ISSN: 2150-4075 Volume 2, Number 2, June 2010

Scientific Research

iBusiness

ISSN: 2150-4075

www.scirp.org/journal/ib

JOURNAL EDITORIAL BOARD

ISSN 2150-4075 (Print) ISSN 2150-4083 (Online)
http://www.scirp.org/journal/ib

iBusiness, 2010, 2, 99-200
Published Online June 2010 in SciRes (http://www.SciRP.org/journal/ib/)

TABLE OF CONTENTS

Volume 2 Number 2 June 2010

iBusiness (iB)

Journal Information

SUBSCRIPTIONS

The *iBusiness* (Online at Scientific Research Publishing, www.SciRP.org) is published quarterly by Scientific Research Publishing, Inc., USA.

Subscription rates:

Print: $50 per issue.
To subscribe, please contact Journals Subscriptions Department, E-mail: sub@scirp.org

SERVICES

Advertisements
Advertisement Sales Department, E-mail: service@scirp.org

Reprints (minimum quantity 100 copies)
Reprints Co-ordinator, Scientific Research Publishing, Inc., USA.
E-mail: sub@scirp.org

COPYRIGHT

PRODUCTION INFORMATION

For manuscripts that have been accepted for publication, please contact:
E-mail: ib@scirp.org

iBusiness, 2010, 2, 99-105
doi:10.4236/ib.2010.22012 Published Online June 2010 (http://www.SciRP.org/journal/ib)

On the Spatial Diffusion of Knowledge by Universities Located in Small and Medium Sized Towns*

Conceição Rego, António Caleiro

Departamento de Economia & CEFAGE-UE, Universidade de Évora, Évora, Portugal.
Email: mcpr@uevora.pt, caleiro@uevora.pt

Received October 1st, 2009; revised January 28th, 2010; accepted March 29th, 2010.

ABSTRACT

Many studies, provided by diverse authors and institutions, demonstrate that, at a territorial level, development is directly related to the level of education and R & D. Territories with higher development levels are, generally, those that have a higher level of education and R & D. The relationship between the acquisition of knowledge and institutional education is therefore decisive. In this area, the role of universities is fundamental. The retention of university graduates is one of the main ways that the cities and the regions can adopt to retain those endowed with higher propensity to innovation, enterprise spirit and management capacity. Given that higher education institutions, in general, and universities, in particular, are obviously crucial in the process of knowledge increase, it becomes important to analyse how can these institutions act as ways of spatial diffusion of knowledge given that their graduates may migrate to other regions of the country (*or for another country*). *The alleged increased probability of this migration to occur when the university is located in a small or medium sized town makes that analysis also interesting from the viewpoint of the development role that this kind of cities can perform, not only in the adjacent rural areas, but also across all the urban areas of the territory. The focus of our work consists in this analysis, which complements a theoretical approach with an empirical part based upon the results that can be observed for the influence of one university located in a small/medium sized town* (*the University of Évora*) *in the spatial diffusion of knowledge through its graduates.*

Keywords*: *Human Capital, Small Towns, Spatial Diffusion of Knowledge, Universities

1. Introduction

Many studies, provided by diverse authors and institutions, demonstrate that territory development is directly related to the level of education and R & D characterising those territories. Indeed, territories with higher development levels are, generally, those whose area is characterised by a higher level of education and R & D. As a consequence, any insufficiency in these territories on those matters constitutes an obstacle to development.

As is well-known education plays an inter-generational role. Education is a legacy of one generation to the following one; this being its main social function [1]. It is a medium-term investment, made by the society in general and by households in particular, to the extent that expectations of higher contributions in the future mean forgoing the productive contribution of the young in the present [2]. Parents want their children to receive a high-quality education because they understand that in this way they are better preparing them for the labour market.

In the European Union framework, the debate on the role of higher education institutions (henceforth, HEIs) within the knowledge economy is deeply important. The creation of a Europe of knowledge has been defined as main goal for the European Union since the Lisbon Council (March 2000). The Lisboa agenda include many players, in which the universities are certainly to be included. In terms of growth, the knowledge society depends upon the production of new knowledge, its transmission through education and training, and its dissemi-

*A previous version of this paper was presented at the conference "Knowledge in Small and Medium Sized Towns: Towns as a Place of Knowledge and Diffusion", which took place at the Universidade do Algarve, Portugal, in December 04-05, 2008. The authors are grateful for the comments obtained there as well as for the subsequent ones. All remaining errors and/or shortcomings are of our own responsibility. This final version is to be related to the research project PTDC/CPE-PEC/103727/2008 (Rebuilding the Portuguese higher education system's network: challenges from demographics, economic growth and regional cohesion).

nation through information and communication technologies. In this context, universities traditionally play their role in the fields such as those of research and development of their results, due to industrial cooperation and spin-off, education and training, in particular training of researchers, and local and regional development.

As a matter of fact, according to the Communication from European Commission [COM (2003): 58 final][1], universities play a key role to the knowledge economy and society. For example, universities employ 34% of the total number of researchers in Europe and are responsible for 80% of the fundamental research pursued in Europe. In addition, universities train an increasing number of students with increasingly higher qualifications, which contribute to strengthening the competitiveness of the European economy. Universities also contribute to the objectives of the Lisbon strategy, particularly employment and social cohesion, and to the improvement of the general level of education in Europe: in the total population aged 25-64, the rate of employment of persons holding higher education qualifications stood at 84% in 2001. On the other hand, the rate of unemployment amongst those which have higher education qualifications remains at 3,9%, about one third of total of persons with a low qualifications level.

The analysis of local and regional role of HEIs is related to local economic, social and cultural environment. In this sense, HEIs are important instruments of regional development and of strengthening European cohesion. The development of technology centres and science centres, the proliferation of regional cooperation structures between the business sector and the universities, the expansion of university regional development strategies, the regional networking of universities are some dimensions of university activity. In addition, universities can play an important role as a source of expertise and a catalyst for multiple partnerships between economic and social players with multiple networks at the regional and local levels [COM (2003): 58 final].

The contributions of HEIs to regional economies have been made through different ways [3] to identify eight different functions, or outputs, of modern research universities that may potentially lead to economic development impacts:

1) Creation of knowledge;
2) Human-capital creation;
3) Transfer of exiting know-how;
4) Technological innovation;
5) Capital investment;
6) Regional leadership;
7) Knowledge infrastructure production;
8) Influence on regional milieu.

[1]Communication from the Commission, *the role of the universities in the Europe knowledge*, Commission of the European Communities, Brussels, 05.02.2003.

Obviously, each of the previous outputs may cause a distinct pattern of effects on the regional economy, ranging from the direct and indirect effects of university spending to productivity gains in private enterprises, from the creation of new firms to increases in regional creativity and the capacity to sustain long-term development and growth [3]. According these authors, traditional approaches to assessing the impacts of universities have focused largely on the impacts arising from direct spending and regional investment activities. On the other hand, extensions of these spending-impact studies have branched into considering the effects of human-capital creation and induced regional migration patterns. In this sense, the recent approaches have focused on the basic knowledge creation, knowledge-infra-structure provision, technological innovation, and technology-transfer activities of universities and HEIs, in general [3].

