completion of an action, the object of all the parts should be fully operational. ❷ Remove useless and intermediate actions. ❸ Replaced with the turning motion back and forth movement.
21. Rapid effect ❶ At high speeds the completion of harmful or dangerous actions.	22. Would be detrimental to become a useful ❶ So harmful factor to achieve a positive impact.	23. Feedback ❶ Feedback to improve the introduction of an action or process.	24 Mediator ❶ The use of an intermediate material to the conversion or complete an action.

	❷ Of another harmful factor to replace the harmful factor. ❸ Increase in harmful factor in the amount of damage until it stops.	❷ If feedback already exists, then change its size or influence.	❷ Being an object and another object will be connected together to facilitate remove it.
25. Self-help ❶ Enable the object to him to supplement and repair operations. ❷ So that materials and energy are not wasted.	26. Reproduce ❶ A simple, inexpensive replica to replace the complex, expensive, fragile, not convenient to manipulate objects. ❷ With optical copies, optical image instead of an object or system, a scale can be used to reduce or enlarge images. ❸ In order to replace the visible light, infrared or ultraviolet copy to copy.	27. Disposable ❶ The use of various composite low-cost substitutes for expensive items, to meet quality compromise.	28. Mechanical system replacement ❶ Visual, auditory, olfactory system to replace the mechanical systems. ❷ With electric field, magnetic field, electromagnetic field so that objects interacts. ❸ The static field into a dynamic field, the structure of the market into non-structured games. ❹ To make field and activation of particles (magnetic) combined.
29. The use of gas or liquid ❶ Of gas or liquid to replace the solid parts of an object and these parts can use air or water or air or expansion of hydrostatic cushion.	30. Flexible shells and thin films ❶ A flexible membrane and thin-film structure to replace the original. ❷ To pure film will be isolated objects and the external environment.	31. Porous materials ❶ To make or use an object-oriented add-porous porous component objects (embedded pieces, cover, etc.). ❷ If the object has many holes, then the pre-populated with the material.	32. Color change ❶ An object or to change the color of things around it. ❷ An object or to change the color of things around it. ❸ The use of color additives to observe an object or process is not easy to see. ❹ If such additives have been used to re-trace the use of light-emitting elements.
33. Homogeneous ❶ So that the interaction of objects derived from the same material or materials close to their behavior.	34. Disposal and recovery ❶ When the object reached a post-functional or useless when it abandoned	35. Parameter changes ❶ Changes in various states of an object, density, concentration, flexibility, temperature.	36. Phase transition ❶ Phase in the material transformation process to achieve an effective growth. For example,

	or revised (etc, abandoned, decomposition, dissipation). ❷ Direct recovery of parts or objects has been depleted.		in the course of volume change can release heat or absorb heat.
37. Thermal Expansion ❶ The use of the material thermal expansion or contraction. ❷ Used with different coefficient of thermal expansion material.	38. Use a strong oxidizing agent ❶ In order to replace the normal air-enriched air ❷ In order to replace the oxygen-enriched air. ❸ Carried out in air or oxygen ionization. ❹ The use of oxygen ions.	39. Blunt Environment ❶ Replaced by a non-active environment, a normal environment. ❷ In its air to complete the process. .	40. Composites ❶ Homogeneous materials with synthetic materials to replace the.

problems and consider them one by one.

Statistical Results of Innovative Principles Occurred Frequently in Contradiction Table are Priority Level

Make statistics and ordering of innovative principles suggested corresponding to contradictions in TRIZ Contradiction Table and conduct innovative consideration in the sequence of occurrence probability until problems are resolved. Its sequence :

5>10>1>28>2>15>19>18>32>13>26>3>27>29>34>16>40>24>17>6>14>22>39>4>30>37>36 >25>11>31>38>8>5>7>21>23>12>33>9>20 （Terninko, J., Zusman, A., Zlotin, B. 1998).

Single Engineering Characteristic Principle

According to statistical and ordering levels of all principles in each entire column of Contradiction Table corresponding to every improving parameter (and avoiding -worsening

parameter), the higher level an innovative principle is at, the more times this principle was ever used for, i.e., the higher successful rate of resolving problems related to engineering parameters by use of this innovative principle is. Therefore, level sequence should be used to find suitable innovative principle when Single Engineering Characteristic Principle is adopted（Chen Liu and Jahau Lewis Chen .2001).

Engineering Parameter Pairing Statistical Method

Firstly find out engineering parameters possibly affecting this design and regard each of them as "improving" or "avoiding-worsening" parameter, secondly pair them to get multi-groups of contradictions, and then seek out and record inventive principles corresponding to each group by Contradiction Matrix. These inventive principles occurring for more times are the top-priority solutions, and it is considered in the last place whether these engineering parameters are fit for their designs or not. If necessary, people should be regarded as judgment basis（Zhang Xiangtang, 2003).

Statistical Method of Innovative Principles after Contrasting Multi-groups of Contradictions to Engineering Knowledge

Firstly obtain multi-groups of contradictory relations, secondly delete more inapplicable or little-effect contradictions according to the degree of users' grasping engineering knowledge of this problem, and then make statistics of innovative principles and conduct creative consideration one by one in the sequence of occurrence probability.

After Multi-groups of Contradictions Defining Statistical Method of Innovative Principles One by One

List one by one the engineering parameters and their contradictory relations affecting problems, hereby obtain innovative principles suggested to each group of contradictions by TRIZ, and then make statistics of these principles and conduct creative consideration one by one in the sequence of occurrence probability. （Chen Liu and Jahau Lewis Chen .2001).

Single Conflict for the Next to Innovative Principle Every Time

Firstly find out one "improving" engineering parameter and one "avoiding-worsening" engineering parameter definitely, and then look up corresponding principles suggested in Contradiction Table for innovative consideration.

Product Design Method

By taking Green Design Method of Liu Zhicheng and Wang Shuiduo (2007) for reference, product design process is planned in this Research, as shown in Chart 1. For design objects, there are 7 steps as below. First is to analyze a problem or demand of a product. Second is to establish a subassembly function analysis table and confirm improving engineering parameters of the product. Third is to try to find a feasible conventional method and analyze probably-caused side effects of this method. Forth is to contrast it to contradiction contrast table of 39 engineering parameters, seek one group or multi-groups of contradictions and find out an innovative principle suggested. Fifth is

to construct a feasible solution. If unable to find out contradiction message, you can use improving

parameters corresponding to Single Characteristic Innovative Principle to find an innovative

principle suggested and visualize a feasible solution. Sixth is to inquire about whether there is any

similar product or correlative patent in the market. If any, you should give up your design concept

and get back to conventional methods for analysis. Seventh is to file an application for a patent.
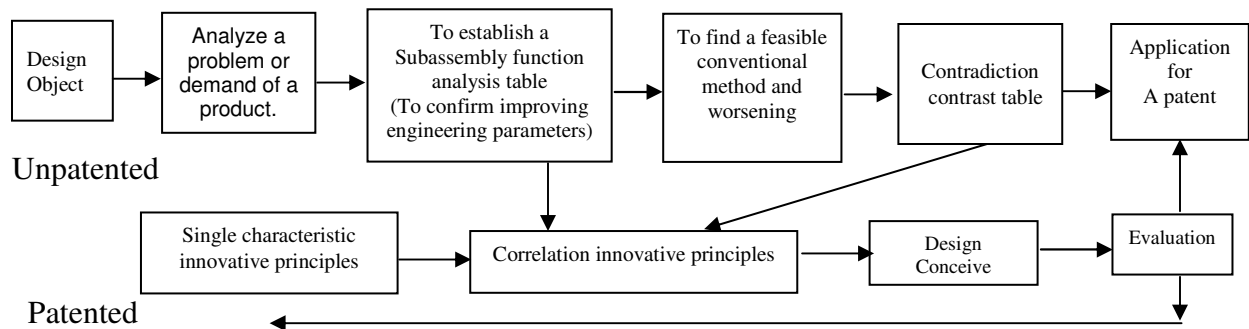
Chart 1 Product Design Process

Innovative principles corresponding to single engineering characteristic are applied in

this Research. Firstly apply each "improving engineering characteristic" in TRIZ Contradiction

Table, and then sort out their correspondent innovative principles. Here, occurrence times of

some principle can be regarded as the amount of kinds of "avoiding-worsening engineering

characteristics" probably matched at the time of improving "some engineering characteristic" of

a system. The more times some principle occurs for, the higher successful rate of solving

problems by this principle is. Here, vertical axis shows 39 engineering parameters of TRIZ, and

horizontal axis indicates occurrence times of innovative principle corresponding to this

engineering characteristic. Principle table is as shown in Table 3 (only list engineering

parameters applied in this Research that are No. 07, 27 and 33 parameters, and their occurrence

times), table of innovative principle corresponding to single engineering characteristic is as

shown in Table 3, and innovative principle flow chart is as shown in Chart 2.

Table 3 Innovative Rule Table Of Corresponding To The Single Engineering Properties

grade / Engineering parameters	A 19times or more	B 16~18 times	C 13~15 times	D 10~12 times	E 7~9 times	F 4~6 times	G 1~3 times
07. The volume of moving objects		35	02.10.29	01.15.34.04.06	13.40.	16.28.14.39.17.18.26 22.30.25.37.36	24.28.11.12.32.19.09.23 .27.20.2105.03
27. Reliability	35.10.11	40.	28.27.03	01	13.24.08 02.32.29	19.21.0414.16.23	17.39.2615.36.06.34.31 09.30.3825.05.18
33. Use of convenience	01.	13	02.28.35.32.	12.15.34.25.	16.26.17.27.	04.03.1024.40.19.39.29.	22.30.0518.23.06.08.0931.07.11

Data source：（Liu Zhicheng, 2003）Finishing this study

| To improve characteristics Characteristics of an Engineering | or | Prevent further deterioration of the of an Engineering's |

Innovative rule table of corresponding to the single engineering

Innovative rule
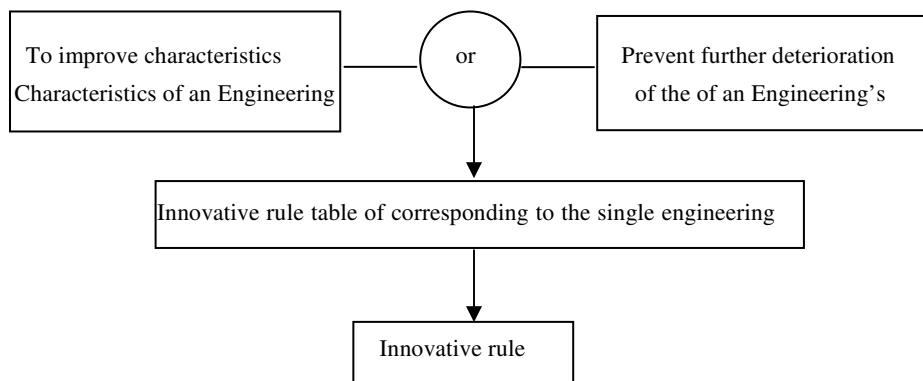
Chart 2.Innovation Rule Flowchart Of Corresponding To The Single Engineering

Case Study

Product Name: Balanced Sailboat

Case Demand

Abecedarians of windsailing sport often overturn sailboats due to improper operation. In this Research, we try to infuse water into the hole of balanced seat to prevent sailboat from being overturned, and thereby improve safety and convenience of windsailing abecedarians' using their sailboats, reduce their feeling of fear and increase function of entertainment. Its subassembly functions are as shown in Table 4.

Table 4 Menu bar components

Code name	Component	Function
1	Plate body	First or second surface contains Plate body
11	First surface of Plate body	Sail body connecting to fixed mast
12	Second surface of Plate body	To connect balance block
2	Sail body	To produce thrust
21	Mast	To fix mast
3	Balance seat	To lower center of gravity to the underwater
31	Cabin	Let water in and out to maintain a balance of the balance seat
32	Voids	Let water flow out

Innovative Procedure

Seek for Improving Parameter.

Method of Using 40 Principles One by One is applied to this product. It is known from

Innovative Principle Table corresponding to Single Engineering Characteristic (Table 3) that this

product has improving engineering parameters, such as 07. Volume of Moving Object: 3-D

Measurement Moving Object; 27.Reliability: System has the ability to properly carry out its

functions; 33. Convenience of use： System was the ease of operational or use.

Innovative Principle Corresponding to Single Engineering Characteristic.

In accordance with No. 07, 27 and 33 improving engineering parameters of this product

and in contrast with single engineering parameter, it is found that No. 07 parameter (volume of

moving object) is applied more than once and correlative principles related to this product are

No. 03, 06, 08, 10 and 11 principles, No. 27 parameter (reliability) is applied more than once and

correlative principles related to this product are No. 03, 06, 08, 10 and 24 principles, and No. 33

parameter (convenience to use) is applied more than once and correlative principles related to

this product are No. 03, 06, 08, 10, 11 and 24 principles. Therefore, the innovative principles

correlated to this product are as below. No. 03 Principle -- Partial Quality: convert windsailing

steel plate structure into the structure made up of different components and enable each part with

different and useful functions. No. 06 Principle -- Multifunction: enable structure of balanced

sailboat with multifunction to eliminate demands of other parts. No. 08 Principle -- Antigravity:

produce interaction with water buoyancy in order to compensate weight of wind fans. No. 10

Principe -- Beforehand Function: preset balanced seat and capacity room of balanced sailboat for

needs of abecedarians. No. 11 Principle -- Prevention: take countermeasures of reducing center

of gravity in order to compensate possibility of sailboat overturn. No. 24 Principle -- Mediator:

use water to complete action of balance.

Presenting Design Concept.

In this Research, the principle of reducing gravity center is used for sailboat learners to

avoid risk of sailboat turnover and feeling of fear at the time of operating sailboats. By use of

No. 03 principle that is partial quality, sailboat plate is changed into 2 surfaces. A mast is fixed

on the first surface, and lashing ring of the second surface is connected with a balanced seat.

There is a capacity room set inside the balanced seat. Furthermore, plural holes penetrated into the capacity room are set on the balanced seat.

By use of No. 06 principle that is multifunction, sailboat plate is able to stand on as well as store water to increase gravity center. By use of No. 08 principle that is antigravity, gravity center is reduced for increase of wind fans' weight, and water in windsailing sport environment enters into balanced seat of plate to realize the aim of balance. By use of No. 10 principle that is beforehand function, balance room and capacity room preset in plate are convenient for abecedarians to use before sailboat turnover so as to avoid turnover. By use of No. 11 principle that is prevention, a balance room is preset for purpose of containing water to reduce sailboat gravity center and prevent sailboat from turnover. By use of No. 24 principle that is mediator, a mediator is added in order to increase gravity center, comes from inexhaustible water in windsailing sport environment and possesses function of environmental protection. Such sailboat with better balance designed on these grounds to reduce accident occurrence is easy for abecedarians to overcome fear. Tridimensional appearance chart, plan profile chart, user operation chart and forward moving chart of balanced sailboat are as shown in Chart 4, Chart 5, Chart 6 and Chart 7.

Patent Search.

As to this design, search Patent Information Network of Republic of China, enquire

whether there is any correlative patent product registered or not. After inquiry with key word

"windsailing", No. 1302513 patent is searched out. Search results are as shown in Table 5 & 6.

Table 5 Patent Search Results

Patent Search Keywords	Search Results	Resemble Patent
Stabilizer	1	1

Source: Republic of China Patent Information Retrieval System

Table 6 Ship Stabilizer

Search Date：October 9, 2009
Certificate No：I302513
Applicants：Xie Minpu
Proposal Name：ship stabilizer

Source: Republic of China Patent Information Retrieval System

Comparison of Search Results.

Through search of each patent, a product with similar function named ship stabilizer is

found. This stabilizer mainly uses a servomotor to cause movement of a quality body and

generate from boat body corresponding to movement of the quality body a reaction moment as

anti-rolling moment to realize anti-rolling effect. It shows after evaluation that its structural parts

is more sophisticated than new-style patent studied in this Research as well as with higher cost,

so this creation is valuable.

Evaluation.

Except this creation, no design completely same with this creation is disclosed in Patent

Information Search System of Republic of China at present. Moreover, patents with similar

principle are with more sophisticated structural parts and higher cost. Therefore, this creation is

novel and progressive.

Conclusions

1) When this method of product design process is applicable to product innovation design,

design personnel can find out on the basis of this method an innovation design method beneficial

for product research and development.

2) Utilizing 39 attributes (engineering parameters), Contradiction Matrix and 40 innovative

principles of TRIZ as basis of product innovation can make creators feel convenient and

practical.

3) Utilizing Single Innovative Principle of TRIZ (lack of contradiction message) can simply

analysis process, offer possible solution and make innovation design more efficient.

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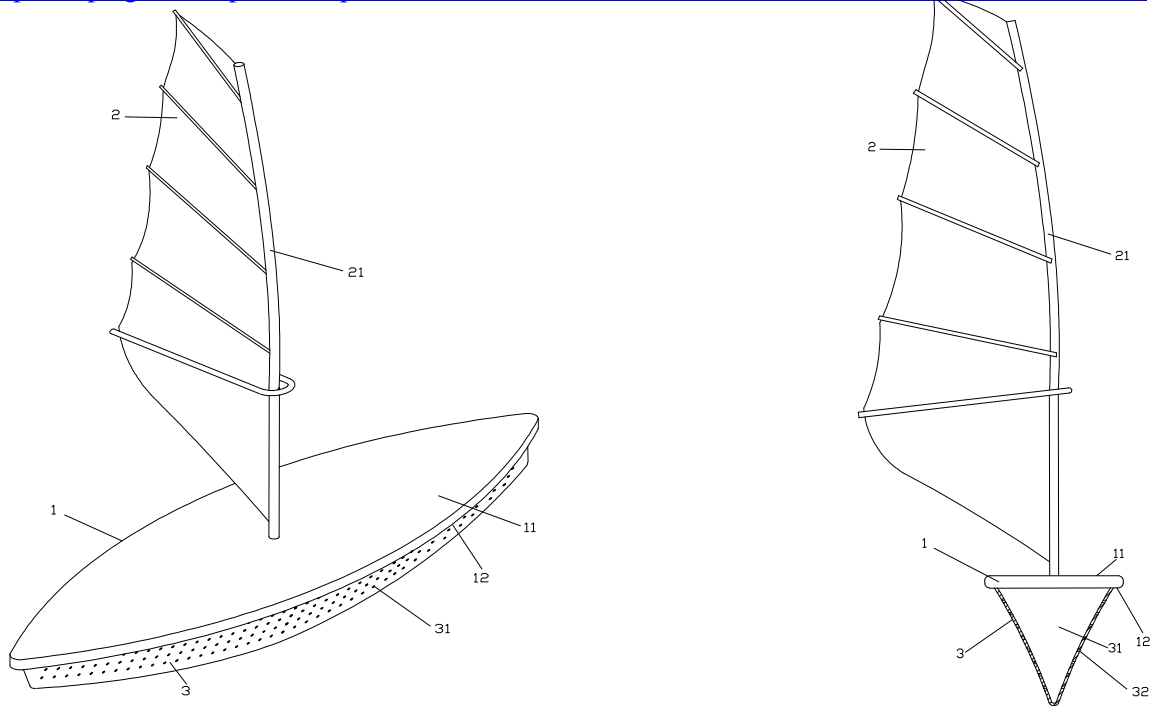
Figure 4: balanced sailboat 3D Appearance   Figure5: balanced sailboat plane insign
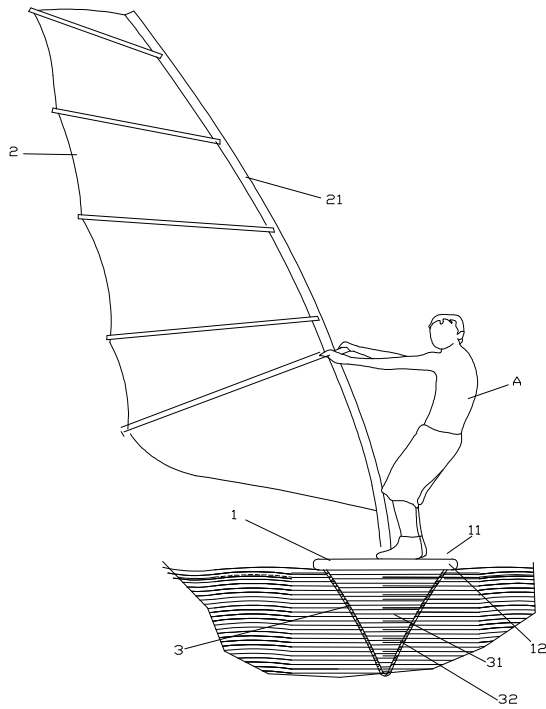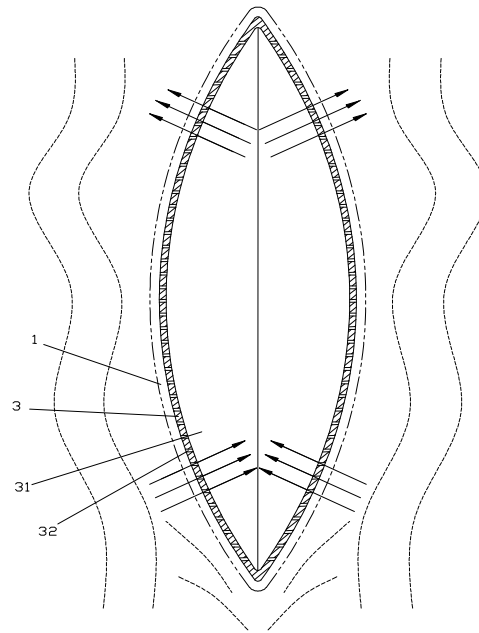
Figure 6: balanced sailboat user operation hint Figure 7: balanced sailboat indicate forward movement
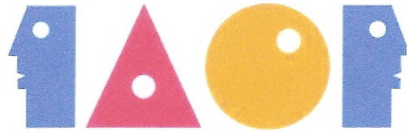
A STUDY ON TAIWANESE ADULTS'COGNITION OF THE COLOR COMBINATIONS OF HEALING TOYS

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Abstract

The Japanese "癒す"means that comfort people and make favor for people. Recently, people buy healing toys because a lot of people feel pain from their work and life. Healing toys are used to make people happy and joy. Therefore, the colors are very important to healing toys.