The focus of our work consists in the analysis sketched up, which complements a theoretical approach with an empirical part based upon the results that can be observed for the influence of one university located in a small/medium town (the University of Évora) in the spatial diffusion of knowledge trough its graduates.

The rest of the paper is structured as follows. From a theoretical point of view, the importance of HEIs in the accumulation and diffusion of human capital through their graduates is analysed in Section 2. From an empirical point of view, it is presented in Section 3 the case of the University of Évora, which is located in small/medium size town, as a source of spatial diffusion of knowledge. Section 4 concludes.

2. The Importance of Higher Education Institutions in the Accumulation and Diffusion of Knowledge

The human capital accumulation is a fundamental issue when the goal is to understand the economic and territorial development process. In this sense, the HEIs role is crucial. The HEIs, in general, and universities, in particular, are promotional agents for the development of the regions where they are located, being also sure that some spatial spillover effects are generally observable. Hence, universities are fundamental entities within the development process, capable of generating positive externalities in improving the performance of human capital through the exercise of the functions of education, R & D and community service.

According to [3], analyses of knowledge production have demonstrated that knowledge, as an output, has qualities that make it unique: knowledge-producing organizations must be considered differently than other large organization with substantial output and employment. External benefits of knowledge production in the form of spatial spillovers lead to increased innovation among other regional firms. In this discussion, the fundamental

issue is understand how knowledge generated through a university's activities adds value to the local economy, and how relation between universities in their teaching and research activities and other agencies in the local economy contribute to the knowledge creation [4].

Undoubtedly, "Human capital is a fundamental variable in the economic development process: the education of the citizens, more than any material wealth, is the force that mobilizes the cultural spread of a country, gives it influence between nations and attributes to it aptitude to cooperate in the development of a world that is becoming, with each day that passes, closer and more interdependent" [5].

This sentence suggests that we can approach the relations between education and economic development in two ways: firstly, education is responsible for increases in private incomes by enhancing the capacity for obtaining jobs and higher wages; secondly, it generates collective externalities and it stimulates the competitiveness of companies and territories.

Capturing the economic impact of higher education in human capital in a region requires determination of the effect of a specific institution's education on future activity levels as well as the comparison of that effect of what would have occurred had the students been educated elsewhere [6]. According to [6] this type of impacts must include a measure of the discount value of the differences in flows of future economic activity – differences that arise from firms and institutions that are located in the area due to the presence of the university.

The accumulation of capital, physical and human, is a basic condition for sustainable economic growth in the long run, and for the reduction of the divergences of income between countries. Economic success, the first condition for the improvement of the standard of living of the population, translates into the capacity of regions or organizations to mobilize different institutions (companies, organizations, infrastructures of information, systems of incentives, etc.) to support learning. The relation between the acquisition of knowledge and institutional education is decisive. In this area, the HEIs role is fundamental. According to [7], is in the level of education and the employment of graduates in the regional labour market, as well as the level of programmes of professional improvement, that the effects of these institutions will be more significant.

The effect of universities on regional economies can be analysed through the skills base approach. This approach attempts to quantify the impact that HEIs have on the long-run course of a region's economy [8]. The HEIs, through teaching and research, produce skilled workers and increases in technology, both of which can directly increase the wages in the region. Higher wages rates can benefit a region's economy through increased tax revenue, increased consumption and higher rates of saving and investment [8].

The studies in this area were developed, for example, by [9] and [10] as well as by [11] or [12]. According to [8] the research done by [9] and [10] use estimatives of the potential future income stream of graduates who stay to work in the region as the measure of the long-run economic impact of HEIs. Other studies – developed by the Institute for Higher Education Policy, 2005 - in this area looked beyond the immediate effect on wages to consider the less tangible effects that universities have on their communities [8]. In this sense, researchers have established that the graduates are more likely to volunteer in their communities, vote and be aware of political events, require less health care, not smoke, experience lower rates and durations of unemployment, participate in the labour force and not require public assistance at some point in their lives.

[11] developed some research about the several ways in which HEIs can influence the local labour markets. On the one hand, HEIs increase job prospects and the chances of earning higher wages for their graduates; on the other hand, by increasing the average level of knowledge, HEIs can promote an increase in local productivity and in capacity to develop and to implement new technologies, depending on the average level of human capital in the economy. One relevant area in the debate between higher education and labour market gives respect to the kind of skills, *i.e.*, the critical issue in this debate is whether or not the training at first-degree level should be professionalized to impart skills or should provide general education to prepare graduates to respond to their specific circumstances [13].

[4] quoted Felsenstein which identified three tips of 'forward linkage', in the form of changes to the local level of human capital, to the pool of knowledge, and to the attractiveness of the local area to households and firms:

1) Universities raise the level of human capital in their local economy but only to the extent that graduates stay in the local area after completing their studies;

2) Universities add to the knowledge base of the area through a whole series of university-business links, including consultancy and contract research;

3) Universities may also add to the attractiveness of an area through the creation of positive 'quality of life' externalities.

Very close with this proposal, [14] suggests a model to analyse the effect of agglomeration on local university knowledge spillovers, knowledge transfer mechanisms based into three categories:

1) Information transmission via local *personal networks* of university and industry professionals (local labour market graduates, faculty consulting, university seminars, conferences, student internships, local professional associations, continuing education of employees).

2) Technology transfers through *formal* business rela-

tions (university spin-off companies, technology licensing).

3) Spillovers promoted by university *physical facilities* (libraries, science laboratories, computer facilities) [14].

In this sense, knowledge is an asset in constant formation and accumulation at the university level and can be expected to filter into the local economy in due course, through teaching, consultancy and research; also, a university's international connections can also be important in arresting any inertia that might otherwise contribute to the loss of competitiveness of the local economy [4]. However, it is very likely that geographic proximity may not be a sufficient condition of meaningful university technology transfers [14]. For example, the absence of a 'critical mass' of the enterprises 'side', the lack of producer services, venture capital and entrepreneurial culture may explain the dissonance in local spillover effect, *i.e.*, HEIs and local companies and other institutions should have the same 'language' and understand their complementarities in order to promote the rising of territorial knowledge effects.

One of the fundamental factors in the economic success of a region is the extent it can attract or retain graduates, in that these citizens generally become more productive. A great part of the economic effect of the HEIs depends in the decisions of its graduates not to migrate [12]. It must be admitted that higher education increases the probability of migration, in so far as graduates are better equipped to compete in the national and international labour markets and thus leave the region where they have studied. Migration decisions are based on job chances: if a given region does not have a tradition of growth of jobs in specific sectors, but has graduates in these areas, then these will be potential emigrants. At the same time, the increase in the knowledge of the HEI cannot influence the development of economies if there is a lack of adequate and available jobs for graduates.

So, the retention of graduates is one of the main means that the cities and the regions can adopt to hold in to those endowed with sensitivity to innovation, enterprise spirit and management capacity. Retention rates show, however, a relationship of many factors: the capacity of the HEIs to offer studies and training that take into account the needs of the local and regional economy; stability, diversity and importance of the economic regional base, the context of the national or regional economy, the origin of the students, the type of educational establishment and the economic and social context of the students.

Given that HEIs, in general, and universities, in particular, are obviously in the process of knowledge increase, it becomes important to analyse how can these institutions act as means of spatial diffusion of knowledge given that they graduates may migrate for other regions of the country (or for another country). The alleged increased probability of this migration to occur when the university is located in a small or medium sized town makes that analysis also interesting from the viewpoint of the development role that this kind of towns can perform, not only in the adjacent rural areas, but also across all the urban areas of the territory.

3. The Case of the University of Évora

The University of Évora is located in a small/medium size town, *i.e.* in Évora, which has a population of about 55 000 inhabitants. Évora is the main urban agglomeration of the 'Alentejo Central' (NUT III) as well as of the province of Alentejo, which is the least densely populated region of Portugal and one of the poorest in the European Union. The evidently distinct behaviour of Évora, in economic and demographic terms, from the rest of the Alentejo (Central) is due to some factors, in which the importance of the University of Évora can undoubtedly be included.

Being the main institution of higher education and of research and development (R & D) located in the Alentejo, the University of Évora has increased responsibilities in the areas of higher learning, research and community service. With reference to education and research, the areas prioritised for development are Natural Sciences, Social and Human Sciences, Economics and Management as well as Agrarian and Veterinarians Sciences.

In the area of the activities of community service, the University of Évora offers services at the level of training and consultancy, or by promoting the insertion of graduates in the regional labour market. It also participates in many regional entities, at the level of the respective administrations, seeks regional partners for the institution through participation in activities of education or research, and maintains a special relationship with the schools involved in other levels of education. The accomplishment or promotion of cultural and similar activities has been one of the most systematic ways used for involving the city.

As a matter of fact, after the re-establishment of the University in 1979, the presence of this HEI has contributed decisively to the modification of the dynamic of the city through the increasingly significant presence of students, many of them coming from regions other than the Alentejo (see [15]). Particularly in the 1980s and 1990s the University of Évora has contributed to fulfil the needs of the job market in Évora and throughout all the Alentejo through its graduates. This migration of human capital, therefore of knowledge, towards Évora (and Alentejo) can therefore be viewed as complementary to the economic-base relevance of the University of Évora (see [12] for an argument of how the skill-base approach, which is considered here, does not disregard the traditional economic-base approach, but, indeed, adds to it).[2]

[2]From a different, but complementary, perspective, [16] analyse the importance of science in the diffusion of knowledge. See also [17], who consider the case of India when analysing the diffusion of knowledge through migration of scientific labour.

Having said that, it is our point that the diffusion of knowledge that is due to the University of Évora can be proxified by a positive proportion of the number of graduates that enter the job market in which they exert a profession requiring the knowledge and competencies earned at the University. In doing so we distinguish four territories of diffusion: Évora, (rest of) Alentejo Central, (rest of) Alentejo and the (rest of) Portugal.

In accordance to our main goal, it is illuminating to present a figure showing those four territories of diffusion, not only in terms of their location in the country but also in terms of their areas, as both aspects are clearly important in the understanding of the real importance of the spatial process of diffusion of knowledge by the graduates of the University of Évora. **Figure 1** thus shows all Portugal, the NUT III Alentejo Central (in red), the location of the UE, and the location of the Alentejo (which is composed by the Alentejo Central and the 4 NUTs III (out of the 5) surrounding the Alentejo Central with largest areas.

Figure 1. The four territories of diffusion

As pointed out by some authors, one fruitful source of knowledge diffusion is the mobility in the job market (see [18]). In order to consider this issue, we take the results of a recent enquire to the graduates of the University of Évora as representative. In what concerns the job market, the responses to the question: "Where did you get your first job" vs. "Where are you working nowadays?" can be consulted in **Table 1**.

From **Table 1** it can easily be inferred the importance of Évora as an attraction pole, despite being also evident that many graduates do indeed take their knowledge with them to other parts of the country.

As some authors recognise, the diffusion of knowledge can be measured by the analysis of the migration between jobs, which, being a dynamic process, can be analysed from a Markov chain point of view.[3] Following this approach, the transition matrix corresponding to the data is given in **Table 2**.[4]

Under the usual hypothesis, the stationary distribution of the dynamic process is given by {Évora = 15%; Alentejo Central = 5%; Alentejo = 13%; Portugal = 67%}.[5] Plainly, these figures have to be made proportional to the area of the four territories of diffusion, in order to accurately point out the importance of the diffusion of knowledge due to the University of Évora via its graduates. The values obtained after dividing those values by the areas (measured in Km^2) of their corresponding territories are represented in **Figure 2**, this being constructed in order to include the territory with less area in the one with the area immediately above, *i.e.* obviously, Évora in the Alentejo Central, the Alentejo Central in the Alentejo and the Alentejo in Portugal.

Being understood as a rainbow (cold/hot) plot, **Figure 2** clearly point out the importance of the diffusion of knowledge particularly in Évora and in the rest of Portugal, that can be associated to the graduates of the University of Évora, being also observable that the (rest of the) Alentejo is the territory where that importance is less evident.

Table 1. The dynamics between jobs

		Current job			
		Évora	Alentejo Central	Alentejo	Portugal
First job	Évora	201	12	23	66
	Alentejo Central	21	74	16	30
	Alentejo	14	11	169	53
	Portugal	33	12	22	581

Table 2. The transition matrix

		Current job			
		Évora	Alentejo Central	Alentejo	Portugal
First job	Évora	0,666	0,040	0,076	0,219
	Alentejo Central	0,149	0,525	0,113	0,213
	Alentejo	0,057	0,045	0,684	0,215
	Portugal	0,051	0,019	0,034	0,897

[3][19] also use a Markov chain approach in order to analyse the role of knowledge in the sequential processes of negotiation.

[4]As the values in the transition matrix are obtained dividing each of values in **Table 1** by the sum of each row, each row in **Table 1** adds to one.

[5]This stationary distribution corresponds to the percentages that in the long-run, each of the (four territories in the case) would benefit from the spatial diffusion of knowledge. As such those values can be seen as the steady-state solution of the dynamic process, which is supposed to be ruled by the transition matrix.

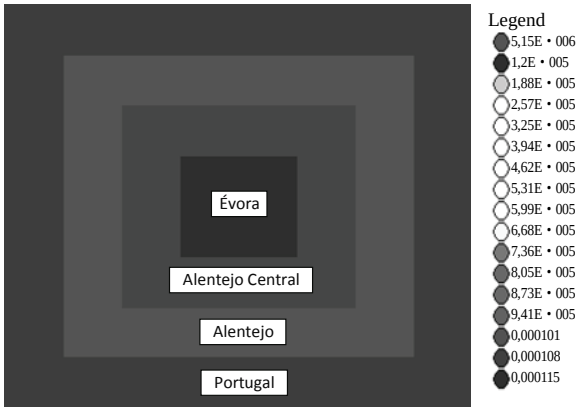

Figure 2. The spatial diffusion of knowledge by the University of Évora

4. Conclusions

The HEIs can contribute to improving and to consolidating the regional knowledge capacity, through mechanisms in the area of education and research. The coherence of regional knowledge creation and diffusion system will become more robust through a rigorous selection of courses and curricula adapted to regional technological needs, and by supporting the development of a culture using local techniques (accumulation of codified knowledge), *i.e.*, more adapted to the local and regional labour market characteristics. From this point of view, the dynamics of local enterprises are crucial, particularly through the employment promotion and retaining the graduates.