The purposes of the study were as follows: (1) To analyze how healing toys of the market match the colors. (2)To understand healing toys towards psychological cognition influence of color combinations from adults' views of different age brackets (3) To realize healing toys towards satisfaction of color combinations from adults' views of different age brackets. (4)To explore adults of different age brackets towards main factors of color combinations of healing toys.

The findings of the study were as follows: (1) The healing toys of the market now have soft and warm color combinations. (2) The adults of age brackets prefer healing toys that have soft and warm color combinations of people and animal styles. (3) Each adult of age bracket did not show significant satisfaction difference. (4) The adults of age brackets towards matching color images of healing toys the influence is affected by feeling factors.

Key words: Healing Toys, Color Image, Color Combinations

Introduction

Research Background and Motives

'癒す', a Japanese word, means healing in English, and it indicates one type of cultural fashion in Japan in recent years. The fashion of healing toys has also begun to spread in the toy market in Taiwan. Do the color combinations of healing toys meet Taiwanese adults' needs? What color combinations of healing toy do adults from different age groups, who have different values and living styles, respectively prefer? These are both the motives behind the study. The color of a commodity has influence on whether or not people need the commodity. Consequently, it was expected to find out different-aged Taiwanese adults' cognition of the color combinations of healing toys as references and concrete suggestions for following research, industries, the Government, and academia.

Research Purposes

The major purposes of the study are indicated as follows:

1. Analyzing and compiling the color combinations of healing toys available in the market.

2. Understanding the influence of the color combinations of healing toys on each adult age group's color cognition.

3. Studying each adult age group's preference for the color combinations of healing toys.

4. Comprehending the major influential factors in each adult age group's preference for the color combinations of healing toys.

The study was expected to analyze and integrate the color combinations of healing toys as well as to investigate the color combinations which fit in with each adult age group in Taiwan. The principles of color combination in the study can be reference for designers and to the market positioning of a product.

Research Scope and Limitations

The relationship between the color combinations of healing toys and each adult age group in Taiwan was investigated in the study. The research scope and limitations are indicated as follows:

1   Aiming at the healing toys currently available in the market in Taiwan.

2   Targeting only at the color combinations of healing toys and excluding other factors from the investigation.

3. Investigating Taiwanese adults over 18 years old.

Literature Review

The Life Stress of Adults

The general definition of adult mainly focuses on one's physical and psychological changes and the social missions. Since adulthood is not stable, one, no matter internally or

externally, will have slow or dramatic physical and psychological changes in the entire

adulthood. Therefore, integrations and adjustments will unceasingly emerge in one's entire

adulthood (Huang, 1992). In order to achieve social expectations, an adult has the so-called

stress generated when confronting the missions in each stage.

Stress can be resulted from diversified reasons. Due to the developing mission in the

adulthood, an adult's stress comes more frequently from the financial stress of work. Siegrist

(2000), a German sociologist, deemed that the symptoms of stress emerged from the imbalance

between one's work effort and work reward.

In terms of stress relief, Rice & Rice (1986) brought up the idea changing an individual's

internal reactions through cognitive channels or transforming one's mindset through

entertainment sublimation to enhance one's positive emotions and ease the physical and

psychological fatigue. Healing toys designed and developed by Japanese manufacturers for

adults are exactly stress-releasing products aiming at adults' stress resulted from the integrations

and adjustments of life or work.

Healing Toys

In the Chinese dictionary reedited by the Ministry of Education, Taiwan, a 'toy' is

interpreted as something playable. For an item to become a toy, there has to be a process in

which a toy player, namely a human, bestows meaning upon the item. It is the item which brings

a toy player, or a human, some kind of fun and satisfaction through certain formulas and ways acting on itself.

Healing toys originated from the healing culture prevailing in Japan in recent years.

Healing indicates '癒す' in Japanese, which was translated from English, and the verbal explanation is 'to cure', indicating curing illnesses or the needs resulted from mental depressions. Healing series can also be called remedy series or curing series, and there is not a particular name (Lan, 2006).

The healing culture basically originated from the 1980s, in which healing mainly indicated, in terms of spirit, the religious world and, in terms of physical body, the pain caused by illnesses and physical tortures when it was used as a noun. Until the later half of 1990, the interpretation was extended to heart relief, which included higher psychological levels and emphasized overall recovery.

Color Cognition

According to Zimbardo (1995), cognition is a psychological function, indicating the progress for people to understand things.

Colors provoke one's brain physically, further influence the psychology, and generate emotional and active reactions in one's daily life. Therefore, based on color quality, two categories, namely color perception and color feeling, are generally established.

Hebb (1958), a Canadian psychologist, regarded perception as the direct process of the

stimuli resulted from the activities of sense organs and the medium process caused directly by

feelings. Consequently, color feeling is the most primitive and simple spiritual element whereas

color perception indicates the integration of feelings, which is more complicated than color

feeling (Tsou, 2000). Our facial features and all the organic organs frequently have various color

feelings about colors, which can be divided into, for instance, cool colors and warm colors as

well as advancing colors and receding colors. As for that colors influence perceptions,

physiologists have found that muscular strength and blood circulation will display different

colors of reaction rate due to different illumination colors (Hsieh, 2000). In light of the aforesaid,

colors indeed influence human beings physically and psychologically.

Color Images

A color image is interpreted as follows: 'It indicates one's ideas of, judgments on,

preferences for, and attitudes about colors; it emphasizes the content perceived on one's mind or

in one's feeling ; in short, colors make people generate psychology and feelings' (Chen, 2008).

Aiming at color images, the Nippon Color & Design Research Institute (NCD) developed the

color image scale.

The classifications of the color image scale are based on the psychological feelings

caused by colors. The vertical axis of the scale indicates the colors from soft to strong, and the

horizontal one indicates the colors from warm to cool to form a rectangular coordinate system. In addition, according to color images, the most appropriate location is chosen, and the arrangement is applied to enable this system to construct a simple and convenient scale connecting color images with verbal images.

Color Combinations

Cheng & Lin (2006) were of the opinion that color combination indicated that more than two colors were combined to generate new visual effects. There are a lot of methods to combine colors, including the combinations based on hue, those based on brightness, those based on saturation, and those based on color tone. Furthermore, hue selecting is the top priority in the combinations based on hue, in which the constructed effect and the predominant color hue of an image should be considered, and the thinking associated with colors, color features, and the differences between color preferences should be understood. Moreover, in the combinations based on hue, colors are combined generally in light of color circle. According to the angles constructed in the color circle, colors can be divided into the color combinations within the same hue, those within similar hues, those within complementary hues, those within multiple hues, etc.

The combinations within multiple hues can be further divided into the combinations within three hues and the combinations within four hues. In the color circle, the combinations within three hues can be divided into the regular-triangle color combination and the isosceles-

triangle combination. The previous combination establishes a strongly contrastive and lively feeling whereas the latter one creates a stable and tranquil feeling. Additionally, the combinations within four hues can be divided into the square color combination and the four-angle color combination (See Figure 1 for details). The previous combination has two pairs of complementary colors, so the contrast is strong; the latter one is stable and unified. The combinations within three hues may adopt the combination method of three equal colors or two-to-one. The combination of three equal colors is tense; in the combination of two-to-one, one of the colors can be the predominant color while the other two are the auxiliary colors.
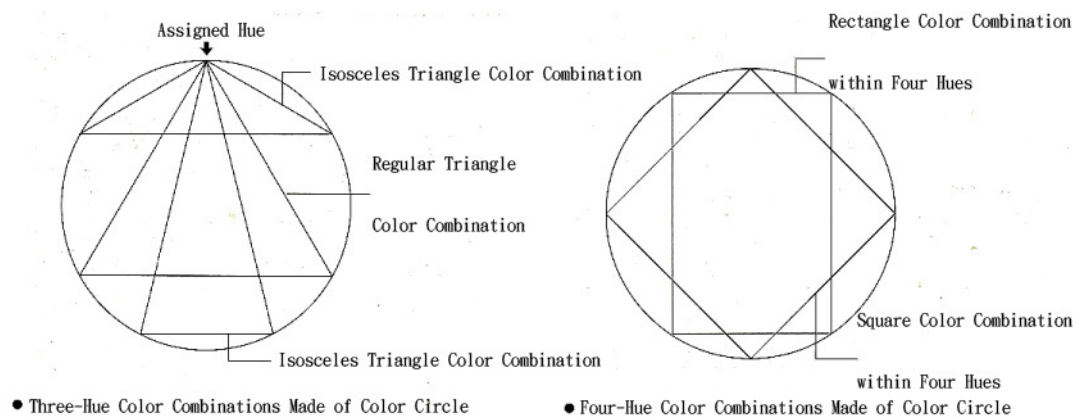
Figure 1 Combinations within Multiple Hues
Data sources: Cheng & Lin (2006). *Color Planning*, p76.

In terms of color combination essentials, Cheng & Lin (2006) brought up the following opinions:

1. Taking hold of the general goal, deciding the images of the major color tone, such as being cool, warm, bright, dark, gorgeous, and simple, and the auxiliary colors, emphasizing the relationship between color tones, and considering how to create more appropriate color combinations and how to make better effects.

2. Selecting one proper predominant color according to the major color tone.

3. When selecting the second color, considering the contrast, balance, and brightness/darkness of the color tones and the size and shapes of the colors according to the necessary effects.

4. In the following color combinations, considering the relationship between colors, applying comparisons or auxiliary tools, such as color chip and color palette, in order to approximately make sure the colors, and, then, slightly modifying in light of one's aesthetic experience.

Hence, as for the color combinations of healing toys, it is necessary to decide the images of color tone first, select then appropriately a predominant color and auxiliary colors, and match up with the contrast, balance, and brightness/darkness of the color tones and the size and shapes of the colors in order to create good color combinations consistent with one's psychological cognition.

Research Methodology and Implementation Steps

Research Methodology

The semantic differential technique, usually known as SD was employed in the study. It have been extensively applied to diversified investigations and descriptions on psychological feelings after being established by Charles E. Osgood et al., Ohio University, U.S.A., and the major advantage lies in being able to further divide meaning into several stages to more minutely comprehend one's psychological feelings (Lai, 2006).

A SD profile linearly connects the means obtained by the application of the semantic differential technique on the scale, by which feelings are objectively analyzed and compared through values, the tendency of each set of color combination samples on the semantic scale is discovered, and the images of each set of color combinations are further comprehended.

Research Implementation Steps

Stage 1: Selecting the Representative Samples of Healing Toys and the Adjectives for the Images of Color Combinations.

This stage focused on selecting the representative samples of healing toys and the adjectives for the color images. To select the representative samples of healing toys, the healing toys currently available in the market in Taiwan were collected, categorized, and sifted out; finally, by means of questionnaire survey, the representative samples most familiar to Taiwanese adults from various age groups were selected for color combination.

In terms of the adjectives for the images of the color combinations of healing toys,

relevant literature and research were consulted to collect related adjectives, and a questionnaire

survey was conducted by interviewers with design background to select the adjectives suitable

for the investigation on the images resulted from the color combinations of healing toys.

Furthermore, 30 adults were pre-tested in order to revise or delete the adjectives difficult to

understand.

Selecting the Representative Samples of Healing Toys.

Lan (2006) classified healing toys into 3 categories, namely person, animal, and plant. In

the study, 30 person samples, 30 animal samples, and 30 plant samples, that is, totally 90

samples, were selected from the healing toys currently available in the market in Taiwan.

According to literature, the color combination of predominant color and auxiliary colors,

in which the predominant color should be larger in arrangement, was adopted in the study, so

respectively 9 person samples, 9 animal samples, and 9 plant samples, namely 27 samples in

total, were accordingly selected from the collected samples, and by means of questionnaire

survey, the most selected sample and the second most selected one in each category represented

respectively each category.

Selecting Adjectives for the Images of the Color Combinations of Healing Toys

As for the adjectives for the color images of healing toys, in the study consulted The Color for Designer published by Image Research Institute Inc. (I.R.I.), Korea (compiled and translated by Dr. Master Press, 2007), Color Image Scale by Nippon Color and Design Research Institute (Kobayashi, 2000), An Investigation on Seniors' Perceived Images of and Preference for the Color Combinations of Web Pages (Huang, 2006), A Study on the Color Combinations of Plastic Sunglasses from the Aspect of Color Cognition (Lin, 2007), and The Influence of the Square Measure of Color Combination on Color Images (Chen, 2008). After the study compiled, selected, and deleted repeated adjectives from the vocabulary suitable for describing healing toys, 80 adjectives were finally selected.

Survey Result

This questionnaire survey was conducted in March, 2009, and the participants' age was between 18 and 32 years old. The questionnaire copies were delivered personally. In total, 30 copies were delivered, retrieved, and valid. From 9 person samples, 9 animal samples, and 9 plant samples, namely 27 samples in total, and 80 selected adjectives, the participants selected the most familiar healing toys to be the representative samples of the color combinations of healing toys and the adjectives for the images resulted from feeling.

As for the representative samples of healing toys, Sample 1 in the category of person was the most selected, accounting for 40%, and the second most selected one was Sample 5,

accounting for 23%. Sample 5 in the category of animal was the most selected, accounting for

34%, and the second most selected one was Sample 8, accounting for 23%. In the category of

plant, the most selected one was Sample 3, accounting for 43%, and the second most selected

one was Sample 1, accounting for 30%. The detailed percentages are indicated by the following

table, from left to right and from high to low:

Table 1 Selected Percentage of Each Representative Sample of Healing Toys

Character Samples	No.1	No.5	No.2	No.6	No.8	No.4	No.3	No.7	No.9
%	40	23	13	7	7	7	3	0	0
Animal Samples	No.5	No.8	No.7	No.4	No.3	No.1	No.2	No.9	No.6
%	34	23	13	10	7	7	3	3	0
Plant Samples	No.3	No.1	No.8	No.5	No.4	No.6	No.9	No.2	No.7
%	43	30	10	10	7	0	0	0	0

The study statistically compiled the top 15 adjectives for the color images of healing toys.

From high to low, they were respectively comfortable (23 times), warm (22 times), gentle (21

times), delighted (20 times), broad-minded (19 times), optimistic (19 times), sensitive (18 times),

relaxed (18 times), close (17 times), light (17 times), soft (16 times), natural (15 times), sweet

(15 times), calm (15 times), and pleasant (15 times).

To be the test vocabulary, the top 15 adjectives were selected by means of questionnaire

survey, and proper opposite adjectives were discovered by referring to literature. The opposite

adjectives of 'adorable' and 'pleasant' both indicate 'abominable', and the meanings are too

close to each other, so 'adorable,' the selected times were less than those of 'pleasant,' was

deleted, and the rest adjectives were classified into totally 14 pairs.

To avoid the situation in which the participants misunderstand or do not understand the

vocabulary in the formal test, 30 adults were pre-tested by means of questionnaire to test the

semantic understanding of the opposite adjectives. The test location was in Daan District, Taipei

City, and the 30 participants were all adults. The 14 tested and revised pairs of opposite

adjectives are indicated by the following table 2:

Table 2 Revised Opposite Adjectives

Opposite Adjective	Opposite Adjective
comfortable ←----→ painful	relaxed ←----→ nervous
warm ←----→ cold	close ←----→ distant
gentle ←----→ passionate	light ←----→ heavy
delighted ←----→ sad	soft ←----→ hard
broad-minded ←----→ heavyhearted	natural ←----→ artificial
optimistic ←----→ pessimistic	sweet ←----→ bitter
sensitive ←----→ rational	calm ←----→ lively

Stage 2: Selecting the Samples of the Color Combinations of Healing Toys

The purpose of this stage was to combine colors on the representative samples of each healing toy category selected in Stage 1. Referring to literature, the color combinations were based on the combination of predominant color and auxiliary colors within three hues.

In order to investigate whether or not the color combinations of the healing toys currently available in the market in Taiwan met Taiwanese adults' preference, the study intended to find out the basis for color combination from the 90 collected samples of healing toys.

In addition, the samples of color combination were divided into the market group and the control group. The color image scale mentioned in the literature was applied to the color combination sampling of the market group to induce the color combination tendency of each category of healing toys available in the market, from which the representative sample of color combination was then selected. The control group employed the hue and tone system developed by the Image Research Institute Inc. (I.R.I.), Korea to statistically calculate the most frequent color in each category to be the samples of color combinations.

Since samples were displayed in images in the study, in order to avoid any error occurring when the combined colors were displayed on the samples, it was necessary to picture the representative samples to make the images more concise and simple. The pictured figures were taken as the representative samples of color combination.

Selecting the Samples of the Color Combinations of the Market Group

The most appropriate coordinates for the samples of color combination in this group were chosen on the color image scale on which the samples were arranged in order. Furthermore, by means of the collected healing toys, including 30 person samples, 30 animal samples, and 30 plant samples, totally 90 samples, the distributing tendency of each category of healing toys on the scale was induced, and, from each quadrant, a color combination with the most average vertical and horizontal coordinates was selected to be one of the samples of the color combinations of the market group.

The samples of the color combinations of the market group were induced as follows:

A. Person: Most of the color combinations tended to be located in the quadrant of warm and soft. The sample of color combination with the most average vertical and horizontal coordinates (2, 2) was selected as the representative sample (See Figure 2 for details).

B. Animal: Most of the color combinations tended to be located in the quadrant of warm and soft. The sample of color combination with the most average vertical and horizontal coordinates (1.8, 2) was selected as the representative sample (See Figure 3 for details).

C. Plant: Most of the color combinations tended to be located in the quadrant of cool and soft. The sample of color combination with the most average vertical and horizontal coordinates (2, 2) was selected as the representative sample (See Figure 4 for details).