Also, the processes of creation, acquisition, adaptation and diffusion of new knowledge developed in the universities, can consolidate the relationship capacity of the region where they are inserted, developing projects that involve the sharing of co-operation between companies. This can contribute to diminishing the distance between science, technology and the society, between pure and applied research and between the discovery of new technologies and the development of products and viable processes of production (facilitating the accumulation of tacit knowledge).

In empirical terms, the main conclusion is the University of Évora is an important sources of knowledge diffusion in terms of the small/medium sized town where it is located (*i.e.* Évora), despite not being ignorable the importance in terms of the rest of the country. From this point of view, the importance of the University of Évora, in terms of spatial diffusion of knowledge, is to be added to the economic impact of this university as measured in [20].[6] As a matter of fact, when adding up also the diffusion of knowledge that is certainly due to the scientific activity of the academic staff of the University of Évora, the importance of this HEI is obviously closer to its real figure.

As directions for further research we would like to study an issue that despite being apparently/intuitively important could not be studied due to lack of information in the enquiry (which may require the application of another enquiry). As a matter of fact, in order to better understand the regional effects of the University of Évora, it seems crucial to know if graduates, during their study period, had some contact with enterprises operating in the region of Évora and/or in the region of actual residence, thus favouring the admission of students to business jobs after their graduation degrees.

[6]See also [21] and [22].

REFERENCES

[1] D. Thomas, "Education and the Role of the University in Economically Developing Regions," *Higher Education Policy*, Vol. 8, No. 2, 1995, pp. 51-62.

[2] R. Lopes, "Competitividade, Inovação e Territórios," Celta Editora, Lisbon, 2001.

[3] J. Drucker and H. Godstein, "Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches," *International Regional Science Review*, Vol. 30, No. 1, January 2007, pp. 20-46.

[4] H. Battu, J. Finch and D. Newlands, "Integrating Knowledge Effects into University Impact Studies: A Case Study of Aberdeen University," Report Prepared for the Principal for Aberdeen University, Department of Economics, University of Aberdeen, 1998.

[5] V. Crespo, "Uma Universidade para os anos 2000, o Ensino Superior numa Perspective de futuro," Editorial Inquérito, Lisbon, 1993.

[6] M. Blackwell, S. Cobb and D. Weinberg, "The Economic Impact of Educational Institutions: Issues and Methodology," *Economic Development Quarterly*, Vol. 16, No. 1, 2002, pp. 88-95.

[7] J. Goddard, "Contribuition au Développement National et Regional," UNESCO, *Conférence Mondiale sur l'enseignement Supérieur*, Paris, 1998.

[8] M. P. Nagowsky, "Assessing the Economic Impact of Higher Education Institutions in New England," Memorandum, New England Public Policy Center, Federal Reserve Bank of Boston, Boston, 2006. http:// www.bos.frb.org/economic/neppc

[9] B. Bluestone, "UMASS Boston: An Economic Impact Analysis," John W. McCormack Institute of Public Affairs, The University of Massachusetts, Boston, 1993.

[10] M. C. Berger and D. A. Black, "The Long Run Economic Impact of Kentucky Public Institutions of Higher Education," University of Kentucky Center for Business and Economic Research, Lexington, 1993.

[11] P. Beeson, and E. Montgomery, "The Effects of Colleges and Universities on Local Labor Markets," *Review of Economics and Statistics*, Vol. 75, No. 4, 1993, pp. 753-761.

[12] R. H. Brown and M. T. Heaney, "A Note on Measuring the Economic Impact of Institutions of Higher Education," *Research in Higher Education*, Vol. 38, No. 2, 1997, pp. 229-240.

[13] M. K. Mayanja, "A Comparative Study of Makerere University Graduates of the Faculties of Arts and Sciences," AAU Research Paper Series, Study Program on Higher Education Management in Africa, 2001. http://www.aau.org/studyprogram/pdfiles/mayanja3.pdf

[14] A. Varga, "Local Academic Knowledge Spillovers and the Concentration of Economic Activity," Conference Paper 493, 38th Congress of the European Regional Science Association, Vienna, 1998. http://www.ersa.org/ersaconfs/ersa98/papers/493.pdf

[15] A. Rego and A. Caleiro, "Universities and Economically Depressed Regions: How 'Attractive' is the University of Évora?" Conference Paper 23, European Regional Science Association, 2004. http://www.ersa.org/ersaconfs/ersa04/PDF/23.pdf

[16] O. Sorenson and L. Fleming, "Science and the Diffusion of Knowledge," *Research Policy*, Vol. 33, No. 10, 2004, pp. 1615-1634.

[17] A. Kale, D. Wield and J. Chataway, "Diffusion of Knowledge through Migration of Scientific Labour in India," Paper Given at the SPRU 40th Anniversary Conference, *The Future of Science, Technology and Innovation Policy*, mimeo, 2006.

[18] A. M. Franco and D. Filson, "Spin-Outs: Knowledge Diffusion through Employee Mobility," *RAND Journal of Economics*, Vol. 37, No. 4, 2006, pp. 841-860.

[19] L. R. Weingart, M. J. Prietula, E. B. Hyder and C. R. Genovese, "Knowledge and the Sequential Processes of Negotiation: A Markov Chain Analysis of Response-in-Kind," *Journal of Experimental Social Psychology*, Vol. 35, No. 4, 1999, pp. 366-393.

[20] C. Rego, "Impactes da Universidade de Évora: Estudo de Alguns efeitos no Território Envolvente," Tese de Doutoramento, Universidade de Évora, 2003.

[21] A. Caleiro and C. Rego, "Os Efeitos Económicos das Universidades nas Regiões: Porque se deve Usar a Análise Input-Output na sua Medição?" Paper Given at the XI Congresso da Associação Portuguesa para o Desenvol-vimento Regional, Universidade do Algarve, Faro, September 16-18, 2005.

[22] A. Rego, "Universities in Peripherals Countries: Researching 'in the Regions' or 'for the Regions'? – Some Evidence Based on the University of Évora Experience," Paper Presented at the UNESCO Forum for Higher Education, Research and Knowledge: "Universities as Centres of Research and Knowledge Creation: An Endangered Species? UNESCO, December 2006.

iBusiness, 2010, 2, 106-115
doi:10.4236/ib.2010.22013 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Theory and Practice of the Design of Monthly Reports

Bernhard Hirsch, Anne Paefgen, Sven Schaier

Universität der Bundeswehr München, Neubiberg and WHU - Otto Beisheim School of Management, Vallendar, Germany.
Email: bernhard.hirsch@unibw.de, {anne.paefgen, sven.schaier}@whu.edu

Received January 20th, 2010; revised March 10th, 2010; accepted April 17th, 2010.

ABSTRACT

This paper focuses on the design of management reports. Based on theoretical considerations concerning the personal information demand, hypotheses were developed and tested in a field study in German major enterprises. The findings from the field study show a high diversity of monthly reports to the top management. Furthermore it is shown how design improvements for these reports can be derived from the personal information demand of the recipients. The paper will also discuss deficits of the reporting system during the study.

Keywords*: *Recipients of Reports, Design of Reports, Field Study, Provision of Information, Monthly Report

1. Introduction

Providing management with information is one of the key tasks of management accounting (controlling). Numerous approaches to define management accounting do focus on the supply of information as the core task of management accounting [1-5], and empirical studies do confirm that substantial resources of management accounting are required for this key focus [6,7].

Within the framework of the information supply, the internal corporate reporting system plays an outstanding role [8-11]. Information collected and processed by corporate information systems are usually passed on to management in the form of *reports*, with the corporate information system comprising the preparation and transmission of information in the form of reports to employees, primarily to the leaders of an enterprise [12]. The corporate information system essentially supports the business-related decision-making processes [8].

As a consequence, shortcomings in terms of the conception of the information supply frequently only become apparent at the reporting stage, and moreover, successful results achieved within an otherwise well designed information supply are still susceptible to threat at this point. Reporting, to be understood as the entirety of reports directed to internal addressees of a corporation, may thus be viewed as the point of crystallization of information supply.

The science of business economics puts numerous demands on the design of reports. As a rule, the core idea behind these demands is to provide the recipients of reports the information they need to facilitate decision making [13]. So far only few studies have investigated the extent to which these demands are actually implemented in corporate practice. Göpfert [8] thus sees the need for research on the reporting sector. Moreover, up to now only few studies exist which investigate the structure of reporting [14].

Therefore, on one hand, this paper aims at illustrating the current status of the (monthly) reporting system in selected large German corporations, with the focus of the field study being the monthly report sent to the members of the board by corporate management accounting. All heads of corporate management accounting of the companies investigated agreed to rate the monthly report as one of the five most essential "products" of their respective departments. On the other hand, proceeding from this stocktaking, theory-based evaluations of the practice of the design of monthly reports are to be carried out from which suggestions for improvement will be derived.

The paper is structured as follows: The following section starts by developing the conceptional basis of the examination. First, the need for information is identified as the theoretical starting point for the design of the information supply and the reporting system. Based on conceptional considerations, hypotheses are derived which were empirically plausibilized within the framework of the field study. Afterwards the principal options for the design of the reporting system are shown. In the third section, the results of the empirical study are illustrated by first describing the further details of the methodology used for the study, followed by the presentation of the

results of the field study in two steps: The reports examined are described by means of the design aspects as described in the second paragraph. In a second step, the procedure used for the evaluation of the reports and the assessment of possible options for improvement is described. Since the study is focused on only seven corporations, the empirical results can therefore not be claimed to be representative. Nevertheless, in our opinion, they are a valuable theory-based contribution beyond mere exploration, supporting the empirical plausibilization of theoretical considerations based on the reporting practice applied in large German corporations. Since the suggestions for improvement are basically corporate-specific, the relevant statements concentrate on the commonalities found in all corporations. In winding up, the fourth section summarizes the most important results in a resume.

2. Development of a Conceptional Frame of Reference

2.1 The Need for Information as the Starting Point for the Design of the Reporting System

The *need for information* by the addressee of the report represents the theoretical starting point for the demand of an information supply and its design. The need for information can be generally defined as the "sum of information required for the fulfillment of an informational interest" [15]. The goal of the information supply is to satisfy this need for information in the best possible way.

For the concretization of the information need it would be suitable to distinguish between an *objective* and a *subjective need for information* [16].The *objective need for information* results from the *tasks* fulfilled by the recipients of the information. In the event that the recipients of the information are primarily assigned routine tasks, there is only relatively little objective need for (new) information. However, for the accomplishment of tasks where problem-solving or decision-making skills are of central importance, the objective need for information often strongly increases. Thus – depending on the task to be accomplished – information such as details of the market environment, decisions taken in other parts of the corporation or available capacities is needed [5]. The more comprehensive the tasks to be fulfilled, and the more freedom is allowed for their accomplishment, the more difficult it is to directly define the required need for information by the mere formulation of the task.

While the objective need for information is solely derived from the formulation of a task, thus being defined independently by the individual person, *i.e.* the recipient of the information, the s*ubjective need for information* also considers the *individual capabilities* and the attitudes of the *recipients of the information* [13,17]. The abilities of an information recipient may primarily be concretized in view of his or her (professional) experience and his or her cognitive abilities. It must be assumed that the information recipients are limited as far as their processing capacities are concerned, however are capable to extend these capacities because of their experience [18,19]. The attitudes of an information recipient do affect his or her opinions and perceptions as to which information he or she wishes to obtain or requires to accomplish the task. There are certain factors that play a role for the subjective information need, such as the risk-taking characteristics of an information recipient and the question if he or she is more number-oriented or rather averse to numbers. The kind of how information is taken in by someone also has an effect on the subjective need for information.

The following sections are intended to examine if and to which extent the design of the reporting system should be primarily oriented towards one of these two components of information need. Two aspects are to be taken into consideration which will both be described below: First, the degree to which the respective need for information can be assessed and second, the interaction between controllers and managers regarding the design of the reporting system.

As far as the methods used to assess the need for information, a distinction is made between the deductive and the inductive assessment [20]. Within the framework of the *deductive* assessment of an information need, either logical analyses of the task or problem are used to determine who the recipients of the information are, or model analyses are used to assess the *objective* information need of the information recipients. As already mentioned, in practice, the assessment of the objective information need is especially difficult in such cases where the formulation of a task is characterized by high complexity and where considerable freedom is allowed to accomplish the task. However, this is exactly what especially applies to the relevant tasks to be accomplished by the members of a corporate board. Also to be taken into consideration are the theoretical arguments which have already been outlined, *i.e.* that both the abilities and the wishes or requests of the recipients are different regarding the design of a report. If the wishes expressed by the recipients of the reports are interpreted as their individual preferences, individual aspects regarding the design of reports must by no means be neglected, according to the principle of the economic theory: "De gustibus non est disputandum".

This theory favors an *inductive* approach to assessing the information need, with the goal to identify the *subjective* information need based on the information demand by the recipients of the information. Thus, the situation-dependent settings are automatically considered in view of both the available sources of information and the information behavior of the recipients of the information. First conclusions on the subjective information need may be drawn on the basis of an analysis of the existing

documents and information systems within a corporation. Another option is to observe the information behavior of the recipients of the information as well as to interview them. Interviews are the most direct option to assess the subjective information need. Since, as a rule, it must be assumed that managers themselves have the best overview of their tasks, problems and decision-making situations, the two last mentioned approaches are especially suitable to assess the information need of the management. In view of the difficulties of a deductive assessment of the objective information need of managers it must be assumed that such an inductive approach also represents a good basis for the assessment of the objective information need. Thus, a detailed survey of the information need should be based on the observation of the behavior (regarding the information demand) of the recipients of reports, as well as on interviews with the recipients.