After the aforementioned induction of color image scale, the color combination tendency

of each healing toy category was comprehended. The representative sample of color combination

selected from each category was then employed in the samples of healing toys, indicated Table

3. In this stage, by means of the hue & tone system, the most frequent color in each category was

discovered from 90 samples of healing toys to be the predominant color of the samples of color

combination. Moreover, by referring to the color combinations of regular triangle as well as

isosceles triangle in the color combinations with three hues in the literature, auxiliary colors were
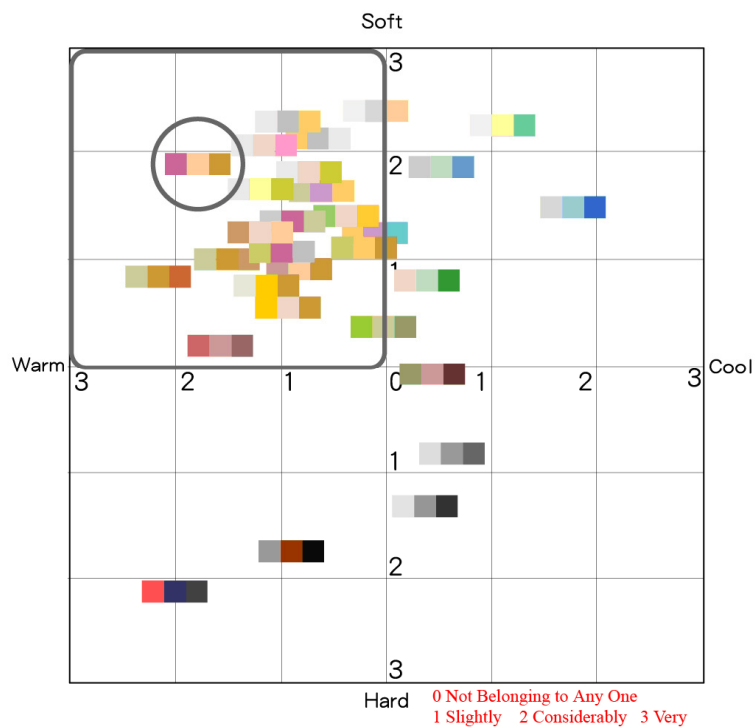
Figure 2 Color Image Scale of Person
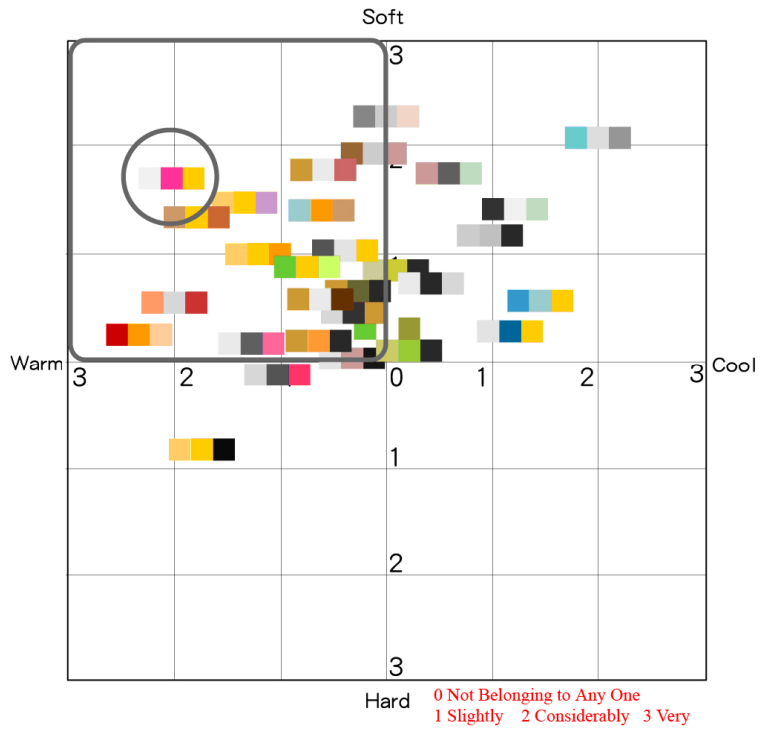
Figure 3 Color Image Scale of Animal
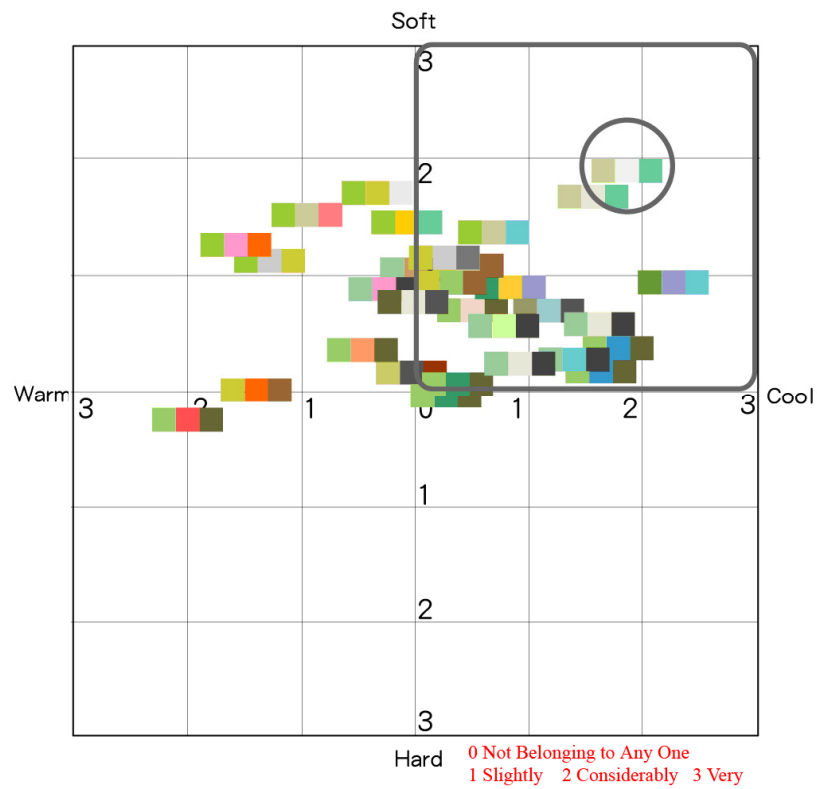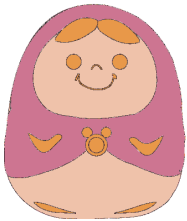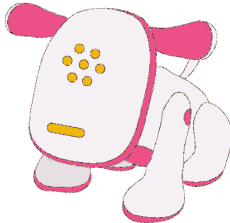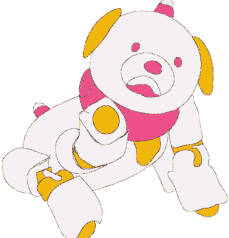
Figure 4 Color Image Scale of Plant

combined, and, eventually, two sets of the samples of the color combinations of the control group were established. In order to achieve the purpose of the study, the color system of hue & tone 120 (Figure 5) established by IRI, Korea was employed in the study. This color system is based on the Munsell color system and ISCC-NBC color names, and it, meanwhile, indicates color hue and color tones. Based on 10 color hues and 11 stages, the hue & tone 120 color systems by IRI is composed of 110 colors and 10 stages of neutral colors distinguished in light of brightness (See Table 4 for details). After statistic   calculation, the most frequent color in each category was employed as the predominant color, and by referring to the color tone of IRI color system, consistent auxiliary colors were discovered on the color tone circles of the predominant colors by means of the color combinations of regular triangle and isosceles triangle.

Table 3 Samples of the Color Combinations of the Market Group

	Sample 1	Sample 2
Person		
Animal		

Plant

Selecting the Samples of the Color Combinations of the Control Group

Table 4 Abbreviations of IRI Hue & Tone 120 Color System

Hue	R	YR	Y	GY	G	BG	B	PB	P	RP	
	red	yellow Red	yellow	green yellow	green	blue green	blue	purple blue	purple	red purple	

Tone	V	S	B	P	Vp	Lgr	L	Gr	Dl	Dp	Dk
	vivid	strong	bright	pale	very pale	light grayish	light	grayish	dull	deep	dark
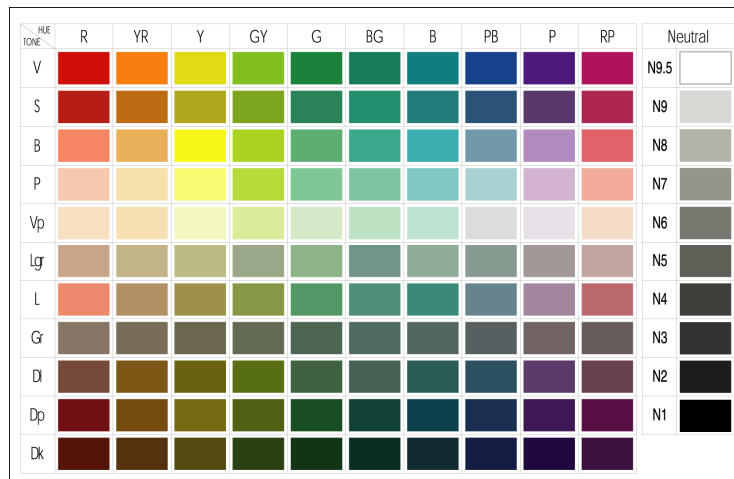
Figure 5 Hue & tone 120 Color System Data sources: Youngjin.com. (2007) *The Color for Designer.* (Drmaster. Comp. &Trans.). P:25

The result for the Samples of the Color Combinations of the Control Group

A. Animal: The color hues tended to focus on yellow red and yellow; the color tones tended to be bright and pale. The top three hues in the color hue statistics were respectively Yr(23 ％), Y(21％), and Pb(16％); the top three tones in the color tone statistics were respectively B(29％), P(18％), and V(13％). Yr/B, the most frequent color, was the representative sample color (See Table 5).

B. Plant: The color hues tended to focus on yellow and green yellow; the color tone tended to be pale and bright. The top three hues in the color hue statistics were respectively Gy(31％), Y(17％), and Bg(14％); the top three tones in the color tone statistics were respectively P(37％), B(21％), and Dl(17％). Gy/P, the most frequent color, was the representative sample color (See Table 5).

Table 5 Statistics of the Color Hues and Color Tones of Each Category
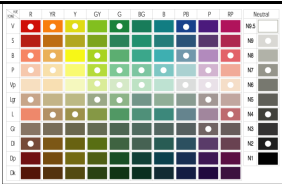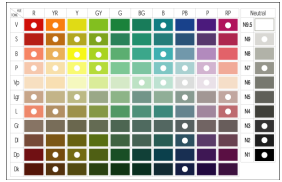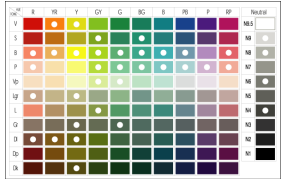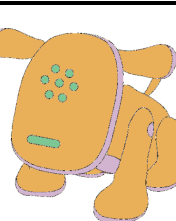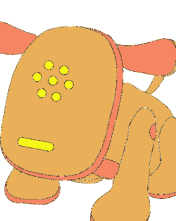
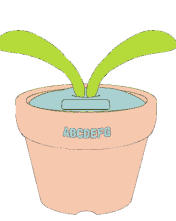|	The Distribution of Color Hues and Color Tones	The Occurrence Frequency of Colors
Person		YR/P, P/P, R/P, YR/B, P/VP
Animal		YR/B, N9, Y/B, N9.5, N3
Plant		GY/P, BG/P, Y/DI, GY/Vp, R/DI

Table 6 Samples of the Color Combinations of the Control Group

	The Method of Color Combination	Sample 1	Sample 2
Person	The Color Combination of Regular Triangle		
	The Color Combination of Isosceles Triangle		
Animal	The Color Combination of Regular Triangle		
	The Color Combination of Isosceles Triangle		
Plant	The Color Combination of Regular Triangle		
	The Color Combination of Isosceles Triangle		

Stage 3: Investigating Adults' Images of and Preference for the Color Combinations of Healing

the samples of healing toys, the result of which was indicated by Table 6:

Toys

The representative sample color of each category mentioned above was combined by respectively the color combinations of regular triangle and isosceles triangle to discover the consistent auxiliary colors. Additionally, each representative color combination was applied to

In this stage, the scale of the 14 pairs of opposite adjectives selected above was divided into 7 stages by means of the semantic differential technique, in which 3 and -3 indicated the strongest feeling, 2 and -2 indicated a very strong feeling, 1 and -1 indicated a strong feeling, and 0 indicated an ordinary feeling. The participants selected the values respectively on the scale according to how they felt the images of the 18 representative samples of color combination. An investigation on the preference for healing toys was also added to the questionnaire to analyze the correlation between the image adjectives and the preference.

The formal investigation was implemented as follows:

A. The time of implementation: April, 2009.

B. The venue and environment of implementation: The laboratory of H407, Department of Applied Arts and Design, Nanhua University, Taiwan. Day-light fluorescent lamps with the color temperature of approximately 6500K were installed in terms of the indoor environment.

C. The method of implementation: The questionnaires were delivered personally. The participants were given a break of 3 minutes each time after accomplishing the survey of

6 pairs. The average time for accomplishing the questionnaire was approximately 30 minutes. After the investigation, the participants were given little gifts for appreciation.

D. Investigated Participants: Random sampling was adopted to survey the adults over 18 years old in Taiwan. There were 125 participants, including 61 males and 64 females.

Research Results and Analyses

Describing the Research Participants

There were totally 125 copies of questionnaire provided in the study. After inspection, 5 invalid copies were eliminated, and the valid samples were 120 copies in total, in which the retrieval rate of valid questionnaire was 96%. In terms of age, the participants centered the most among 24 and 35 years old, accounting for 37.5%; the top second distribution was 18 to 23 years old, accounting for 20.0%; the top third distribution was 46 to 57 years old, accounting for 18.3%, the details of which were indicated by the following table 7:

Table 7 Distribution Structure of the Age of the Participants

		Times	Percentage	Valid Percentage	Accumulative Percentage
Valid	18-23 years old	24	20.0	20.0	20.0
	24-35 years old	45	37.5	37.5	57.5
	36-45 years old	20	16.7	16.7	74.2
	46-57 years old	22	18.3	18.3	92.5
	Over 58 years old	9	7.5	7.5	100.0
	Sum	120	100.0	100.0	

Analyzing Adults' Images of the Color Combinations of Healing Toys

In order to employ statistic software for statistics, the scale of 3 to -3 was transformed from right to left into the evaluation standard of 7 to 1, such as that 3 was transformed into 7 and that 2 was transformed into 6. A mean between 3.50 and 4.49 on the scale indicated an ordinary feeling; a mean between 3.00 and 3.49 or 4.50 and 4.99 indicated a slight feeling; a mean between 2.00 and 2.99 or 5.00 and 5.99 indicated an apparent feeling; a mean smaller than 2.00 or greater than 5.99 indicated a strong feeling.

The SD profiles of person, animal, and plant were respectively indicated the following table 8. In each figure, the blue line represented the samples of the color combination of the market group, the red line represented the control group's samples of the color combination of isosceles triangle, and the pink line represented the control group's samples of the color combination of regular triangle:

Table 8 SD Profiles of Person, Animal, and Plant

Sample	SD Profile
No. 1、2、3	

No. 4、5、6

No. 7、8、9
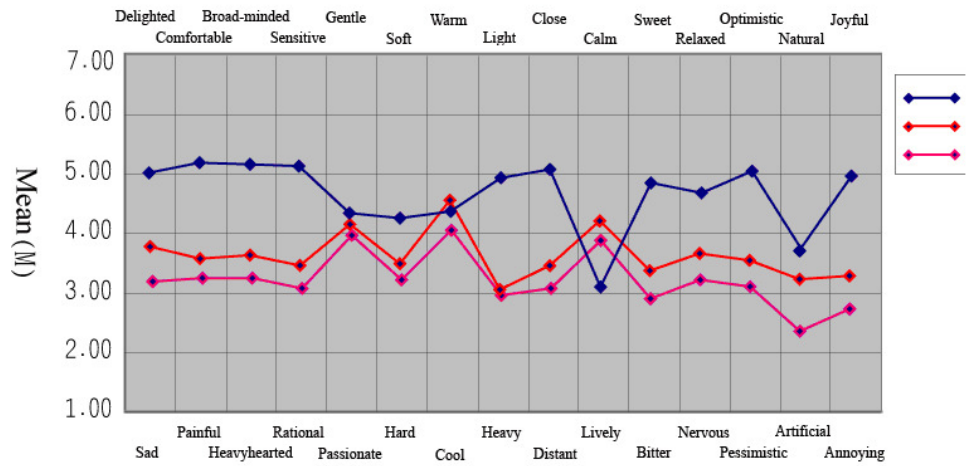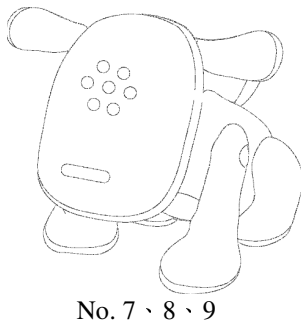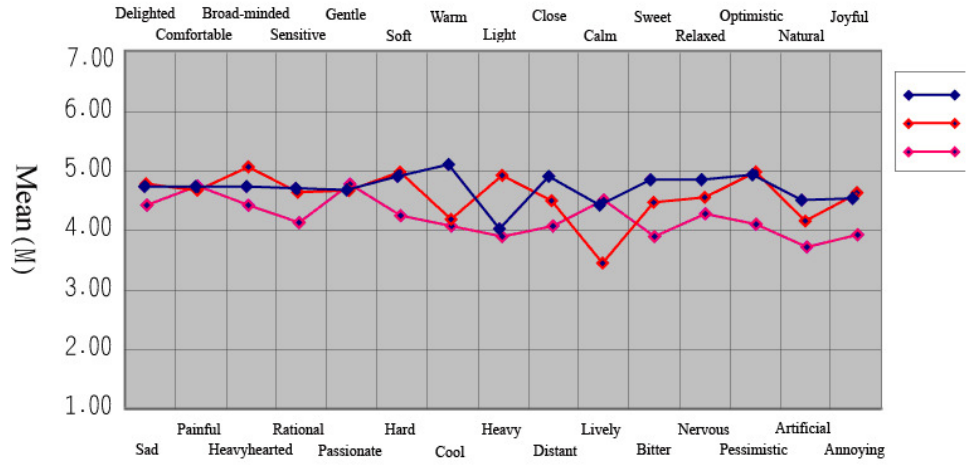
Table 8 (Continued) *SD Profiles of Person, Animal, and Plant*

No. 10、11、12
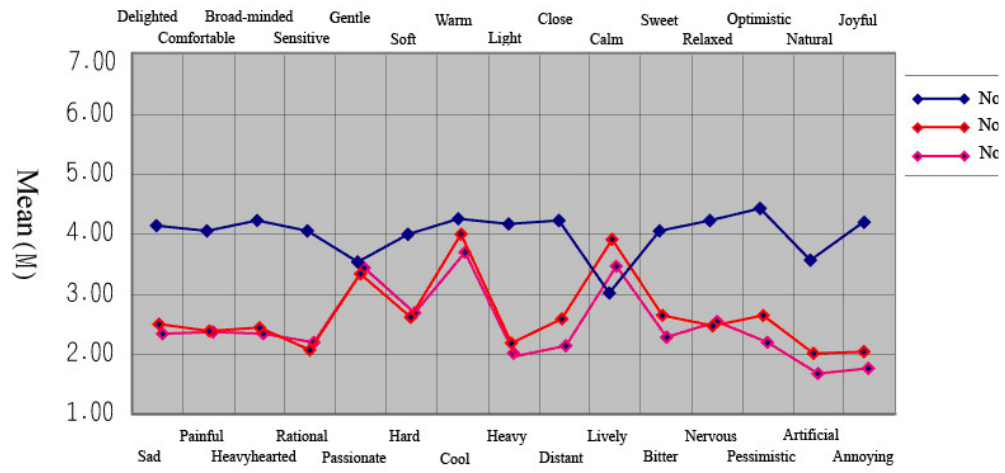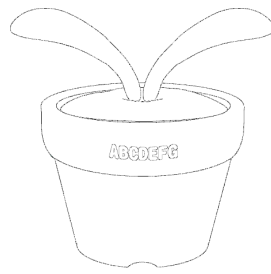
No. 13、14、15
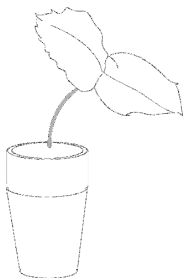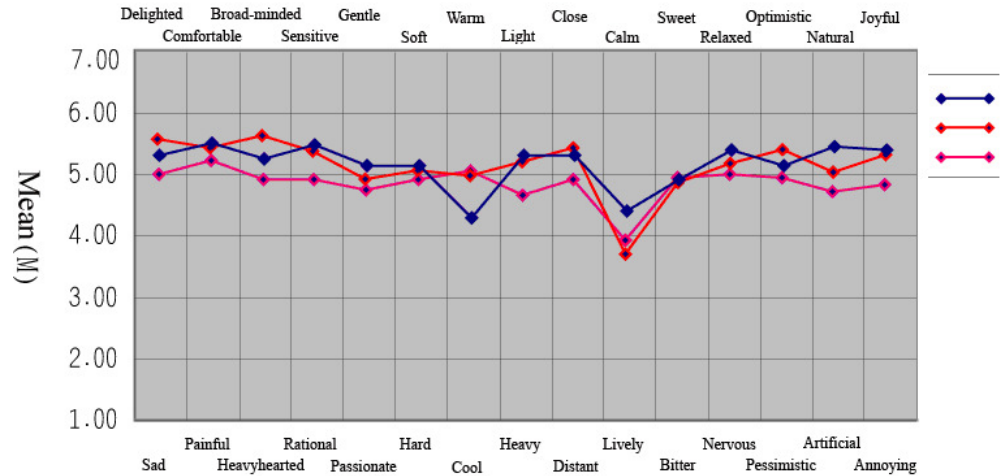
No. 16、17、18
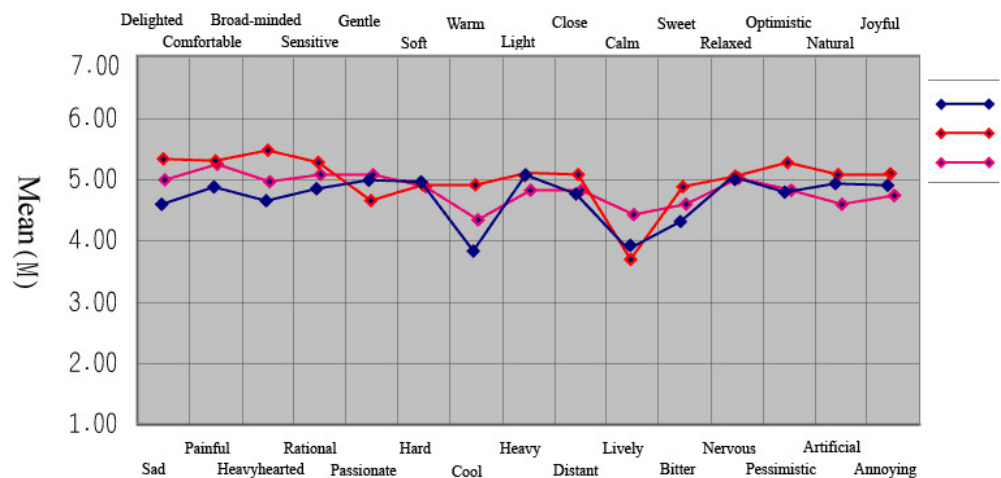
In the SD profiles of person (No. 1, 2, 3, 4, 5, and 6), it was found that the mean values of the control group's samples of the color combination of regular triangle (No. 3 and 6) were slight smaller than those of the market group (No. 1 and 5) and those of the control group's samples of the color combination of isosceles triangle (No. 2 and 4). In the SD profiles of Animal (No. 7, 8, 9, 10, 11, and 12), it was found that the mean values of the market group (No. 7 and 10) and the control group (No. 8, 9, 11, and 12) were obviously different; the two sets of the mean values

(M) of the market group were both greater than those of the control group. In the SD profiles of

plant (No. 13, 14, 15, 16, 17, and 18), it was found the mean values of the market group (No. 13

and 16) and the control group (No. 14, 15, 17, and 18) were similar.