A consequent orientation of the information supply towards the subjective demands of the recipients of the information will affect the interaction of controllers (as the suppliers of information) and managers (as the recipients of information). If management accounting is assigned the task to provide adequate information to the management, it is very obvious to interpret management, as the recipient of the service "information supply", also as an (internal corporate) client of management accounting. Existing empirical studies investigating the customer orientation of cost calculators however give reason to assume that the idea of an internal customer orientation has often not yet been internalized by management accounting, while information supply is strongly approached through the information offer in the form of technical information systems [21,22].

In spite of the high significance which, for conceptional reasons, has been acknowledged to the subjective assessment of the quality of monthly reports by the recipients , it must be mentioned that this view does not exclude the fact that, within the framework of the reporting system, controllers should also have the right to make suggestions or to express disagreement. Such positioning of management accounting in the sense of a critical counterpart [23] becomes especially necessary if the information demand evidently differs from the objective information need. On one hand, such right to express disagreement requires the manager's confidence in the competence of the controller. On the other hand, the fulfillment of the counterpart function within the reporting system requires detailed knowledge as to how and for what purpose managers use the supplied information. Such knowledge may be particularly won by a successful interaction between the controllers as the suppliers of reports and the managers as the recipients of reports. Through frequent exchange and attentive observation, controllers can learn to estimate the subjective and objective information need of the managers and counteract possible discrepancies. It also allows them to gain clues as to whether management may need other information, or if support is needed for the interpretation of the report information, or if the information supplied is perhaps not used for the intended purposes.

Based on the above conceptional considerations on the design of the reporting system, hypotheses are derived which underwent an empirical verification within the framework of the field study.

The first assumption is that the monthly reports in the examined companies are clearly different as far as their design is concerned since it must be expected that the recipients' information need relevant for the design of the report will also greatly differ. Since the examined companies are active in different industrial sectors, pursue different business models and are also different as far as their internal organization is concerned, it must be expected that the objective information need of the management of these companies will differ from each other. Moreover the corporate management will probably show different abilities and attitudes which entail the assumption that the subjective information need will also be different. There are also other reasons, like the path dependence [24] regarding the design of information and report systems, leading to expect differences in the design of reports. Hence, the first hypothesis is that:

H1: *The monthly reports in the examined companies do greatly differ in their design.*

Second, it was derived that the design of the reports should primarily be oriented towards the subjective information need of the recipients of reports. Based on existing studies, it must be assumed that controllers strongly neglect the orientation towards the needs of their internal clients. These considerations are summarized as follows in the second hypothesis:

H2: *The product "monthly report" which has to be established by management accounting does not sufficiently consider the needs of managers as internal clients.*

In order to empirically verify the second hypothesis, the managers of the examined companies collected client requirements and client satisfaction data regarding the monthly reports they had received from management accounting. On one hand, this method allowed to verify if and to what extent the current monthly reports are oriented towards the needs and wishes of the recipients, and thus, towards their subjective information need. On the other hand, the results of this survey could be used to identify potentials for improvement in view of the reporting system of the examined companies. Common potentials for improvement found in all corporations also give a hint to typical deficits of the reporting system.

The basis for the verification of the first hypothesis was a comparison of the monthly reports in the various companies. The reports were examined in view of the

design characteristics available for the design of the reports. The following section explains the design options that are available for the reporting system.

2.2 Design Options of the Reporting System

A report – and thus, a monthly report, too – can be described by the following design options [20]: Of great significance in view of the fulfillment of the information requirements, is (a) the purpose of the report. Personal design options refer to (b) the author of the report and (c) the recipient of the report. The time factor of the report is characterized by (d) the reporting date. Moreover, reports can be distinguished by different (e) types of reports. Finally, (f) the content and (g) the form offer the corresponding design options.

Ad (a): The *purpose of the report* is an essential aspect for the design of reports. There are five different purposes for a report: The superordinate purpose, especially for standard reports, is to inform the recipients of the report in the sense of a supply with "basic knowle- dge" of the business development. In more detail, this purpose of a report can be fulfilled by providing reports serving as brief information ("An overview of the essential key performance indicators"), and/or as a refere- nce guide. A second essential purpose of a report is planning, where the information of a report is used to prepare decisions. Moreover, reports are frequently used for control purposes. Another purpose of a report is steering. The transmission of information leads to counter measures. The documentation purpose of a report basically follows the regulations of the external accounting and the Law on Monitoring and Transparency in Businesses (German: KonTraG). These regulations define certain types of information which have to be reported to the management [20].

Ad (b): Another design dimension of the reporting system is the *author of the report* (synonym: report bearer). The reporting system and, within this system, in particular the monthly report, is one of the core tasks or core products of management accountants (controllers). In corporate practice, controllers usually are the primary authors of reports [20].

Ad (c): The *recipients of reports* are the addressees. Since the definition of the reporting system used in this paper comprises the internal corporate transmission of information, the circle of the recipients is restricted to the managers of the company. Monthly reports are of particular relevance if they are presented to top management. Management takes decisions that have a particular effect on the success of a corporation. Apart from managers, other groups of employees, such as division managers are possible addressees of monthly reports [20].

Ad (d): The *reporting date* of a report is the time-related design aspect of reports, which for instance means the frequency of reports. The reporting date also includes the date of issue after the occurrence of a certain event.

Ad (e): If a reporting system is very sophisticated, various *types of reports* may be employed. Reports may be classified as standard reports, deviation reports and reports on demand. Standard reports are common use in corporate practice. They are written in regular intervals, at a certain point of time, for a certain circle of addressees and with a largely standardized content. Deviation reports do not follow any predetermined report cycle, instead they are triggered as soon as certain values either exceed or fall below a given threshold. Reports on demand required by the recipients in certain cases are the third type of reports [20].

Ad (f): The design of the *content of a report* may be further broken down into the features structure, objective of the information, type of information and related subject of the information. The *structure* of a report refers to its breakdown and the organizational units focused in the report. The facts captured in a report are - quite generally - called the objective of an information [23], including for instance, the decision taken due to the key performance indicators (KPIs) supplied in a report. By means of the dimensions of the Balanced Scorecard, these key performance indicators can be classified as finance, process, market/customer, employee and innovation KPIs [25]. Along with this classification, it is also possible to separate the KPIs into monetary (financial KPIs) and non-monetary (concerning all other categories of the Balanced Scorecard) KPIs. The *type of information* is intended to describe the character of the statements made on the objectives of the information. Possible types of statements include for instance fact-oriented, forecast-oriented, explanatory or normative statements [23]. The explanatory power of information depend its subject relatedness. Only if data are related to each other, *i.e.* qualified, deviations can be deduced which can be analyzed and then deliver findings which are relevant in terms of steering and management accounting. In this context, the subject-relatedness of information is to be understood as those values that compared to the actual values. Typical reference values to be considered are past or forecast values.

Ad (g): The *form* of a report refers to aspects regarding the formal layout of a report. It can be broken down to design features that include the length or volume, the appearance and the presentation form. While the volume or length of a report simply refers to the number of pages of a report, the appearance means the number density, *i.e.* the number of figures per page, as well as the use of colors. For the presentation of the reported information tables, diagrams and comments can be used. Tables are an option to present a larger volume of data and are thus especially suitable for data rows and developments. Diagrams on the other hand allow an intuitive comprehen-

sion of the presented facts. It is important that the chosen type of diagram (e.g. columns, line charts, pie charts, or waterfall diagrams) best possible reflect the related facts. Additionally it may be useful to verbally formulate essential qualitative facts and findings and to add them as a comment [23].

3. Empirical Study

Based on conceptional considerations and the established hypotheses, the results of the empirical studies will be presented in this section. First, aspects regarding the methodology of the study will be described in further detail. Afterwards, the results of field study will be presented in two steps: First, the differences regarding the design of the monthly reports, which is the subject of hypothesis 1, will be examined. In a second step, the quality of the examined reports will be presented from the point of view of the recipients, and potentials for improving the reports will be shown (Hypothesis 2).

3.1 Methodology of Examination and Approach

The field study [26] presented in this paper was carried out in 2004. It examines the monthly report system of seven leading German enterprises which are active in different industrial sectors. The study is intended to facilitate the identification of the characteristics of the monthly reporting that are common in all companies. A commonality of all companies is their leading position in their respective market - all companies hold European and worldwide top positions.

An essential component of the study was the detailed comparison of the monthly reports supplied to the corporate management by management accounting. Due to the amount and high sensitivity of the information to be examined it was necessary to limit the scope of the sample inspection to these reports. Since the information contained in the reports is subject to confidentiality, the companies taking part in the study provided us reports from which one could read the type of information and the layout; however which did not contain any data.

In addition to the analysis of the documents, 22 personal interviews were held during the field study with both authors and recipients of reports of the companies involved. As authors of reports, management accountants (controllers) of the central management accounting department were interviewed. In order to gain the opinion of recipients, interviews with top managers of the corporate headquarters were held. Moreover, standardized questionnaires, which had been verified in pre-tests, were used in order to gain assessments regarding the monthly report of both the authors and the recipients on a broader basis.

3.2 Design of the Monthly Reports

Hypothesis 1 implies that, due to different requirements, monthly reports highly differ in their design. The following statements support this hypothesis in most parts. Since the study is focused on the examination of the monthly reports corporate management accounting supplies to the top management, the design aspects author and recipient, reporting cycle and type of report are similar in all examined reports. Nevertheless are there significant differences as to the purpose, form and content of the reports.

As far as the intended *purpose of the report* is concerned, it must be pointed out that in all companies, information is the superordinate purpose that prevails. This purpose of the report is however put into practice in different ways: In one of the companies of the study, the monthly report is mainly used as a reference guide, while the other companies primarily use it as a short overview of the current business development.

The *form of the report*, *i.e.* the volume of the reports as well as their design and presentation, highly differs. Regarding the determination of the volume or length of a report there seems to be a conflict between comprehensively informing the management and focusing the attention of the management on the key facts. This conflict is also mirrored in the analyzed reports (**Figure 1**). The volume of the reports ranges between 5 and 295 pages. Companies with a short monthly report in particular use this report primarily as a brief information (Point 4.0 on a total scale of 7). The company with the longest report by far, uses the report as both a reference guide and as a short overview of the current business development.

The components examined as the design features of the reports included the number density and the color design. The number density of the examined reports varies between 43 and 300 numbers per page. It is also noticeable that the number density is not proportional to the volume of the report. While the shortest report also shows the lowest number density, the second shortest report reaches the highest number density (with an average of over 300 numbers per page). The use of colors

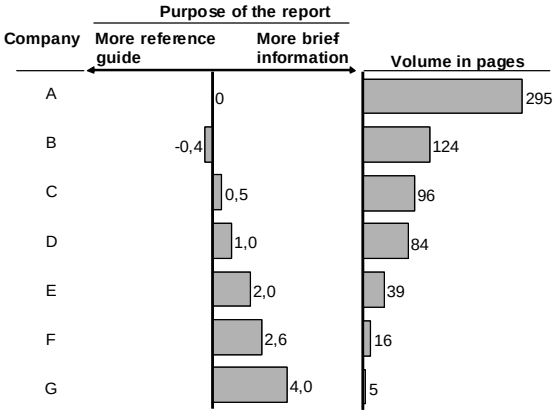

Figure 1. Purpose of the report and number of pages

shows an incoherent picture. While three companies do without any color design, four companies make use of this option to make their reports visually appealing.

The last formal design feature to be mentioned is the form of presentation. As can be seen in **Figure 2**, the use of the available presentation forms – tables, diagrams and comments – strongly varies. The analysis of the seven reports shows that a larger proportion of diagrams and comments are corresponding with a larger report volume.

In summing up, the reports examined in the field study can be clustered in three groups according to their volume and presentation form – the comprehensive type, the short type and the well-structured type (**Figure 3**). Four out of the seven examined companies have developed well-structured monthly reports. Two companies write short reports. One monthly report may be characterized as comprehensive.

The design of the content of a report is subsumed under the features structure, objective of the information, type of information and related subject of the information. As far as the structure is concerned it must be emphasized that the structure of all reports corresponds to corporate structure. They start with an overview of the corporation before providing further details on the individual divisions. Four out of seven reports do have a table of contents. In addition to an organization-oriented structure, one company also reports according to geographical regions. A view on the organizational units focused in the reports shows that the proportion of information exploring the corporate level, the sub-group level and the product and sales level respectively do vary considerably. While one company uses 92% of the report content for data coming from decentralized corporate divisions, another company only uses 20% for such data.

As expected, the financial key performance indicatiors (KPIs) prevail in all monthly reports as far as the objective of the examined information is concerned. With 54% to 100%, their proportional range is relatively high. The analysis of the reports resulted in the following illustration showed in **Figure 4**.

The illustration demonstrates that financial KPIs do prevail in all corporations. However, the extent to which financial KPIs are prioritized does vary. While company G does completely without the report of non-financial KPIs, such figures account for almost half of the reported KPIs in company F. Among the non-financial KPIs, process KPIs often plays a prominent role.