Analyzing Each Adult Age Group's Preference for the Color Combinations of Healing Toys

The mean values of the five age groups of 18 to 23 years old, 24 to 35 years old, 36 to 45

years old, 46 to 57 years old, and over 58 years old were respectively calculated and arranged

from high to low. The top three samples preferred by each age group were indicated by the

following table:

Table 9 Preference Ranking of Each Adult Age Group

Age	18~23			24~35			36~45			46~57			Over 58		
Ranking	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
No. of Sample	No. 13	No. 14	No. 16	No. 13	No. 7	No. 14	No. 14	No. 17	No. 15	No.1 3	No. 14	No. 17	No. 6	No. 13	No. 17
Mean (M)	5.71	5.38	5.00	5.69	5.33	5.31	5.70	5.25	5.20	5.64	5.59	5.36	5.67	5.44	5.33

According to Table 9, it was found that the age group of 18 to 23 years old generally

preferred the color combinations of the market group of plant (No. 13 and 16). The age group of

24 to 35 years old generally preferred the color combinations of the market group of plant and

animal (No. 13 and 7). The age groups of 36 to 45 years old and 46 and 57 years old generally

preferred the isosceles-triangle color combination of the control group of plant (No. 14 and 17).

Analyzing the Influential Factors in the Images of Each Adult Age Group

Green and Salkind (2005) pointed out that factor analysis focused on analyzing factor selection and factor replacement. Aiming to discover the common factors in the semantic reactions of the adult age groups, factor analysis was employed in the study to obtain the factor loading of each scale and further extract the common factors. The result of extract was described as follows:

KMO (Kaiser-Meyer-Olkin) measure of sampling adequacy and Bartlett test of sphericity were used, in which the value of KMO (Kaiser-Meyer-Olkin) measure of sampling adequacy was 0.697, which was greater than 0.6, indicating that it was suitable to carry out analyses. The significance of the Bartlett test of sphericity was $0.000 < 0.05$, indicating statistical validity.

After the tests, principal component analysis, a form of factor analysis, was employed to extract the common factors. Based on the principle of selecting eigenvalues greater than 1 as the common factors, two critical factors were selected in this analysis, and these two factors could explain 80.636% of the overall variance. Furthermore, varimax was applied to the selected factors, and each factor's factor loadings greater than 0.5 were kept to make the meaning represented by each factor more obvious and explainable, the details of which were indicated by the following table 10:

Table 10 Principal Component Analysis of Semantic Factors

Factor	Semantic name	Factor loading	Eigenvalues	Variance Explained
Emotion Factor	broad-minded -heavyhearted	0.968		
	delighted-sad	0.955		
	close – distant	0.946		
	relaxed – nervous	0.936	7.170	51.215％
	optimistic-pessimistic	0.930		
	comfortable – painful	0.876		
	sensitive – rational	0.773		
	gentle -passionate	0.657		
	sweet - bitter	0.682		
Value Factor	soft –hard	0.868		
	warm – cold	0.815		
	light-heavy	0.813	4.119	29.421％
	calm- lively	0.691		
	natural -artificial	0.593		

The factor of emotion mainly consisted of 9 pairs of higher relevant variables, including 'comfortable-painful,' 'broad-minded-heavyhearted,' 'delighted-sad,' 'close-distant,' 'relaxed-nervous,' 'optimistic-pessimistic,' 'sensitive-rational,' 'gentle-passionate,' and 'sweet-bitter.' The loading of each variable was between 0.682 and 0.968, the eigenvalue was 7.170, and the variance explained was 51.215％. Since the loadings of the previous five pairs were higher, in which the semantic images tended to be emotional, these variables were classified into 'the factor of emotion.'

The factor of value mainly consisted of 5 pairs of more relevant variables, including 'soft-hard,' 'warm-cool,' 'light-heavy,' 'calm-lively,' and 'natural-artificial.' The loading of each variable was between 0.593 and 0.876, the eigenvalue was 4.119, and the variance

explained was 29.421%. Since the loadings of the previous four pairs were higher, in which the semantic images tended to be of value, these variables were categorized into 'the factor of value' in the study.

The total variance of the aforesaid factors of emotion and value was 80.636%, in which the factor of emotion accounted for 51.215% of the variance whereas the factor of value accounted for 29.421%. The variance of the factor of emotion was obviously greater than that of the factors of value, which indicated that the surveyed adults tended to be influenced by the factor of emotion more in terms of their cognition of the color combination samples of healing toys.

To observe the distribution of each semantic phrase between the factors of emotion and value, a figure for the semantic space of factors was established in the study, in which Axis X indicated the factor of emotion whereas Axis Y indicated the factor of value. The figure 6 was indicated in figure 6.

According to the distribution of the images on the coordinate system, it was discovered that the images of the factor of emotion mainly centered in Quadrant 4 while the images of the factor of value mainly distributed in Quadrant 1 and 2.

Conclusions and Recommendations

The study on Taiwanese adults' cognition of the color combinations of healing toys was

concluded into the following four points:
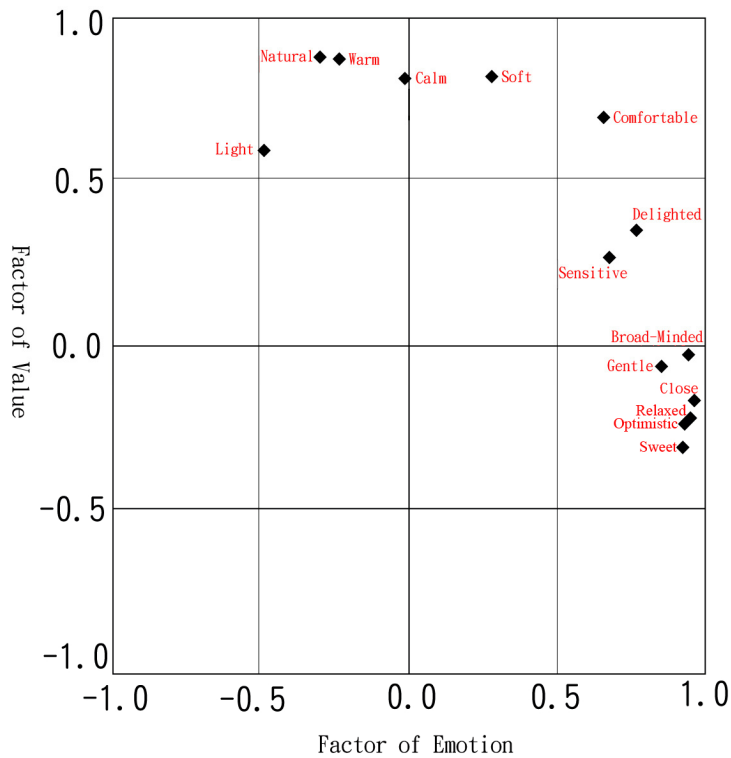
Figure 6 Spatial Cognition of the Factors of Emotion and Value

1. The color combinations of the healing toys in the market in Taiwan: In terms of the healing

    toys currently available in the market in Taiwan, the color combinations of the healing toys

    in the category of person tend to be warm, pale, and soft, those of the healing toys in the

    category of animal tend to be warm, bright, and pale, and those of the healing toys in the

    category of plant tend to be cool, bright, and pale.

2. Each adult age group's color cognition of the color combinations of healing toys: Adults

    tend to feel better about the healing toys with warm and soft color combinations in the

    categories of person and animal whereas they tend to feel better about the healing toys with

    cool color combinations in the category of plant.

3. Different adult age groups' preference for the color combinations of healing toys: There is

    not significant difference between different age groups' preference. The adults tended to

    prefer the color combination samples of isosceles triangle in the control group of plant,

    indicating that all the age groups prefer tranquil color combinations.

4. The major factors in adults' preference for the color combinations of healing toys: Adults'

    preference for the color combinations of healing toys is mainly influenced by the dimension

    of emotion.

    In conclusion, the research findings of the study on Taiwanese adults' cognition of the

color combination design of healing toys will be provided as references and concrete suggestions

for following researchers, industries, the Government, and academia.

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MODERATION OF GENDER ON THE RELATIONSHIP BETWEEN TASK CHARACTERISTICS AND PERFORMANCE

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Abstract

Gender as an individual characteristic has been used in many studies to provide some explanations of different effects on outcomes. Different effects of gender on employee's attitudes and behavior has been found in many studies. Recent study by Humphrey et al (2007) found out that successful work design innovation has positive impact on employee's behavior and attitudes such as performance, satisfaction, commitment, involvement, motivation, role perception of outcomes, anxiety and stress. However, few scholars have investigated the effects of gender on task characteristics and performance relationship. This study employed self efficacy theory to provide further insight into gender differences in this relationship. Work design proposed by Morgesson (2006) was used to explore task characteristics of job design. Structural equation modeling was used to analyze the model. The result showed that male and female employees have different effects on task characteristics and performance relationship. Implications of the findings and suggestions for future research are discussed

Keywords: Task Characteristics, Performance, Gender

Introduction

Work design becomes something of a fad among leaders and organizational consultants. The practice of job design produced popular programs such as TQM and reengineering, and human capital management (Deming, 1986; Juran et al 1988; Waldman, 1994; Hammer et al, 1993; Lepak & Snell, 1999). Job was designed to simplify employee activities at work, manage social-interpersonal daily work, and help to achieve the goal of work efficiently. Hence successful work design innovation had positive implications on employee's behavior and attitudes such as performance, satisfaction, commitment, involvement, motivation, perception of outcomes, anxiety and stress (Humphrey et al 2007).

Conceptually, employees and organization's conditions influence the design of job (Humphrey et al, 2007, MacKinnon, 2008). Human resources department sometimes change the requirement and characteristics of the job to increase organizational effectiveness and business competitiveness, and improve employee capability and competency fit so as to accelerate their performance achievement (O'Reilly et al 1991; Chatman, 1991; Edward, 1996; Judge, 1996; Saks et al, 1997). Employee's capability and competency fit on the job is related to individual characteristics such as tenure, gender, ages, job experiences, and level of education. Hence scholars have investigated employee's cohort and demographic characteristics in order to provide explanations of when and why workers have different performance at work (Frazier et

all, 2004; Judge, 2007). Gender has been used in social studies to provide explanations for different effects on outcomes. It was found to have different effects several contexts ranging from interpersonal relationships to household decision-making (Qualls, 1987, Baghat et al, 2008). For example, females were known to be more expressive than male, and this was manifested in their socio-emotional behavior which in turn had affect on their attitude and behavior at work (Meyers-Levy and Maheswaran, 1991).

Empirically, correlation between job design and job satisfaction, work motivation, performance, and absenteeism, was found in various studies. Furthermore, various jobs also had different affects on job design. Perker (1998) outline job performance based on self-efficacy. Employees who feel confident are able to carry out broader and more proactive roles, and achieve higher performance. However, Morgeson et al, (2008) found out that job characteristics and performance relationship were influenced by the moderation effects of individual differences such as urban-rural, middle-class norm, community size, religiosity, growth need strength, ability level, quality of interpersonal relationships, and effectiveness in terms of the stable tendency to experience emotions. Male and female employees were found to have an inverse working achievement on the job. For example, Haswel et al. (1991) and Bernardi (2008) indicated that females have better achievement at work, whereas O'neil et al. (2008) found that male have better working performance. Different performance of male and female was also because of

differences in the type, nature and requirements of the job (Meece, 1991; Pajares et al, 1994; Wigfield et al 1996; Eisenberget al, 1996; Wilson et al, 2009). However few scholars have investigated gender to explore the effects of job characteristics innovation on job performance.

Researchers found that male and female employees have different sensitivity, expressive behaviors, and motivational response on the job (Haswell et al., 1999; Lysonski and Gaidis, 1991; Whipple and Swords, 1992; Bernardi, 2008). This study employed self efficacy of motivation theory to provide further insight into gender differences and outcome relationships (Deci et al, 1985; Baghat et al, 2008). Hence, employee's belief of their capabilities to perform the task will influence the achievement of their job performance. Therefore, it is worthy of exploring whether the task characteristics may engage employee's gender-base to achieve higher performance. Does a difference in gender of employees influence different beliefs to achieve higher performance within certain task characteristics of jobs? Accordingly, by employing self efficacy theory, this study has therefore attempted to investigate the relationship between task characteristics and performance moderated by gender.

Task Characteristics of Work Design and Performance

Work design has emerged as a topic of central importance in the management discipline. Interest was prompted by concerns that work design produced work quality effects on employee well-being and performance (Hollman, 2009). A job can be defined as a collection of related

positions that are similar in terms of the work performed or goals served by the organization

(Brannick, Levine, & Morgeson, 2007). Work design thus refers to the content and structure of

jobs that is performed by employees (Oldham, 1996). The focus of work design research tends to

be on the tasks and activities that job incumbents perform on a day to day basis. Task

characteristics are primarily attributable to the traditional focus on job design of the work itself.

Recent research demonstrated the importance of task characteristics (Humphrey et al., 2007;

Morgeson & Humphrey, 2006).

Conceptually the task characteristics included five dimensions that make jobs more

satisfying for workers: autonomy, skill variety, task identity, task significance, and feedback

from the job (Morgeson and Humphrey, 2008). Autonomy is the freedom an individual should

have in carrying out work. Skill variety reflects the extent of which various skills are needed for

job performance. Task identity is the extent of which an individual completes an entire piece of

work. Task significance reflects the degree of which a job impacts the lives of others, both inside

and outside the organization. Feedback from the job is the extent of which a job imparts

information about an individual's performance.

Empirically, Fried and Ferris (1987) found that dimensions of task characteristics were

strongly related to job satisfaction, growth satisfaction, and internal work motivation, with

weaker relationships to job performance and absenteeism. Partially support to Fried and Ferris,

Humphrey et al (2007), found that all five motivational characteristics were positively related to job satisfaction, growth satisfaction, and internal work motivation. Autonomy was related to objective performance. In contrast, autonomy, task identity, task significance, and feedback from the job had non-zero correlations with subjective performance. However, they were all related to absenteeism, but had zero significance on skill variety and task significance.

Task characteristics were expected to have effects on employee behavior such as decreased absenteeism and increased job performance. Job performance is a commonly used, yet even the concept is poorly defined. It refers to whether a person performs their job well. Performance is an extremely important criterion that influences organizational outcomes and success. Among the most commonly accepted theories of job performance are theories from the work of John P. Campbell and colleagues (1990, 1993) who describe job performance as an individual level variable. That is, performance is something a single person does. Conceptually, task characteristics were closely related to high performance achievement. Autonomy is ability to carry out work freely. Skill variety implies performing a job with different skills. Using task identity, employees can complete a whole piece of work. Nevertheless, interaction of task significance and other characteristics are able to influence performance achievement. Feedback from the job is able to impart information about an individual's performance (Humphrey et al, 2007).

Empirically, Morgeson et al (2008) concluded that overall these five task characteristics have effect on performance. Autonomy has been linked to both objective and subjective performance ratings. Skill variety does have the expected effect on keeping workers motivated, involved and satisfied which in turn supports achievement of higher performance. Task identity can be useful information to start and finish the work and it is related to performance evaluation. Task significance is positively related to subjective performance. Nonetheless, feedback from the job is able to timely provide reliable information and direct accurate feedback from the job performed.

However, individually, a range of knowledge, skills, abilities and other characteristics (KSAOs) are needed to perform a job. Job knowledge reflects the declarative and procedural knowledge of the job and role, whereas technical skill reflects the capability to perform the work itself. Knowledge of the job and technical skills will appear to be essential if one work effectively in a job. Whereas, Self efficacy theory employed the understanding on the level of employee belief in order to achieve higher performance with their actual skill level (Gist & Mitchell, 1992). The level of employee belief found in the task experience is the most important aspect (Tesluk and Jacobs, 1998). Task experience reflects the amount of time spent performing a task and the number of times the task has been performed. Task experience confers job knowledge, and thus provides workers with the ability to effectively enact their task

responsibilities. Therefore, it is likely that having higher task experience will help workers perform successfully in jobs that have breadth or depth of knowledge, whereas technical skills are reflected in the capacity to perform the broader roles. It was implied by many of the task on work characteristics. Hence, it is directly related to the performance of work (Morgeson, Reider, & Campion, 2005). It is also supported by Burr and Cordery (2001) who provided evidence on the importance of further skills of self-management. Therefore, the theory of efficacy strengthens the evidence of task characteristics and performance relationship. Based on the aforesaid discussion, the following hypothesis is proposed:

Hypothesis 1: task characteristics related to performance positively

Gender of employee is known as one of the controlled variable in researches. Different effects of gender on employee's attitude and behavior have been found in many studies. Gender was found to have an effect on outcomes such as performance, commitment, satisfaction, involvement, and stress (Bernardi, 2008, Baghat, 2008, William, 2008, Tanriverdi, 2009; Burke, et al, 2008, Jones et al, 2009). For example, job career of female employees has been identified as pattern of their larger-life contexts, families and careers, career paths patterns, and human and social capital are critical factors for their career (O'Neil et al, 2008). Empirically, O'Neil et al (2008) indicated that females tend to be more expressive (Meyers-Levy and Maheswaran, 1991), and sensitive (Haswell et al., 1999; Lysonski and Gaidis, 1991; Whipple and Swords, 1992,

Bernardi, 2008). Accordingly, females respond to work design and thus achieve work performance differently from male (Haswel et al, 1991; Meece, 1991; Pajares et al, 1994; Wigfield et al 1996; Eisenberget al, 1996; Bernardi, 2008; O'Neil et al, 2008; Wilson et al, 2009)

Self-efficacy beliefs function as an important set of proximal determinants of human motivation, affect, and action [which] operate on action through motivational, cognitive, and affective intervening processes. Identification allows the observers to feel a one-to-one connection with the individual being imitated and will be more likely to achieve those imitations if the observers feel that they have the ability to follow through with the mimicked action. It is believed that if how some future event turns out is under their control, they may or may not believe that they are capable of behaving in a way that will produce the desired result. Research found evidence that male may have a greater believe that they control their life related to academic achievement (Schultz & Schultz, 2005). Expressiveness of female employee suggested reinforces the autonomy and strengthens the task variety of job (O'Neil, 2008). Besides, sensitivity characteristics of female precipitates precisely impart information on performance and may influence the degree of live impact (Bernardi, 2008). Accordingly, self-efficacy theory strengthened the evidence of task characteristics and performance relationship and therefore it proposed that:

Hypothesis 2: Male and female employees have different effects performance

Hypothesis 3: Male and female employee have different effects on the task characteristics and performance relationship
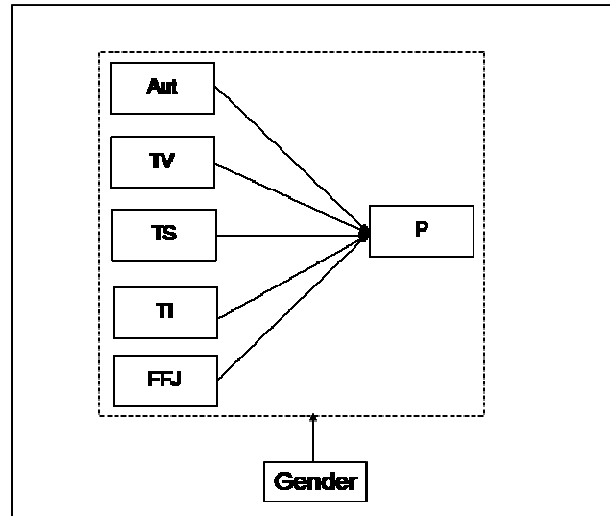
Aut=autonomy, TV=task variety, TS=task significant, TI=task identity, FFJ=feedback from job,

P=performance

Figure 1

Model Of Moderating Of Gender On Autonomy, Task Variety, Task Significant, Task Identity, Feedback From Job, And Performance Relationship

Methods

Sample

This study collected 412 responses from 750 questionnaires distributed to various businesses (55% response rate). They were approximately 35.16 years old and worked for 13.36 years, 299 (72.6%) were married, and 150 (36.4%) were men. From the participants 145 (35.2%) graduated from college, 121 (29.4%) held a graduate degree, 21 (5.1%) held a master degree and 32 (7.8%) held a doctorate degree.

Measures

Items were written by the authors or obtained from previous research. After reviewing of words, content, and so forth, 31 item sets for total items were retained for inclusion in the instrument. Responses were made on a 5-point Likert-type scale with scale anchors ranging from 1 (strongly disagree) to 5(strongly agree). Task characteristics were measured using 24 items taken from Morgeson & Humphrey's (2006) WDQ. Participants were asked i.e., "The job allows me to make my own decisions about how to schedule my work". The five task characteristics dimension included work scheduling autonomy, decision-making autonomy, work-method autonomy, task variety, task significant, task identity and feedback from job. Performance was measured using 7 items taken from William and Andersons (1991). Participants supervisor were asked i.e., "Adequately completes assigned duties".

Result and Analysis

Measurement Model Analysis

This study tested the assumptions underlying the use of structural equation modeling. Confirmatory analysis using the traditional factor loading of SPSS generated the formulation of each construct. Initial solution with KMO and Bartlett's test of sphericity, maximum likelihood extraction method, and varimax rotation was used in this CFA. The result on the Table 1 extended the Hackman (1974) study by combining the work scheduling autonomy, decision-

making autonomy, and work-method autonomy into one single dimension "autonomy".

Table 1

Rotated factors and loading for task characteristics

		Autonomy	Performance	Task Variance	Task Identity	Task Significant	Feedback from Job
Autonomy	Autonomy_1	0.520					
	Autonomy_2	0.588					
	Autonomy_3	0.616					
	DMA_1	0.658					
	DMA_2	0.679					
	DMA_3	0.672					
	WMA_1	0.642					
	WMA_2	0.661					
	WMA_3	0.642					
Task Variety	TV_1			0.610			
	TV_2			0.794			
	TV_3			0.765			
	TV_4			0.786			
Task Significant	TS_1					0.409	
	TS_2					0.423	
	TS_3					0.923	
	TS_4					0.782	
Task Identity	TI_1				0.574		
	TI_2				0.693		
	TI_3				0.807		
	TI_4				0.717		
Feedback from Job	FFJ_1						0.519
	FFJ_2						0.889
	FFJ_3						0.803
Performance	P1		0.734				
	P2		0.711				
	P3		0.726				
	P4		0.700				
	P5		0.609				
	P6						
	P7						

DMA= Decision making autonomy, WMA=work-method autonomy, TV=task variety, TS=task significant, TI=task identity, FFJ=feedback from job

A confirmatory factor analysis using AMOS 7.0 was conducted to test the measurement model. The chi-squared ($\chi^2 = 279$) was significant ($p < 0.05$; Bollen 1989). The ratio of chi-

square to degree of freedom (df.) was 1.516 for measurement model not exceed 2 (Marsh and Hovecar 1985). Goodness-of-fit of the model represented on the root mean square error of approximation (RMSEA) .039 and the standardized root mean square residual (RMR) = .028. RMSEA values was less than .06 and RMR values was less than .08 therefore, indicating a good fit of the model to the data (Hu & Bentler, 1999, Browne & Cudeck, 1992; Steiger, 1990). The goodness-of-fit index (GFI) = .926, the adjustment goodness-of-fit index (AGFI) = .900, the comparative fit index (CFI) =.970, Non-normed Fit Index (NFI) = .927, and the Tucker–Lewis index (TLI) =.963. According to Marcoulides and schumacker's (1996) standard of fitting, the result of CFA indicated a satisfactory fit for the measurement model. Second order analysis confirmed the single factor of task characteristics was with the following model of fit GFI=.920, AGFI=.891, RMR=.044 CFI= .953, TLI = .942, IFI= .953, RFI=.902, NFI=920, and RMSEA= .0457 (Kline, 2004; Byrne, 2006).

Confirmatory factor analysis (CFA) is adopted to test for the quality and adequacy of the measurement model (Anderson and garbing, 1988). Therefore, this study investigates reliability, convergent validity, and discriminant validity. Evidence for the unidimensionality of each construct included appropriate items that loaded at least 0.524 on their respective hypothesized component and loaded larger than .30 on other components in a factor of analysis. In addition, the overall goodness of fit supported unidimensionality (Steenkamp and van Trijp 1991).

Convergent validity was supported by all loadings being significant (p < 0.01) and all SMC (square of multiple correlation) exceeding 0.275 (Hildebrandt 1987). This study assessed reliability jointly for all items of a construct by computing the composite reliability and average variance extracted (Steenkamp and van Trijp 1991). Cronbach's α is the most widely used criteria to measure the reliability of the items for each construct (Cronbach's, 1991). The Cronbach's α of constructs are shown in table 2. Cronbach's α of perception of Autonomy = .867 (eight six items), Task Variety = .866 (four items), Task Significant= .798 (three items), Task Identity = .878 (four items), Feedback from Job = .817 (three items), and performance= =.830 (five items) are all greater than 0.7. Hence internal consistency of each measurement construct has been achieved.

Table 2

Correlations and Cronbach α

	1	2	3	4	5	6	7	8
1. Gender	-							
2. Autonomy	.018	**0.867**						
3. Task variety	.045	.420**	**0.866**					
4. Task significant	.040	.428**	.332**	**0.798**				
5. Task identity	.029	.394**	.380**	.479**	**0.878**			
6. Feedback from Job	-.037	.240**	.236**	.318**	.494**	**0.817**		
7. Task Characteristics	.029	.698**	.694**	.741**	.756**	.634**	**0.736**	
8. Performance	.152**	.183**	.144**	.192**	.216**	.252**	.277**	**0.830**

** Correlation is significant at the 0.01 level (2-tailed).

Cronbach α value are shown in parentheses

Convergent validity is determined by the reliability of each construct and the average variance extracted (AVE) of each construct. Anderson and Gerbing (1988) suggested that convergent validity can be assessed from the measurement model by determining whether each indicator's estimated pattern coefficient on its posited underlying construct factor is significant or not. Table 3 revealed that each item's factor loading is more than 0.5 and their loading range is between 0.55 and 0.99, which are in line with Anderson and Gerbing's (1988) suggestion. Variance extracted is not only the average percentage of variation explained among the items, but also a summary measure of convergence among a set of items representing a latent construct. Variance extracted is computed as the total of all squared standardized factor loadings divided by the number of items. In other words, it is the average squared factor loading. Fornell and Larcker (1981) suggested that variance extracted of 0.5 or greater than squared multiple correlations is good. Table 4 shows AVE exceeding correlations in all squared multiple correlations. Therefore the indicator variables of this study have a good convergent validity. Discriminant validity describes the degree to which the operationalization is not similar to (diverges from) other operationalizations that it theoretically should not be similar to. Campbell and Fiske (1959) introduced the concept of discriminant validity in their discussion on evaluation of validity test. They stressed the importance of using both discriminant and convergent validation techniques when assessing new tests. A successful evaluation of Table 3

Table 3

Convergent Validity and Reliability

			t-value	SMC	C.R.	AVE
Autonomy	Autonomy_2	0.568		0.323	**0.867**	**0.459**
	Autonomy_3	0.669	12.630	0.448		
	DMA_1	0.657	10.460	0.432		
	DMA_2	0.713	9.206	0.508		
	DMA_3	0.721	9.201	0.520		
	WMA_1	0.693	9.605	0.480		
	WMA_2	0.681	9.315	0.464		
	WMA_3	0.705	8.780	0.497		
Task Variety	TV_1	0.658		0.433	**0.866**	**0.621**
	TV_2	0.828	14.244	0.686		
	TV_3	0.837	14.248	0.701		
	TV_4	0.815	13.885	0.664		
Task Significant	TS_2	0.524		0.275	**0.798**	**0.646**
	TS_3	0.898	10.114	0.806		
	TS_4	0.926	10.210	0.857		
Task Identity	TI_1	0.692		0.479	**0.878**	**0.635**
	TI_2	0.725	16.693	0.526		
	TI_3	0.890	16.521	0.792		
	TI_4	0.862	15.948	0.743		
Feedback from Job	FFJ_1	0.602		0.362	**0.817**	**0.631**
	FFJ_2	0.933	12.325	0.870		
	FFJ_3	0.812	12.729	0.659		
Performance	ip1	0.744		0.554	**0.830**	**0.493**
	ip2	0.716	13.424	0.513		
	ip3	0.716	13.252	0.513		
	ip4	0.718	12.996	0.516		
	ip5	0.608	11.333	0.370		

DMA= Decision making autonomy, WMA=work-method autonomy, TV=task variety, TS=task significant, TI=task identity, FFJ=feedback from job

discriminant validity shows that a test of a concept is not highly correlated with other tests designed to measure theoretically different concepts. In showing that two scales do not correlate, it is necessary to correct for attenuation in the correlation due to measurement error. It is possible to calculate the extent of which the two scales overlap by using the following formula where r_{xy} is correlation between x and y, r_{xx} is the reliability of x, and r_{yy} is the reliability of y:

$$\frac{r_{xy}}{\sqrt{r_{xx} \cdot r_{yy}}}$$

Although there is no standard value for discriminant validity, a result less than .85 tells us that discriminant validity likely exists between the two scales. A result greater than .85, however, tells us that the two constructs overlap greatly and they are likely measuring the same thing. Therefore, the results shown in table 4, demonstrated adequate unidimensionality, convergent validity, reliability, and discriminant validity.

Table 4

Average Variance Extracted, square correlation, and

Discriminate Validity

		1	2	3	4	5	6
1.	Autonomy	**0.459**	0.176	0.183	0.155	0.058	0.033
2.	Task variety	0.485	**0.621**	0.110	0.144	0.056	0.021
3.	Task significant	0.515	0.399	**0.646**	0.229	0.101	0.037
4.	Task identity	0.452	0.436	0.572	**0.635**	0.244	0.047
5.	Feedback from Job	0.285	0.281	0.394	0.583	**0.631**	0.064
6.	Performance	0.216	0.170	0.236	0.253	0.306	**0.493**

AVE value are shown in parentheses

Discriminate validity are shown on the left side AVE value

HypothesisTtesting

Table 2 shows that task characteristics are positively related to performance. Gender was also found to be positively related to performance, implying that 262 female employees (mean=4.04) achieved higher performance (t value = -107.427, p<.001) than 150 male counterparts (mean=3.884). Thus hypothesis 1 and 2 were supported.

Hierarchical moderated regression analysis was conducted to test the mediating effect of employee gender. Table 5 shows the result of the estimations of the main effect and the moderating effect of gender. The result indicates that moderating effect of gender is significant for dimension of autonomy, task identity, task significant, feedback from job and construct of task characteristics. Although female employees achieved higher performance, the moderation of gender shows that effect of task characteristics and its dimensions on performance were higher for male employees than female employees.

Table 5

Testing result of main effect and moderating effect of gender

	Performance						
	M1	M2	M3	M4	M5	M6	M7
Main effect							
Autonomy	.053	.334**					
Task variety	.032		.194*				
Task significant	.073			.323**			
Task identity	.061				.377**		
Feedback from Job	.179**					.454**	
Task Characteristics							.509**
Moderator							
Gender		.146**	.145**	.142**	.144**	.165**	.140**
Interaction effect							
Autonomy x gender		-.210*					
Task variety x gender			-.071				
Task significant x gender				-.177*			
Task identity x gender					-.198*		
Feedback from Job x gender						-.235**	
Task Characteristics x gender							-.291**
R^2	.085	.059	.044	.070	.080	.106	.119
ΔR^2	.085	.012	.002	.011	.012	.017	.025
ΔF	7.559	5.326	.772	5.400	5.268	7.735	11.788
p	.000	.022	.380	.021	.022	.006	.001

M1=main effect model; M2= Model of moderation effect of Autonomy; M3= Model of moderation effect of Task Variety; M4=Model of moderation effect of Task Significant; M5= Model of moderation effect of Task identity; M6= Model of moderation effect of Feedback from job; M7= Model of moderation effect of Task characteristics

Moderation effect of gender analyzed using structural equation modeling shown in table 6 was also found equal. To test hypothesis-3, this study built separate structural models for the male and female sub-samples, and conducted tests of moderation to determine whether the respective path coefficients differed. Table 6 summarizes the analyses and results. The procedure that this study used was as follows for each test: this study constructed two multiple-sample models. In the first model, all paths were unconstrained between the two groups. This is the "no constraints" or baseline model in Table 6. In the second model, this study constrained the relevant path to be equal for both sub-samples. This is the "equal paths" model. The difference in chi-square values between the two models provides a test for the equality of the path for the two groups. Similarly, the path is stronger for the male than for female. Gender moderate task characteristics and its dimensions are related to performance. Thus, hypothesis-3 is supported for moderating variables.

Figure 1 provides graphical representation of moderating effects of gender. The graphs show that when the construct of task characteristics is high, male employees demonstrate higher performance, than female employees. Whereas on high and low level of autonomy, task significant, task identity, and feedback from job, female employees demonstrate higher performance than male employees. Male consistently shows higher sloop (γ) of all task

characteristics and performance relationship.

Table 6

SEM Moderation effect of Gender on Task Characteristics and Performance relationship

Path	Gender	
	Male	**Female**
Baseline (unconstrained) model: χ^2 (61) = 243.719		
Constrained model: χ^2 (122) = 304.227		
Autonomy → Performance	γ = .204	γ = .113
	t = -2.711, p =.001	
RMR=.045, GFI= . 888, AGFI= .833, NFI=.864, RFI=.825, IFI=.908, TLI=.881, CFI=. 907, RMSEA=.066		
Baseline (unconstrained) model: χ^2 (26) = 29.746		
Constrained model: χ^2 (52) = 55.028		
Task Variety → Performance	γ = .204	γ = .141
	t =-.768 , p =.17	
RMR=.016, GFI= .984, AGFI= .973, NFI=.980, RFI=.973, IFI=.997, TLI=.997, CFI= . 997, RMSEA=.019		
Baseline (unconstrained) model: χ^2 (19) = 35.911		
Constrained model: χ^2 (38) = 55.543		
Task significant → Performance	γ = .340.	γ = .018
	t = -3.020, p =.001	
RMR=.022, GFI=. 979, AGFI= .960, NFI=.973, RFI=.960, IFI=.987, TLI=.981, CFI .987, RMSEA=.047		
Baseline (unconstrained) model: χ^2 (26) = 103.054		
Constrained model: χ^2 (52) = 126.996		
Task Identity → Performance	γ =.363	γ = .153
	t = -.2.455, p =.024	
RMR=.017, GFI= .950, AGFI=.913, NFI=.939, RFI=.916, IFI=.954, TLI=.936, CFI=954, RMSEA=.085		
Baseline (unconstrained) model: χ^2 (19) = 54.667		
Constrained model: χ^2 (38) = 82.723		
Feedback from job → Performance	γ = .375	Γ = .204
	t = -1.996 , p =.043	
RMR=.030, GFI= .969, AGFI= .942, NFI=.957, RFI=.937, IFI=.972, TLI=.958, CFI=.972, RMSEA=.068		
Baseline (unconstrained) model: χ^2 (34) = 74.037		
Constrained model: χ^2 (68) = 113.038		
Task characteristics → Performance	γ = .549	Γ = .217
	t = -2.852, p =.004	
RMR=.024, GFI= .949, AGFI= .917, NFI=.905, RFI=.874, IFI=.960, TLI=.946, CFI .959, RMSEA=.040		
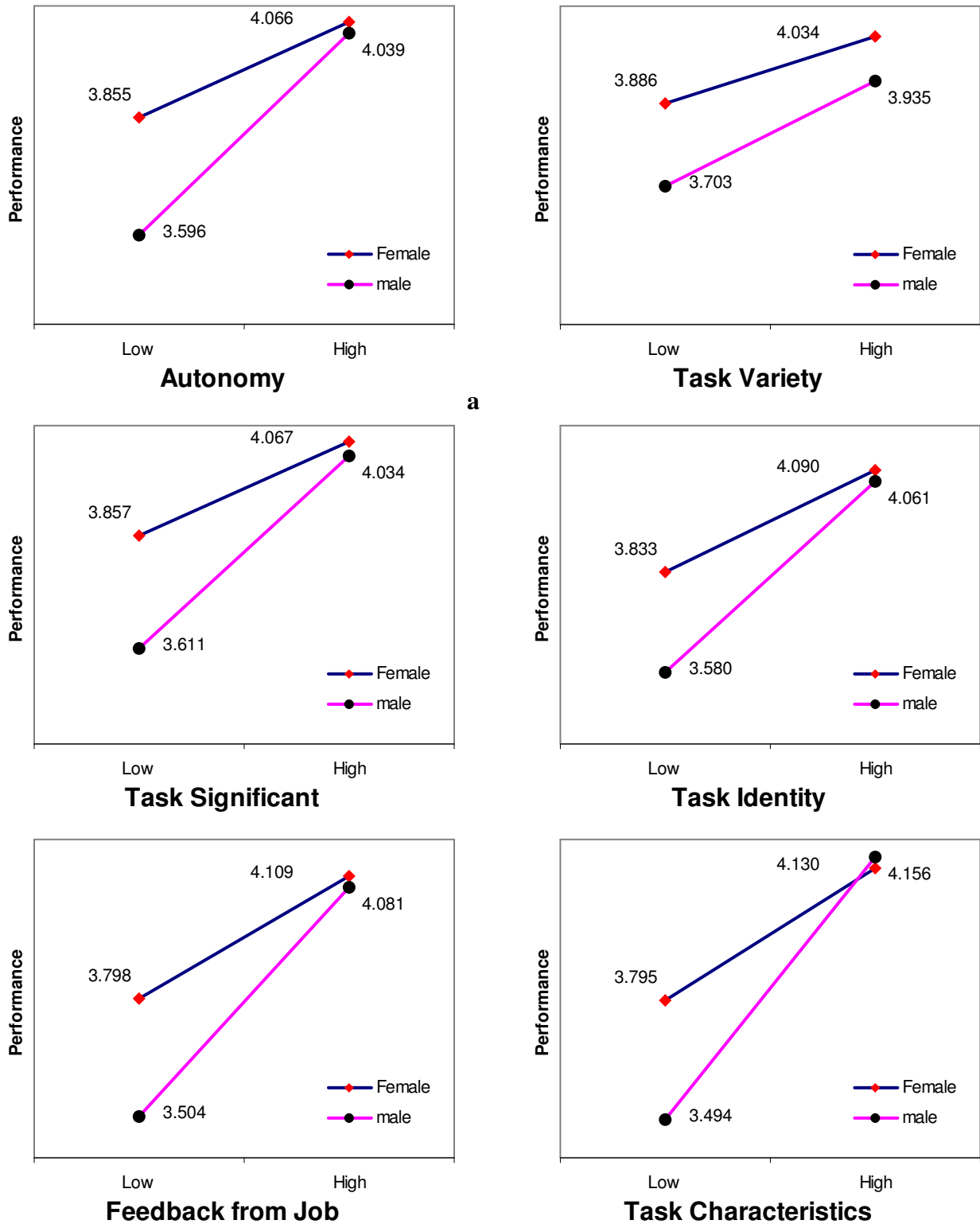
Figure 2

Moderating of gender on task characteristics, autonomy, task variety, task significant, task identity, feedback from job, and performance relationship

Conclusion

Discussion

This study employed self-efficacy theory to investigate the different effects of task characteristics on the performance achieved by gender. Although female employees were found to achieve higher performance than male employees, the results of this study revealed that male employees have higher effect of task characteristics on performance. Therefore male employees indicated to be more confident than female employees. This result is consistent with the findings by Meece (1991), Pajares et al (1994) and a study by Wigfield et al (1996).

Acceptance of the hypotheses provided some notes. It explains that gender has a significant individual attachment effects on performance. Female employees were found to be more likely to accept higher job performance. Expressiveness of female employees (O'Neil et al, 2008) might influence the support of work achievement. However Haswell et al., (1999) and Bernardi (2008) indicated that female employees' sensitivities might inhibit their effort to achieve higher outputs. Therefore, that explains why the effect of task characteristics on performance was higher for male than female employees. This applies to all dimensions of task characteristics.

Expressiveness and sensitivities of gender are important in developing jobs. Zin (2006) indicated that the responsibility for children affect job commitment among female employees. In situations where both family and work roles are equally salient, however, the difficulty of

balancing role obligations may precipitate work-family conflict. These conflicts are predicted in the form of stress, hence affect weakened performance. Therefore, the findings of this study indicate that managers must pay attention to this when designing the tasks for male and female.

Limitation and Future Research Direction

Notwithstanding these contributions, this study also has several limitations. Specific task and level of performance should be determined. Different task might influence the confidence of both male and female employees to achieve high performance. Hence exploring the task and achievement in the academic field might be different from entrepreneurial field (Meece, 1991; Pajares et al, 1994; Wigfield et al 1996; Eisenberg et al, 1996; Wilson et al, 2009).

Although these findings lend strong support to self-efficacy theory, future researchers may, however, want to attempt to develop this work further, incorporating other related psychological theories such as expectancy theory. The use of different theories may enrich the accumulation of related knowledge and further understanding of empirical practices. Another possible direction for further development is to investigate the impact of task characteristics on commitment, work satisfaction and other possible outcomes.

Based on Tesluk and Jacob (1998) suggestion, further investigation on the joint moderating effects of gender and tenure is imperative. Even though, the findings supported one of various job design characteristics, it is still open for further inquiries. Different characteristics of job

design affect performance differently. It is also possible to investigate gender effects on other forms of performance. This study used role performance to represent the performance explored. Extra role performance such as organizational citizenship behavior (OCB) may enrich further understanding of total performance related to task characteristics of job design. Experimental or quasi-experimental research designs are needed to help in ruling out potential alternative explanations for these results (Morgeson, 2006). The sampling data collected was inadequate to improve on the group level analysis (HLM). Other studies can also investigate the effects of individual assessments on the job, since team assessment has become a fad.

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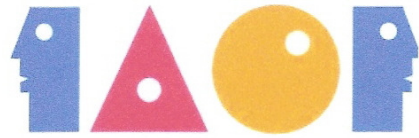
An Empirical Study on the Impact of Differences in Bed and Breakfast Service Quality Attributes on Customers' Revisiting Desires

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Abstract

In recent years, Bed and Breakfast (B&B) operations have quickly grown popular, and, in particular, growth in the Tsing-Ching area of Taiwan has been the fastest and most concentrated. Previous studies have shown that tourists' satisfaction from a visit is significantly and positively related to their desire for revisiting that B&B. But, it seems that from the tourists' satisfaction level we cannot differentiate revisiting incentives deployed by B&B operators with varying characteristics. This paper presents an empirical study, based on questionnaires, on the impact of differing levels of B&B service quality on customers' desires to revisit. The Kano table is first applied to define each quality element, and then through one-way ANOVA analysis the service quality elements perceived by customers with the most significant difference are isolated. Logistic regression is applied to the customers' desire to revisit each B&B to uncover the preferences they hold for specific quality elements that contribute to their decisions to revisit, even among B&Bs that provide similar service elements. This provides an explanation for why customers choose and continue to return to specific B&B businesses over others within highly competitive areas in popular tourist destinations.

Keywords**:** B&B, service quality attributes, SERVQUAL, logistic regression

Introduction

In years past, Taiwan's scenic areas during the holidays were often overfilled with tourists and hotel accommodations were woefully insufficient. Gradually, local residents began to provide their surplus rooms to address the deficiency, and this was the beginning of the Bed and Breakfasts (B&Bs). Naturally, B&Bs were mostly simple and basic, and they did not provide true competition to the resort hotels.

In recent years, however, more and more money has been invested in B&Bs, and the government has introduced legislation for better B&B industry management. B&Bs have sprung up all over Tsing-Ching areas of Taiwan due to demand and profitable business opportunities. In an effort to develop mountainous regions and recreational agriculture, government policies have encouraged the development of B&Bs to expand beyond providing basic accommodation and dining. B&Bs now combine the advantageous resources of local culture, ecology, and scenery to transform themselves into leisure facilities with unique styles and attractions. Tourists now expect better quality of service and satisfaction from the environment and local features in these leisure facilities.

Baker and Crompton (2000) alleged that tourists' satisfaction towards the accommodations depended on a whole, aggregated feeling of comfort, derived from a judgment and analysis process after receiving the services of a B&B. Yet, customer satisfaction with the accommodations cannot be the only indicator when rating competitiveness among B&B operators in Tsing-Ching areas with high B&B density. Previously, promotional activities often emphasized the winning of new customers but neglected the fact that winning new customers was five times more costly than retaining an existing one (Heskett, Sasser and Hart, 1989), making repeat business significant in the overall profitability of an enterprise. Thus, this study

focuses on the specific elements of service quality that contributes to customer loyalty and return patronage.

Morrison *et al.* (1996) believed that tourists chose B&Bs for the personalized interactions with their operators. Zane (1997) polled 1,400 American B&B customers and found that personalized service, comfort of the bed, the homeliness feel, privacy, cleanliness, and a B&B owner's advice on things like tourist attractions and restaurants were the most important factors in their choice of a B&B. Norman (1988) discovered that individualized interactions and "unique touches" were the biggest reasons for B&B patronage. Hence, we believe that there exist specific service quality attributes which attract customers, and that the satisfaction from these service quality attributes affects the customers' revisiting desires. This study assumed that, in Tsing-Ching areas, B&Bs, each with their own style of management, provides different levels of service quality, and that customers, in recognizing these differences, will develop a ranked preference when choosing B&B establishments. Based on this, this study sought to uncover the service quality attributes among sample B&Bs and, at the same time, using Kano's two-dimensional quality model, define the characteristics of service quality attributes and compare differences among customers' cognition of those attributes. Finally, the study aimed to identify the impact of differing service quality attributes on, and their relationship to, customers' motivations for revisiting.

Literature Review

PZB Service Quality Measurement Table

Gronroos (1982) pointed out that on certain levels "service" can be seen as a process that needs the participation of the customer in both its creation and consumption. When customers

compare their anticipated and received levels of service, the result can be called the "perceived service quality". Parasuraman *et al.* (1985) pointed out that, to consumers, service quality is harder to evaluate than product quality, thus a customer's cognition of service quality is the result of comparing the expected and actual service received, and that evaluation also includes the process by which the service was delivered. Parasuraman *et al.*, in research published in 1985, came up with 10 common service quality elements, and in follow-up research further grouped the 10 elements into 5 major categories: Tangibility, Reliability, Responsiveness, Assurance, and Empathy. Along with 22 topics and using the Likert scale as a measurement basis, this is the now well-known SERVQUAL measurement table (Parasuraman *et al.*, 1988, 1991, 1991a). To this day, the SERVQUAL measurement table is used by many different service sectors.

2.2   The Kano two-dimensional quality elements model

Kano's (1984) approach to quality evaluation was different than others, and he believed that the sufficient presence of quality elements did not necessarily bring about customer satisfaction and sometimes even caused dissatisfaction or indifference. Kano also believed that quality elements were dynamic and shifted with time. In 1984, Kano and others applied Herzberg's Two-Factor Hygiene and Motivation Theory to classify quality elements and came up with the following five types:

1. Attractive quality element: when this element is present in sufficient amounts, customers will feel satisfied; but when lacking, customers will accept its levels as "matter of fact".

2. One-dimensional quality element: presence of this element brings about customer satisfaction; lack of this element causes dissatisfaction. This element is similar to the motivational factor in Herzberg's Two-Factor Hygiene and Motivation Theory.

3. Must-be quality element: presence of this element is acceptable to the customer but does not make the customer satisfied; lack of this element causes dissatisfaction. This element is similar to the hygiene factor in Herzberg's Two-Factor Hygiene and Motivation Theory.

4. Indifferent quality element: this element's existence or lack thereof does not affect a customer's satisfaction level.

5. Reverse quality element: presence of this element will cause customer dissatisfaction, and the lack of it will cause customer satisfaction.

From this we see that the Kano two-dimensional model primarily focuses on a customer's satisfaction and feelings toward quality elements, and that the evaluation of quality is based on a customer's subjective perception, making this model suitable for application to the service industry (Yang, 1993). To management, Kano's model provides a precise and easy-to-understand method of gleaming insight into a customer's true feelings towards the product or service and an understanding of the quality elements from the customer's perspective, both of which can be applied to a company's product development and improvement processes in order to get one step closer to the customer's ideal product. In applying it to operational and sales strategies, a company can maintain growth and competitiveness by consistently examining strategy results and feedback on a regular basis. Thus this study used the Kano quality model to explore B&Bs' service quality elements, and attempted to uncover the elements among B&Bs with different characteristics that significantly increased a customer's desire to revisit.

Research Method and Questionnaire Design

Questionnaire Design

Typically, research involving service quality consists of one common characteristic, and that is, due to the fact that "service" is considered intangible and variable and the "construction"

and "consumption" of service usually happens simultaneously, the process of evaluating service quality is unique from evaluation of tangible products. Obviously, it is difficult to identify the specific quality elements from a traditional SERVQUAL measurement table that affect a consumer's decision to re-consume. Because of this, this study used a different approach on certain parts when designing the measurement table. This study's questionnaire was divided into three sections; the first being Kano's two-dimensional quality measurement table, the second being a single question asking the customer whether they plan to revisit, and the third being questions related to population statistics and variables.

The design of the questionnaire was divided into two steps. First, a pre-test questionnaire consisting of 36 questions was produced after review of related literature and referencing the SERVQUAL measurement table and B&B facilities and service data. It used the Likert 5-point interval scale to measure the answer to each question: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. Before formally distributing the questionnaire examining service quality elements and B&B customer revisiting desires, this study analyzed the results from the pre-test. The pre-test target audience was Tsing-Ching area B&B customers. We sent out 150 questionnaires, and received back 134, making the effective return rate 89.3%. After validity and reliability analysis, we deleted 11 questions which did not meet our requirements, leaving 25 questions. The KMO value was 0.801 for this pre-test questionnaire, which achieved an explainable standard. The Chi-square value of the Bartlett's Sphericity test was 958.913, with a degree of freedom of 300, making the sampling of this exercise suitable for applying factor analysis. We used principle component analysis to extract the common factor. Then, we applied Kaiser's method to choose the factors with eigenvalues great than 1. For the purpose of simple structure, we used Varimax for orthogonal rotations. Finally, we created five constructs out of

the service quality elements, as follows: hardware (facilities), software (service), environment, management, and emotion. Then, per Kano's model each of the 25 pre-test questions was assigned as positive or negative (based on sufficiency or lack of the quality element), and this Kano two-dimensional quality classification questionnaire was presented to the subjects.

Research Sample Range and Research Period

This paper's primary focus is on tourists who patronize B&Bs during their visits to Tsing-Ching areas. Because there are no distinct tourist lists to reference in advance, we conducted sampling from B&B tourists who visited Tsing-Ching areas during our research period. Within the registered B&B list published by the Ministry of Transportation Tourism Bureau, we selected six large, legally registered B&Bs with unique characteristics as our research subject. Questionnaires were deployed to collect B&B customer data, and convenient cluster sampling was the sampling method. Questionnaires were placed at check-in counters of selected B&Bs and delivered to customers when they checked-in, and returned to us when they checked-out. As a generally survey, and the data we get via questionnaire is discrete data. The size of the sample can be estimated by the following formula:

$$n = \frac{Z_{\alpha/2}^2 \times p \times (1-p)}{e^2} \qquad (1)$$

n = sample size
e = estimated error
Zα = Z value for which right-tailed area is α/2
1- α = reliability coefficient
p = probability of an attribute displaying difference

Although the actual p value is unknown, we know that when p=1/2, sample size will be the largest, so this was used as the baseline. For a confidence interval of 95%, and an estimated error of 5%, we should collect around 300 questionnaires for analysis. For a total of six B&Bs in the

Tsing-Ching area, we had to deliver 50 questionnaires to each location. But to avoid collection problems and ineffective questionnaires reducing our usable sample size, we opted to distribute 75 questionnaires to each B&B instead, making the total number of questionnaires sent 450. This study chose to conduct the sampling from January 1, 2008 through February 28, 2008, which is peak travel time for the Tsing-Ching areas due to the Chinese New Year holiday. 302 copies of the questionnaire were returned, for a return rate of 67.1%. Seven questionnaires deemed ineffective were eliminated, leaving 295 as an effective sample size (n=295), with a Cronbach's α value of 0.859. This high level of reliability meant that we had a highly consistent questionnaire. Even though the number of questionnaires returned did not meet the expected number of 300, the effect was negligible on our overall results.

Within the 295 effective samples, male subjects totaled 141 (47.8%) and female subjects totaled 154 (52.2%), making females a slightly higher majority among B&B patrons. Within subject age groups, 21 to 30 year-olds dominated with 149 in total for a percentage of 50.5; next, 31 to 40 year-olds came in at 92 people (31.2%); 61 year-old and above were the lowest in number at 2 (0.7%). From this, we can see that younger customers dominate among those who choose B&B-type lodging. The number of subjects who stayed at B&Bs on average of 1-3 times a year ranked the highest at 166 (56.3%), the next being those who averaged 4-6 times a year with 75 (25.4%). As a result, this study's sample can be seen as primarily represented by younger patrons, which included students and young families.

Data Analysis and Method

4.1   Categorization of Kano Quality Elements

In processing the data, the Kano model was used to categorize the questions by relative majority, and the B&B-supplied quality element attributes were defined. This study categorized

the 25 service quality element attributes from the questions into four main quality element attribute types. The four types are: the Must-be quality element, the Attractive quality element, the One-dimensional quality element, and the Indifferent quality element. Each question's corresponding attribute is shown as follows in Table 1.

Table 1.   Categorization of B&B quality elements into Kano's quality element attributes

Construct	Item	Kano's attributes
Hardware (facilities)	B&B is equipped with SPA facilities.	Attractive quality
	B&B provides high quality entertainment equipment.	Attractive quality
	B&B provides computers and internet access.	Attractive quality
	B&B supplies private spaces for the customers.	One-dimensional quality
	B&B is equipped with hot springs.	Attractive quality
Software (service)	B&B provides shuttle buses for customers.	Attractive quality
	B&B has alliances which can supply discounts for extra services to customers.	Attractive quality
	B&B provides lunch or dinner.	Attractive quality
	B&B provides ordering service for local souvenirs and produce.	Indifferent quality
	B&B provides activities that combines local culture, ecology and environment.	Attractive quality
	B&B provides breakfast.	Must-be quality
Environment	B&B has natural scenery and nice views.	Attractive quality
	B&B's location is near scenic spots.	One-dimensional quality
	B&B's building design is incorporated into the surrounding environment.	Attractive quality
	B&B's buildings have a theme.	Attractive quality
Management	Customers can make reservations via the internet.	Attractive quality
	Expenditures can be paid by credit card.	Indifferent quality
	An informative web site is available on the B&B.	One-dimensional quality
	B&B has been interviewed and is highly recommended by the public media.	Attractive quality
	B&B is a legally registered enterprise.	Must-be quality
	B&B's prices are affordable.	One-dimensional quality
Emotion	B&B staff is good at anticipating the customers' needs and shows concern for customers.	Must-be quality
	B&B provides speedy service.	Must-be quality
	B&B has special activities correlating to holidays.	Indifferent quality
	B&B feels just like home.	Attractive quality

Regarding Must-be qualities: In this study, four out of the 25 B&B service quality element questions were categorized as a Must-be quality. They were: (a) B&B provides breakfast, (b) B&B is a legally registered enterprise, (c) B&B provides speedy service, and (d) B&B staff is good at anticipating the customers' needs and shows concern for customers. For most customers, these quality elements are essential, and customers take it for granted when fulfilled. But, when these elements are lacking, customers will immediately notice and become dissatisfied.

Regarding Attractive qualities: Fourteen out of the 25 B&B service quality element questions were categorized as an Attractive quality. They are:

(a) B&B is equipped with SPA facilities.

(b) B&B provides high quality entertainment equipment.

(c) B&B provides computers and internet access.

(d) B&B is equipped with hot springs.

(e) B&B provides shuttle buses for customers.

(f) B&B has alliances which can supply discounts for extra services to customers.

(g) B&B provides lunch or dinner.

(h) B&B provides activities that combine local culture, ecology and environment.

(i) B&B has natural scenery and nice views.

(j) B&B's building design is incorporated into the environment.

(k) B&B's buildings have a theme.

(l) B&B allows reservations from the internet.

(m) B&B has been interviewed and is highly recommended by the public media.

(o) B&B feels just like home.

For most customers, these quality elements are extra efforts to attract customers. When they are fulfilled, customers are satisfied but generally will not take it for granted. Therefore, it will not result in dissatisfaction when they are lacking, but when they are present, the customers' satisfaction will increase.

Regarding One-dimensional qualities: There were four quality elements categorized as a One-dimensional quality out of the 25 B&B service quality element questions. They are: (a) B&B supplies private spaces for the customers, (b) B&B's location is near scenic spots, (c) An

informative web site is available on the B&B, and (d) B&B's prices are affordable. These quality elements are important for the majority of consumers, because when they are fulfilled, satisfaction increases, but when not fulfilled, dissatisfaction will consequently increase.

Regarding Indifferent qualities: There were three quality elements categorized as an Indifferent quality out of the 25 B&B service quality element questions. They are: (a) B&B provides ordering service for local souvenirs and produce, (b) B&B has special activities correlating to holidays, and (c) Expenditures can be paid by credit card. For most customers, they are neutral towards the existence of these quality elements, and their presence or absence has little influence on customers' feelings of satisfaction or dissatisfaction.

Regarding Reverse qualities: There were no Reverse quality elements within the 25 B&B quality element questions of this study. Thus no elements within the questionnaire had the effect of dissatisfaction with its fulfillment.

ANOVA Analysis

Upon completing the categorization of the quality elements, one-way ANOVA analysis was applied to the quality elements of the six B&Bs per the positive question responses within the questionnaire and the previously identified four categories of quality element attributes. Table 2 below displays the results.

After the analysis, the two Must-be quality elements which displayed significant difference were "B&B is a legally registered enterprise", and "B&B provides speedy service". Separately, among Attractive quality elements, five questions displayed significant difference ("B&B is equipped with SPA facilities", "B&B provides shuttle buses for customers", "B&B has alliances which can supply discounts for extra services to customers", "B&B's building design is incorporated into the surrounding environment", "B&B has been interviewed and is highly

Table 2.　Result of ANOVA analysis on quality elements from six selected bed & breakfasts

	Sum of squares	Mean square	F	p-Value
Must-be quality				
B&B provides breakfast	2.563	.513	1.5	0.172
B&B is a legally registered enterprise	5.700	1.140	2.939	0.038*
B&B staff is good at anticipating the customers' needs and shows concern for customers	1.939	.388	1.121	0.349
B&B provides speedy service	6.611	1.322	2.635	0.24*
Attractive quality				
B&B is equipped with SPA facilities	7.206	1.441	1.377	0.233
B&B provides high quality entertainment equipment	4.003	0.801	1.247	0.287
B&B provides computers and internet access	3.603	0.721	0.701	0.623
B&B is equipped with hot springs	13.397	2.679	2.685	0.022*
B&B provides shuttle buses for customers	18.884	3.777	3.599	0.004*
B&B has alliances which can supply discounts for extra services to customers	17.098	3.420	2.567	0.027*
B&B has natural scenery and nice views	4.356	0.871	2.060	0.071
B&B's building design is incorporated into the surrounding environment	6.450	1.290	2.336	0.052
B&B's buildings have a theme	3.602	0.720	1.922	0.091
Customers can make reservations via the internet	8.014	1.603	1.558	0.172
B&B has been interviewed and is highly recommended by the public media	14.192	2.838	2.375	0.039*
B&B feels just like home	5.617	1.123	2.281	0.017*
One-dimensional quality				
B&B supplies private spaces for the customers	12.908	2.582	3.968	0.002*
B&B's location is near scenic spots	0.638	0.128	0.413	0.840
An informative web site is available on the B&B	32.354	6.471	5.298	0.000*
B&B's prices are affordable	6.606	1.321	2.711	0.021*
Indifferent quality				
B&B provides ordering service for local souvenirs and produce	2.732	0.546	0.447	0.815
Expenditures can be paid by credit card	3.282	0.656	0.861	0.508
B&B has special activities correlating to holidays	1.005	0.201	0.266	0.931

Note: * = $P<.05$

recommended by the public media", and "B&B feels just like home"). For One-dimensional quality elements, "B&B supplies private spaces for the customers", "An informative web site is available on the B&B", and "B&B's prices are affordable" were the three displaying significant difference. In total, through one-way ANOVA analysis, it is found that ten quality elements within the customer's recognition display significant difference due to a B&B's distinct characteristics.

Logistic Regression Analysis

Lastly, we applied logistic regression analysis to the ten quality elements with significant difference identified above through one-way ANOVA and the question of the customers' willingness to revisit. Logistic regression is most suitable for dichotomous dependent variable

analysis, in cases where the data consists only of two statuses, such as "success" or "fail".

Logistic regression analysis resembles traditional regression except that it transforms discrete

data into a continuous value between 0 and 1 first, before applying the analysis. The main

purpose of logistic regression analysis is to find the relation between categorical-type response

variables and a series of explanatory variables. This study first assumed willingness to revisit as

1, and unwillingness to revisit as 0, then analyzed the quality elements identified above as having

significant difference. Results are shown in Table 3 below.

These results from Table 3 show that, for the customers of B&B 1, the two Must-be

qualities of "B&B is a legally registered enterprise" and "B&B provides speedy service" and the

two One-dimensional qualities of "An informative web site is available on the B&B" and

"B&B's prices are affordable" are significantly linked to their willingness to revisit. In other

words, for the customers of B&B 1, these four quality elements are the main factors in their

decision to revisit the facility. It is worth mentioning that, for the customers of B&B 1, the

element of "affordable prices" displays a strong positive correlation of $\beta=2.830$. We believe that

this might be due to B&B 1's operator providing the other three quality elements in such a way

Table 3   Result of logistic regression analysis on quality elements with significant difference
and willingness to revisit for each B&B

	Quality element	B&B 1 (n=51)	B&B 2 (n=55)	B&B 3 (n=48)	B&B 4 (n=46)	B&B 5 (n=49)	B&B 6 (n=46)
B&B is a legally registered enterprise	MQ	0.027* (2.386)	0.313	0.023* (1.532)	0.291	0.167	0.022* (5.351)
The B&B provides speedy service	MQ	0.028* (2.034)	0.487	0.278	0.991	0.778	0.092
B&B is equipped with hot springs	AQ	0.093	0.797	0.058	0.040* (2.190)	0.659	0.209
B&B provides shuttle buses for customers	AQ	0.229	0.902	0.534	0.022* (2.529)	0.520	0.911
B&B has alliances which can supply discounts for extra services to customers	AQ	0.724	0.032* (1.534)	0.209	0.184	0.943	0.979
B&B has been interviewed and is highly recommended by the public	AQ	0.599	0.349	0.050* (0.902)	0.722	0.021* (2.384)	0.746

media							
B&B feels just like home	AQ	0.530	0.763	0.451	0.489	0.617	0.812
B&B supplies private spaces for the customers	OQ	0.292	0.686	0.184	0.400	0.889	0.027* (1.534)
An informative web site is available on the B&B	OQ	0.029* (1.734)	0564	0.045* (1.381)	0.367	0.455	0.286
B&B's prices are affordable	OQ	0.017* (2.830)	0.346	0.235	0.301	0.707	0.016* (1.534)

Note: * = $P<.05$
MQ = Must-be Quality
AQ = Attractive Quality
OQ = One-dimensional Quality
( ) = β Value

that made their customers feel the price they paid was well worth the cost. Things like expeditious service and detailed, convenient guides to the facility perhaps added value to the package and hence became a main reason for revisiting.

The customers of B&B 2 appeared to have a strong preference for the special deals and packages that the B&B's alliances with other businesses provided for its guests. This was the most attractive for customers out of all the quality elements and consequently provided this operator with an advantage in this highly competitive market. For the customers of B&B 3, the fact that the "B&B is a legally registered enterprise", the "B&B has been interviewed and is highly recommended by the public media", and "An informative web site is available on the B&B" was the most attractive to them. This demonstrated that, while, in general, travelers often regard advertising or media coverage of a product with suspicion because they have an awareness of prices in an open and fair market (Chan and Wong, 2005), when travelers actually experience the product and the service level matched or exceeded the media's coverage, the media's effects change into an important and influential quality element for them. The customers of B&B 5 seemed to display reactions similar to those from the customers of B&B 3.

As for the customers of B&B 4, the two quality elements of "B&B is equipped with hot springs", and the "B&B provides shuttle buses for customers" were most emphasized. B&B 4 advertised itself as being a bed & breakfast equipped with a natural hot spring, which is

considered a unique selling point among a B&B's facilities. In absorbing the transportation costs of providing a shuttle service to increase accessibility, this B&B also increased its customers' willingness to revisit (β=2.830). The customers of B&B 6 found that the "B&B is a legally registered enterprise", the "B&B supplies private spaces for the customers", and the "B&B's prices are affordable" were the most important quality elements to them. This outcome is very similar to that of B&B 1's and shows that B&B 6's customers also believed that the operator provided services and accommodations well worth the money they had paid and hence are willing to return.

Conclusion and Suggestions for Future Research

Past service quality research which examined tourists' recognition of service quality considered the customer's overall satisfaction level with the services and compared the customers' anticipation with actual services received (Parasuraman *et al.*, 1985). From the research results above, we see that travelers differentiate between and acknowledge different service providers supplying distinct styles, features, and service delivery capabilities via their bed and breakfast businesses, and that these service features do influence the customers' willingness to return for repeat business. This study employed the Kano two-dimensional model and targeted various service quality elements from select B&Bs for categorization. After examining these quality elements, we discovered that cognition of and preference for different service quality elements will change with variations in the facilities' service characteristics. At the same time, the results also show that even with the highest B&B density in Taiwan's Tsing-Ching areas, B&B businesses are able to differentiate themselves enough with unique service elements to facilitate the development of preferences among its customers, thereby ensuring repeat business and the ability to survive among intense competition. It is important to note,

though, that the five quality elements from this Kano model will change and evolve with the passing of time; an Attractive quality element may change into a One-dimensional quality element, and a One-dimensional quality element may change into a Must-be quality element. This study applied a combination of the Kano two-dimensional quality model and the SERVQUAL service quality measurement table to the results of a sample taken within a defined period. B&B businesses should not assume they can take the key quality elements identified out of the five quality attributes outlined in this study and increase competitiveness based on them and be free from worry. Attention needs to be paid to changes in a quality element's attribute, so that a high level of competitiveness can be maintained by keeping a constant pulse on the suitability of the service elements being offered.

Additionally, this study's main goal was to explore how different quality elements affected the customers' willingness to return, and did not take it one step further to examine, on a micro-level, how each quality element is perceived by customers with disparate backgrounds. Thus, it is suggested that further research can target one or many bed and breakfasts and expand the sample size, to make comparisons between quality elements and tourist population variables. Also, due to this study's limited human resources, the investigative scope only included B&Bs in Taiwan's Tsing-Ching areas, and there is the worry that the possibility of homogenous sampling is higher, so future research involving a larger scope (possibly including all of Taiwan's tourist attraction areas with high B&B density) and a longer timeline is called for.

Lastly, we suggest that future researchers can adopt a Resource-Based View (RBV) (Barney, 1991) to extract the highly valuable or irreplaceable quality elements from individual B&B's existing enterprise resources. One can also attempt to apply the Quality Function

Deployment process in designing a superior package of service quality elements after arriving at

a thorough understanding of the traveler's needs via focus group interviews.

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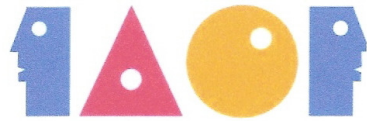
USING DATA MINING TO SOLVE FLOW SHOP SCHEDULING PROBLEMS

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Abstract

This paper presents a novel use of data mining algorithms for the extraction of knowledge from a large set of flow shop schedules. The purpose of this work is to apply rough set methodologies to explore the patterns in data generated by the simulated annealing algorithm performing in a scheduling operation. These patterns are then used to develop a rule set. In using the simulated annealing for flow shop scheduling problems, the solutions are represented by operational sequences for job allocation. Among these optimal or near optimal solutions, similar relationships may exist between the characteristics of operations and the order of jobs' sequence. Rough set methodology is then used to explore the relationship between the attributes of resources and the operation sequence. A set of rules are then developed and these rules can duplicate the performance of simulated annealing on a similar problem. It is believed that these rules can provide the solutions which are superior to a simple dispatching rule in a similar problem.

Keywords: Rough Set; Data Mining; Flow Shop Scheduling; Simulated Snnealing

Introduction

Scheduling is an important process widely used in manufacturing, production,

management, and computer science. It mainly concerns allocating resources to tasks over time

under necessary constraints. A good scheduling can increase effective utilization for resources

and reduce the otiose waste. A general flow shop scheduling problem is a production problem

which can be defined as a set of n jobs which has to be processed with the identical flow pattern

on m machines. Since the sequence of job processing on all machines is the same, the flow shop

sequencing production environment is also known as the permutation flow shop. No job passing

is permitted and the number of possible schedules for n jobs is up to $n!$. Usually, the schedule

performance measure is related to an efficient resource utilization which will minimize the

makespan. Therefore, the makespan, that is, the total time to complete all jobs, is the major

performance measure in this research.

The scheduling problem discussed in this paper is generally based on the following

assumptions: (i) the operation processing times on the machines are known and fixed. Some of

them may be zero if some job is not processed on a machine. (ii) Set-up times are included in the

processing times and they are independent of the job sequence. (iii) Each job is processed by one

and only one machine at any time and each machine processes one job only. (iv) The job

operations on the machines can not be preempted.

Significant research efforts have been devoted to sequencing jobs in a flow shop with the objective of minimizing the makespan. However, since this scheduling problem is NP-hard (Garey, M. R. et al, 1976), the search for an optimal solution is more theoretical than practical importance. Since the 1960s, a number of heuristic methods that provide near optimal or good solutions with limited computation efforts have been proposed for schedule sequencing (Nagano M.S. et al, 2002),. This paper collects the near optimal solutions to form database and extracts "knowledge" from this database. Feature extraction is important to help humans learn gain necessary knowledge about a specific part of a real or abstract world and further use the knowledge to make sound decisions (Zhai Lian-Yin, et al, 2002).

Simulated annealing (SA) can often provide fast solutions to the traditional numeric problems, especially for the manufacturing flow shop problems. Nevertheless, SA does not demonstrate repeatability or provide an explanation of how a solution is developed. This paper presents a methodology for inducting rules from the solutions of an SA that can describe its behavior. These rules have also been applied to other similar job shop cases with success.

Basic Concept

This paper develops a methodology to find rules extracting from the database which consists of optimal solutions generated by the SA algorithm. Those extracted rules can be dispatching rules for shop problems. The following subsections will review the concept of SA

algorithm and rough set, respectively.

Simulated Annealing

Kirkpatrick initially presented the simulated annealing algorithm, attempts to solve hard combinatorial optimization problems through controlled randomization (Kirkpatrick S., et al, 1983). It is motivated by an analogy to the thermodynamics of annealing in solids, such as growing silicon in the form of highly ordered and defect-free crystals.

Simulated annealing is a generic name for a class of optimization heuristics that perform a stochastic neighborhood search of the solution space. At each iteration stage, the new solution searched from the neighborhood of the current solution is accepted as the solution is better. If it is a worse solution, it still can be accepted with a probability that decreases as the temperature is reduced. This temperature, which is simply a positive number, is periodically reduced by a temperature scheme, so that it moves gradually from a relatively high value to near zero as the method progresses (Low C., 2005).

The most important characteristic of this algorithm is the possibility of accepting the worse solutions, which can allow it to escape from a local minimum. Besides this probability, an annealing algorithm also includes the following four components (Tang O. 2004):

(i) *Configuration*: A description of possible problem solutions among which the researchers search for an optimal one. Very often, the decision variables are multidimensional, discrete and having upper and lower bounds.

(ii) *Cost function*: An objective function to measure how well the system performs when a certain configuration is given.

(iii) *Move set*: A generator of random changes in the configuration. It is a set of allowable moves that will reach all feasible configurations.

(iv) *Cooling schedule*: A definition of the cooling speed to anneal the problem from a random solution to a good, frozen one. In details, it must provide a starting temperature, together with the rules to determine when and how much the temperature should be reduced and when the annealing should be terminated.

Rough Set

The theory of rough set was developed in the 1980s by (Pawlak Z., 1982, 1984, 1991) and (Pawlak Z. *et al*. 1995). Among others, it deals with the problem of indiscernibility between objects in a set. Rough set theory is useful when "the classes into which the objects are to be classified are imprecise, but can nevertheless be approximated with precise (crisp) sets" (Nurmi H., et al, 1996) .

Although rough set theory is related, in some respects, to other mathematical tools

developed to deal with vagueness and uncertainty, it is a somewhat different approach. "One of

the main advantages of rough set theory is that it does not need any preliminary or additional

information about the data, such as probability distributions in statistics, basic probability

assignment in the Dempster-Shafer theory, or grade of membership, or the value of possibility in

fuzzy set theory" (Pawlak Z., 1991)   .

Objects characterized by the same properly selected information (referred to as attributes

or features) are indiscernible in view of the available information. Data of the objects, i.e.

attribute values, is often presented in an information table or decision table (Polkowski S.L.,

1998). The information table with its rows and columns is corresponding to objects and

attributes. The rules can identify data patterns hidden in an information table. The procedure of

capturing decision rules from a set of raw data is known as rule induction (Pawlak Z., 1991).

Kusiak (2000) compiled the reduct generation algorithm (Pawlak Z., 1991) as follows:

Step 0. Initialize object number i=1.

Step 1. Select object i and find a set of reducts with one feature only. If found, go to Step 3;

otherwise go to Step 2.

Step 2. For object i, find a reduct with m-1 features, where m is the number of input features.

This step is accomplished by deleting one feature at a time.

Step 3. Set i=i+1. If all objects have been considered, stop; otherwise go to step 1.

This algorithm can be applied to categorical data as well as numerical data (Kusiak A., 2000). If the attribute values are large or differences of the attribute values between different output categories are significant, the numerical data can be transformed into discrete form based on predefined continuous intervals.

Since the scheduling problem is the major concern in this paper, several attributes may be generated from the scheduling problem. Therefore, the reduct generation algorithm is suitable to be directly applied to the scheduling problem and extract knowledge rules.

The Feature Extraction Framework System

The framework of feature system is shown in Fig. 1. The primary function of the system is to extract rules. The system comprises three main modules: a pre-processor, a rough set analyzer, and a rule pruner. A stepwise description is given as follows.

Step 1: Pre-processor

The raw knowledge or data gleaned from near optimal or good solutions is stored and subsequently forwarded to the system for feature extraction. The pre-processor module performs three tasks: accessing input data, collecting SA near optimal solutions, and designing useful attributions.

The purpose of this system is to extract good rule from the database; therefore, the data set generated from pre-processor must be correct. This research uses simulated annealing
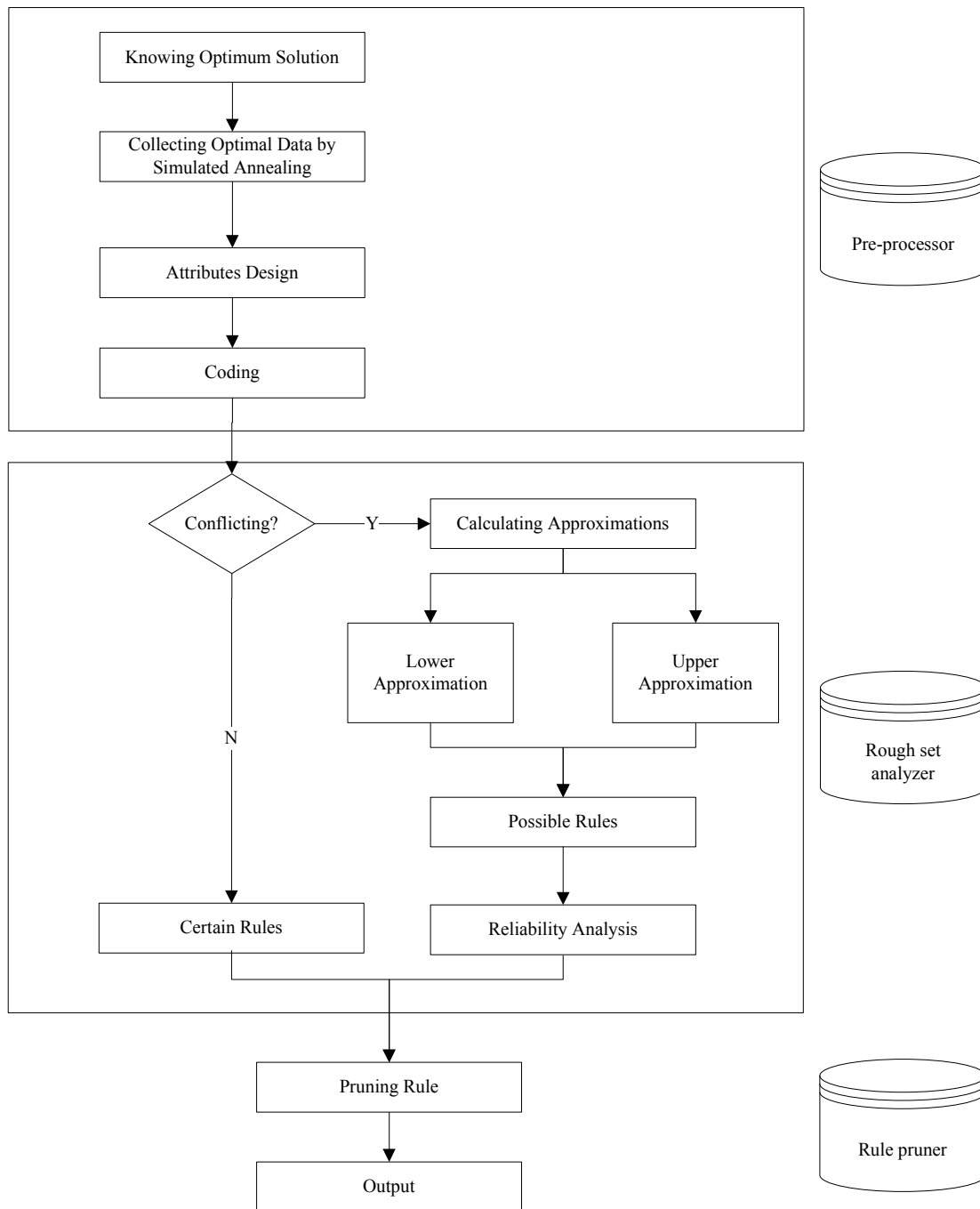
Figure 1. The Feature Extraction Framework System

algorithm to collect near optimal solutions under many different conditions. These solutions form

a data mining's database. It obtains adaptable rules of this database through the following step.

The design of attributes is important because the better design of attributes is, the more useful

rules can get. The design of attributes is divided into the needed layer series which will transfer

the coding to SA input data.

Step 2: Rough set analyzer

The rough set analyzer carries out three sub-tasks, namely consistency check, concept

forming, and approximation. It scans the data obtained from the pre-processor module and

checks its consistency. Once an inconsistency is spotted, it will activate the approximation

operator to carry out the analysis using rough set theory. The approximation operator employs

the lower and upper approximators to calculate the lower and upper approximations. During this

step, the training data set is split into the certain training data set and the possible training data

set based on consistency check and approximation.

Take a simple example to explain the lower and upper approximations to extract certain

and possible rule. As indicated in Table 1, the information table with its rows and columns is

corresponding to objects and attributes. Table 1 shows a typical information system used for

rough set analysis. The set of $Obj^{(i)}$ ($i = 1,2,\ldots 10$) represents objects of the set U to be classified.

The set of a_j ($j = 1,2$) denotes the condition attributes. In addition, d represents the decision

attribute.

More specific definitions are shown as follows:

U is the universe which contains a finite set of all training examples (objects).

$U = \{Obj^1, Obj^2, Obj^3, Obj^4, Obj^5, Obj^6, Obj^7, Obj^8, Obj^9, Obj^{10}\}$

A is the set of all attributes describing the examples.

$A = \{a_1, a_2\}$

B is an arbitrary subset of A.

$B = \{a_1\}, \{a_2\}, \{a_1, a_2\}$

D is the set of classes to be determined.

$D = \{d\}$

V_{a_j} is the value domain of an attribute a_j.

$V_{a_j} = \{V_{a_1}, V_{a_2}, V_d\} = \{\{0, 1\}, \{0, 1, 2\}, \{0, 1\}\}$

When two objects $Obj^{(i)}$ and $Obj^{(k)}$ have the same value of attribute A_j (i.e., $V_{a_j}^{(i)} = V_{a_j}^{(k)}$),

$Obj^{(i)}$ and $Obj^{(k)}$ are said to have an indiscernibility relation (or equivalent relation) on attribute a_j.

Similarly, if $Obj^{(i)}$ and $Obj^{(k)}$ have the same values for each attribute in subset B of A, then $Obj^{(i)}$

and $Obj^{(k)}$ are said to have an indiscenibility relation on attribute set B. Table 1 shows that $Obj^{(4)}$,

$Obj^{(5)}$, and $Obj^{(7)}$ are indiscernible by condition attributes a_1 and a_2. Furthermore, they possess

different decision attributes. This implies that there exists a conflict (or inconsistency) between

objects $Obj^{(4)}$, $Obj^{(5)}$, and $Obj^{(7)}$.

Table 1. A Typical Information System For Rough Set Analysis

Objects U	Attributes a_1	Attributes a_2	Decision d
$Obj^{(1)}$	1	0	0
$Obj^{(2)}$	1	1	1
$Obj^{(3)}$	1	2	1
$Obj^{(4)}$	0	1	0
$Obj^{(5)}$	0	1	0
$Obj^{(6)}$	0	2	1
$Obj^{(7)}$	0	1	1
$Obj^{(8)}$	0	2	1
$Obj^{(9)}$	1	0	0
$Obj^{(10)}$	1	1	1

Rough set theory offers a means to deal with inconsistency in information system. Let X be an arbitrary subset of the universe U, and B an arbitrary subset of attribute set A. For a concept X, the greatest definable set contained in the concept is known as the lower approximation of $B_*(X)$. $B_*(X)$ represents the set of objects(x) on U which can be *certain* classified in the set of attributes, B. $B_*(X)$ is represented in equation (1).

$$B_*(X) = \left\{ x \middle| x \in U, B(x) \subseteq X \right\} \qquad (1)$$

On the other hand, the least definable set containing concept X is called the upper approximation of $B^*(X)$. $B^*(X)$ represents the set of objects(x) on U which can be *possible* classified in the set of attributes, B. $B^*(X)$ is represented in equation (2).

$$B^*(X) = \{ x | x \in U, \textit{and } B(x) \cap X \neq \phi \} \qquad (2)$$

Elements are belonging to only the upper approximation that composes the boundary region (BR$_B$) or the doubtful area. Mathematically, a boundary region can be expressed as equation (3).

$$BR_B(X) = B^*(X) - B_*(X).$$ (3)

Rough set theory offers a powerful means to deal with inconsistency in an information system.

The lower approximation $(B_*(X))$ can confirm certain rules and the boundary region $(BR_B(X))$ can

confirm possible rules. For example, in Table 1, universe U consists of ten objects and can be

described using two decision namely $V_d = 0$ and $V_d = 1$. The conflict, object $Obj^{(4)}$, $Obj^{(5)}$, and

$Obj^{(7)}$, exists in the data set. The conflict causes the objects to be indiscernible and constitutes

doubtful areas by $BR_B(V_d=0)$ or $BR_B(V_d=1)$, respectively, as shown in Fig. 2. The lower

approximation of decision $V_d=0$ is given by Set $\{ Obj^{(1)}, Obj^{(9)}\}$, which forms the certain training

data set of decision $V_d= 0$. On the other hand, the upper approximation is represented by object

Set $\{ Obj^{(1)}, Obj^{(4)}, Obj^{(5)}, Obj^{(7)}, Obj^{(9)}\}$, which contains the possible training data set of decision
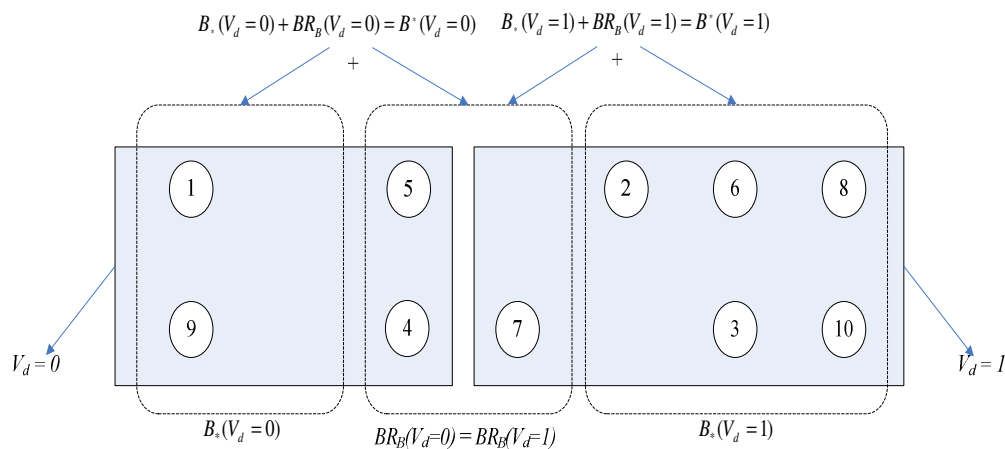

Figure 2. Basic Concepts Of Rough Set Theory

Table 2. Rules Generated From The Example

Decision $V_d = 0$	*Certain rule* When $\underline{a_2=0}$, then *d=0*. When $a_1=1$ and $\underline{a_2=0}$, then *d=0*.
Decision $V_d = 1$	*Certain rule* When $a_1 = 0$ and $\underline{a_2 = 2}$, then *d = 1*. When $a_1 = 1$ and $a_2 = 1$, then *d = 1*. When $\underline{a_2 = 2}$, then *d = 1*.
Conflicting	*Possible rule* When $a_1 = 0$ and $a_2 = 1$, then *d = 0 or 1*.

$V_d=0$. Decision $V_d=1$ can be similarly interpreted. The certain and possible rules are acquired

through the lower approximations and the boundary region, respectively, as shown in Table 2.

Step 3: Prune rule

The pruning rule performs two tasks: pruning (or simplifying) and rule evaluation. It

examines all the certain and possible rules. During the pruning operation, the redundant rules are

removed. In addition, the related rules are clustered and generalized during simplification.

Possible rules are not definitely true. Therefore, the misclassification of possible rules must be

further assessed.

Let two sets *X* and *Y* be the two subsets of the universe set $U(X,Y \subset U)$ and *X* is totally

included in $Y(X \subset Y)$. The misclassification of possible rules is defined as equation (4).

$$\mu(X,Y)=1-\frac{card(X \cap Y)}{card(X)} \tag{4}$$

The threshold value is called β. If the misclassification of possible rules is less than β, the

possible rule could be accepted.

By using the data set in Table 1 and temporary rules in Table 2 as examples, let $X=\{$

$Obj^{(4)}$, $Obj^{(5)}$, $Obj^{(7)}$ } and threshold $\beta=0.4$. When $a_1 = 0$ and $a_2 = 1$, then $V_d = 0$; the

misclassification of possible rules can be calculated as follows.

$$\mu(a_{1=1}a_{2=0}(x), X) = 1 - \frac{card(\{Obj^{(4)}, Obj^{(5)}, Obj^{(7)}\} \cap \{Obj^{(4)}, Obj^{(5)}\})}{card(\{Obj^{(4)}, Obj^{(5)}, Obj^{(7)}\})} = 1 - \frac{2}{3} = \frac{1}{3} = 0.33 \leq 0.4$$

The possible rule is assessed when $a_1 = 0$ and $a_2 = 1$, then $V_d = 0$. But the

misclassification of possible rule that when $a_1 = 0$ and $a_2 = 1$, then $V_d = 1$ is equal 0.66. That is

more than β, so the possible rule is not assessed.

Through pruning rule and calculating the misclassification of possible rules, the results

including certain rules and possible rules are indicated in Table 3.

Table 3. Result Of Pruned And Calculated Rules

Decision $V_d = 0$	*Certain rule* When $a_2=0$, then $d=0$.
Decision $V_d = 1$	*Certain rule* When $a_1 = 1$ and $a_2 = 1$, then $d = 1$. When $a_2 = 2$, then $d = 1$.
Conflicting	*Possible rule* When $a_1 = 0$ and $a_2 = 1$, then $d = 0$.

Once all the rules are extracted from the data set, the significant features with respect to

the target object can be examined.

Example Of Flow Shop Problem

To demonstrate its effectiveness, the developed methodology in this research is applied to

a flow shop problem. According to feature extraction framework system, it uses Mosheiov

(2003) research to be the dataset of knowing optimum solution. Mosheiov uses branch and

bound process to solve flow shop problems. The objective function of these problems is the

minimum of makespan. The problem size contains totally 6 kinds of combinations that are *20*

jobs×5 machines, 20 jobs×10 machines, 20 jobs×20 machines, 50 jobs×5 machines, 50 jobs×10

machines, and *50 jobs×20 machines*. Every combination has 5 different process times. Since the

research paper provides the minimum of makespan only, it is necessary for us to generate the

jobs' sequence by using SA algorithm. These results are then used to find its attribution for good

solution quality in the same problem size. Design parameters of SA algorithm are indicated as

follows: starting temperature 200, cooling temperature $\alpha(T)$=0.9897, and ending temperature

0.0001. Table 4 shows the best solutions of makespan generated by SA and Mosheiov, G.'s

research.

Attributions

The efficient Johnson's algorithm (1954) obtains an optimal solution for the flow

shop problem with unlimited jobs performed by two or three machines. Therefore, the

attributions are identified according to the concept of Johnson's rule. Typically, the size

of flow shop problem is *n job* and *m machine*. T_{ij} is the process time of *job i* in *machine j*.

Table 4. The Results From Simulated Annealing

Problem size (job×machine_no.)	Mosheiov (2003)	SA	Problem size (job×machine_no.)	Mosheiov (2003).	SA
20×5_1	1278	1278*	50×5_1	2724	2729
20×5_2	1359	1360	50×5_2	2836	2838
20×5_3	1081	1081*	50×5_3	2621	2622
20×5_4	1293	1297	50×5_4	2751	2753
20×5_5	1235	1235*	50×5_5	2863	2864
20×10_1	1582	1587	50×10_1	3037	3046
20×10_2	1659	1664	50×10_2	2911	2911
20×10_3	1496	1508	50×10_3	2871	2871
20×10_4	1377	1390	50×10_4	3067	3071
20×10_5	1419	1423	50×10_5	3011	3021
20×20_1	2297	2310	50×20_1	3886	3943
20×20_2	2099	2120	50×20_2	3733	3820
20×20_3	2326	2341	50×20_3	3673	3752
20×20_4	2223	2248	50×20_4	3755	3814
20×20_5	2291	2318	50×20_5	3648	3719

* : The underline indicates that GA generates the optimal solution.

The design of attributions is explained as follows:

(1) $U_i = \sum_{j=1}^{m} T_{ij}$ represents total process time for each job through all machines. The maximum

and minimum of U_i are indicated as equation (5) and (6), respectively.

$$U_i\_\max = U_i / \max\left[\sum_{j=1}^{m} T_{1j}, \cdots, \sum_{j=1}^{m} T_{nj}\right] = U_i / \max[U_1, \cdots, U_n] \text{ for } \forall i \qquad (5)$$

$$U_i\_\min = (U_i - \min[U_1, \cdots, U_n]) / (\max[U_1, \cdots, U_n] - \min[U_1, \cdots, U_n]) \text{ for } \forall i \quad (6)$$

The values of $U_i\_\max$ and $U_i\_\min$ are ranging form 0 to 1. No matter how many jobs

they have, there are only two attributions.

(2) $X_j = \sum_{i=1}^{n} T_{ij}$ represents that each machine should need to spend total process time through all

jobs. The maximum and minimum of X_j are indicated as equation (7) and (8), respectively.

$$X_j \_ \max = X_j / \max[\sum_{i=1}^{n} T_{i1}, \cdots \sum_{i=1}^{n} T_{im}] = X_j / \max[X_1, \cdots, X_m] \text{ for } \forall j \qquad (7)$$

$$X_j \_ \min = (X_j - \min[X_1, \cdots, X_m]) / (\max[X_1, \cdots, X_m] - \min[X_1, \cdots, X_m]) \text{ for } \forall j \quad (8)$$

The values of $X_j \_ \max$ and $X_j \_ \min$ are ranging form 0 to 1. For the case of m

machines, the number of attributes is $2 \times m$.

(3) T_{ij} is the process time of *job i* in *machine j*. The maximum and minimum of T_{ij} for all jobs

and machines are indicated as equation (9) and (10), respectively. The maximum and minimum

of T_{ij} for all jobs in the same machines are indicated as equation (11) and (12), respectively.

$$T_{ij} \_ \max = T_{ij} / \max \begin{bmatrix} T_{11} & \cdots & T_{1m} \\ \vdots & \ddots & \vdots \\ T_{n1} & \cdots & T_{nm} \end{bmatrix} \text{ for } \forall i \ \forall j \qquad (9)$$

$$T_{ij} \_ \min = (T_{ij} - \min \begin{bmatrix} T_{11} & \cdots & T_{1m} \\ \vdots & \ddots & \vdots \\ T_{n1} & \cdots & T_{nm} \end{bmatrix}) / (\max \begin{bmatrix} T_{11} & \cdots & T_{1m} \\ \vdots & \ddots & \vdots \\ T_{n1} & \cdots & T_{nm} \end{bmatrix} - \min \begin{bmatrix} T_{11} & \cdots & T_{1m} \\ \vdots & \ddots & \vdots \\ T_{n1} & \cdots & T_{nm} \end{bmatrix}) \text{ for } \forall i \ \forall j \qquad (10)$$

The value of $T_{ij} \_ \max$ and $T_{ij} \_ \min$ are ranging from 0 to 1. For the case of m machines,

the number of attributes is $2 \times m$.

$$Y_i \_ \max = T_{ij} / \max[T_{i1}, \cdots, T_{im}]) \text{ for } \forall i \qquad (11)$$

$$Y_i \_ \min = (T_{ij} - \min[T_{i1}, \cdots, T_{im}]) / (\max[T_{i1}, \cdots, T_{im}] - \min[T_{i1}, \cdots, T_{im}]) \text{ for } \forall i \qquad (12)$$

The value of $Y_i \_ \max$ and $Y_i \_ \min$ are ranging form 0 to 1. For the case of m machines, the

number of attributes is $2 \times m$.

For the case of *n jobs* and *m machines*, the total number of attributions is *2+m×6*. For

example, if *m= 5*, the total number of attributions is 32. If *m= 10*, the total number of

attributions is 62. If *m= 20*, the total number of attributions is 122. Because the value of all

attributes is ranging from 0 to 1, five classes can be classified as follows: (1) 0 ~ 1/5 as 0, (2) 1/5

~ 2/5 as 1, (3) 2/5 ~ 3/5 as 2, (4) 3/5 ~ 4/5 as3, (4) 4/5 ~ 1 as 4.

The mining task is to find the relationship between attributes and its order from SA

solutions sequence. Therefore, the researchers predict the sequence position of an operation

giving its characteristics. For example, if a flow shop problem with 20 sequence positions is

possible, a decision should be made that five abstract concepts would be substituted during rule

induction. The priority of decision attribute is defined as a range of sequence positions from the

SA solutions. Thus, the value of position is classified into five classes: {1,2,3,4} as 0, {5,6,7,8}

as 1, {9,10,11,12} as 2, {13,14,15,16} as 3, {17,18,19,20} as 4. Each problem size has 5 training

data sets. By using the reduct generation algorithm and pruning rules, the total number of rules

can be gained and indicated in Table 5.

Testing and Result

The applicability of these rules should be further tested using 10 times in the same size of

problems. Those are *20j5m, 20j10m, 20j20m, 50j5m, 50j10m, 50j20m* flow shop test cases which

Table 5. The number of rule form the training cases

problem size (job×machine)	certain rules	possible rules	The number of training case
20j×5m	580	159	5
20j×10m	1714	308	5
20j×20m	7350	606	5
50j×5m	87	159	5
50j×10m	63	308	5
50j×20m	315	606	5

process times generated at random. These cases were all scheduled by using the following algorithms: SA, shortest processing time (SPT), first come first service (FIFO), and priority rules. Under the same size of problems and process times, the makespans of the schedules generated in 20 *jobs* and *50 jobs* by SA, SPT, FIFO, and learned rules are indicated in Figure 3 and 4, respectively. The learned rules were acquired by the application of the feature extraction system. Figure 3 and 4 shows that in *20 jobs* and *50 jobs* the learned rules were able to produce shorter makespan than shortest processing time and first come first service. Table 6 summarized the average makespan of the same problem size that no matter in *20 jobs* or *50 jobs*, the learned rules were able to produce shorter makespan than SPT and FIFO. By comparing the averaged of makespan, the difference between SA and learned rules would be no more than 11.7%.
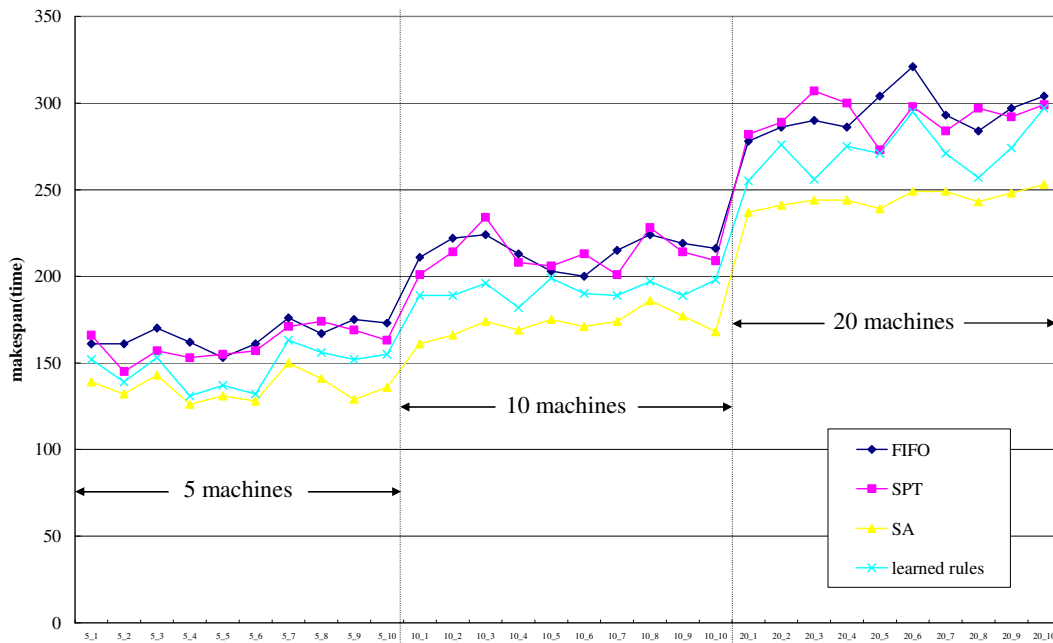
Figure 3. Makespans Of The Schedules Generated In 20 Jobs By
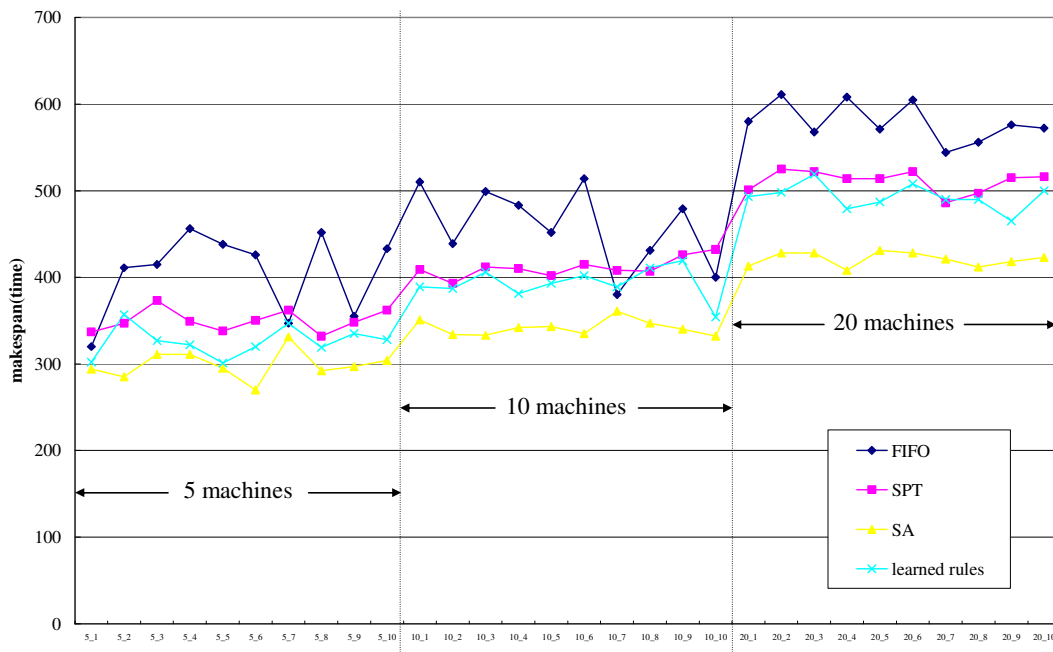SA, SPT, FIFO, And Discovered Rules

Figure 4. Makespans of the Schedules Generated In 50 Jobs By
SA, SPT, FIFO, and Discovered Rules

Table 6. The Average Makespan Of The Same Problem's Size

Problem size	FIFO	SPT	SA (1)	Learned rules (2)	Difference (%)*
20j×5m	165.9	161	135.5	149.6	9.43%
20j×10m	214.7	212.8	172.1	193.3	10.97%
20j×20m	294.3	292.1	244.7	274.2	10.76%
50j×5m	405.3	349.8	299	331.1	9.69%
50j×10m	458.7	411.4	341.8	395.5	13.58%
50j×20m	579.1	511.2	421	499.9	15.78%
Average	353	323.05	269.02	307.27	11.70%

$$* : \text{difference} = \frac{(1)-(2)}{(2)}\%$$

Conclusion

This research has shown that data mining in rough set can be learned from flow shop

schedules produced by simulated annealing. In practice, the efforts required to duplicate the SA's

performance were significant.

In this study, the researchers were able to apply the sequencing knowledge from different

sizes flow shop problems solved by simulated annealing. And then it could be generated rules

learned form the optimal or near optimal solutions that could be solve an identical problem.

When compared to problems with the same structure *(20j5m, 20j10m, 20j20m, 50j5m, 50j10m,*

50j20m Flow Shop) and different operation times and sequences, the rules were able to

consistently outperform the Shortest Processing Time and First Come First Service heuristic.

However, the learned rules were unable to match the performance of the simulated annealing on

these problems. Future research should use the feature extraction system in other problems or

incremental learning into the mining process.

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