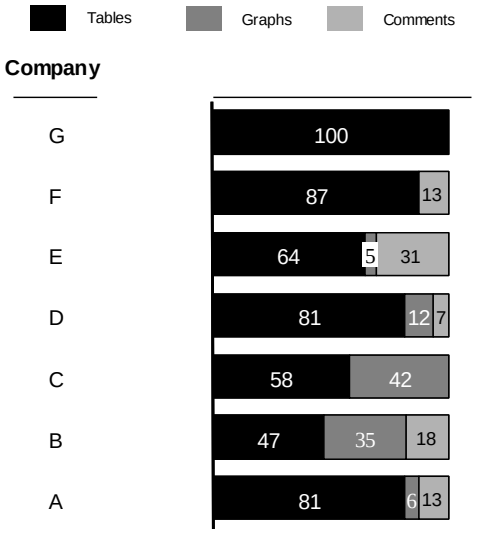

Figure 2. Presentation form of the reports

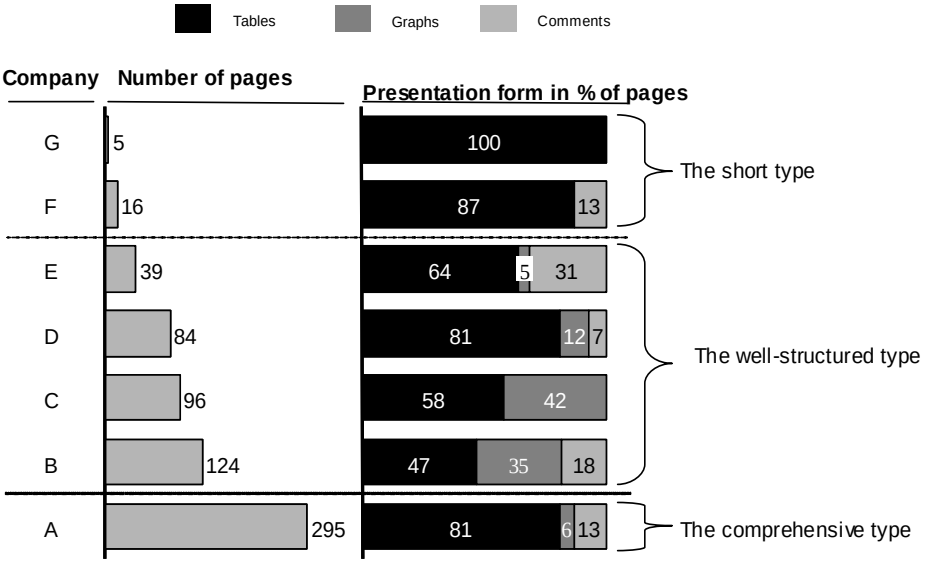

Figure 3. Types of reports

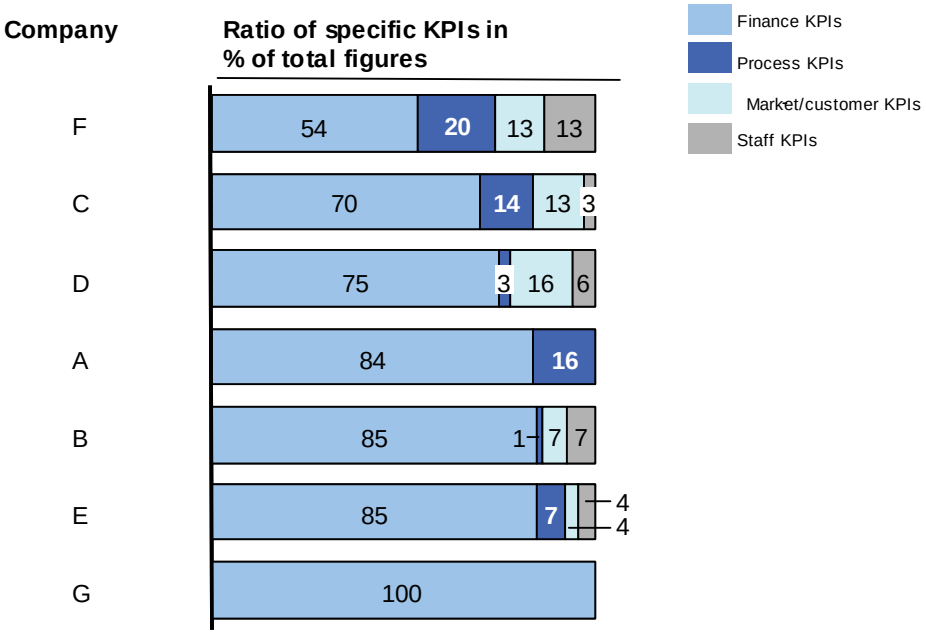

Figure 4. Information objectives of the reports

The type of information was understood as the character of the statements made in the reports, *i.e.* if these statements tend to be fact-related, forecast-related, explanatory or normative. Fact-related in the sense of above said are all actual values represented in the reports. Forecast-related information can be found in the form of planning (budget) values and projections (forecasts). Planning values in the sense of target values may be also be understood as normative information. Comments frequently contain explanatory information. Depending on the design and structure of the content, they may also have a fact-related or normative character. Since fully written-out comments were not available for the analysis, it is not possible to make any statements as to the proportion of the respective type of information in the reports.

The last content-related design feature to be described is the information relatedness of the examined reports. The information relatedness largely depends on the intended purpose of the report. The purpose of information in a report correlates with the dominance of actual values. However it is also possible to use projections for information purposes if they contain information about the current expectations. Projections can also be used for planning purposes, such as the determination of production capacities. The steering purpose of a report can be fulfilled by providing the most recent forecast values. For control purposes, parameters are needed in the form of planning values to compare them with the actual values. In all examined reports the actual values were compared with the corresponding values of the previous year. With the exception of one company, all companies continuously include planning values in their reports. Projections were found in only four out of the seven companies.

As a resume, it can be said that the analyzed reports show a great variance in terms of the relevant design features of the study. Hypothesis 1 may thus be affirmed by the empirical observations.

3.3 Evaluation of the Monthly Reports

In Subsection 2.1, it was formulated in hypothesis two that the monthly report as a “product” is not sufficiently oriented towards the needs of the managers, thus, as a consequence, not sufficiently satisfying the information need of the recipients. Above said must be verified by the evaluations of the interviews with the authors of the reports (controllers) and their clients (managers).

In the interviews held with the managers as the recipients of the reports they were also asked questions regarding their pattern of use, apart from questions concerning their information need. Additionally, a questionnaire with the same content was filled out by the authors of the reports who had been asked to assess the information need and behavior of the managers. This method allows a comparison of the statements made by the recipients with the assessment of the authors of the reports. Thus, it can be verified if or to what extent the authors of the reports are aware of the fact that their reports may possibly deviate from the ideal report design which should be oriented towards the subjective information need of the recipients; and if such deviations are accepted, for instance for financial reasons. Major deviations in the assessments also lead to the assumption that there is an increased need for communication between the recipients

and the authors.

In marketing, the assessments of the importance of and the satisfaction with certain product features are compared in a so-called importance-satisfaction matrix, a widely used marketing instrument [27]. As a rule, the importance of a product feature is mapped on the horizontal axis and the corresponding value of satisfaction is mapped on the vertical axis. Starting from the hypothesis that the most essential quality features of a product also should be fulfilled to the best satisfaction of the customer, it follows that ideally, all points marked in the importance/satisfaction matrix should be on or above the angle bisector starting from the origin of the coordinate system. Any criteria above the angle bisector may therefore be considered uncritical. In view of their importance, the satisfaction with these features is sufficient. The opposite applies for products below the angle bisector. The satisfaction reached is not sufficient considering the importance of the feature. The greater the distance of a point from the angle bisector, the more critical this aspect is evaluated by the recipient and the more urgent measures should be taken to improve the situation. The importance-satisfaction matrix is therefore an instrument to identify and visualize the fulfillment of the subjective information need of the recipients. The visualization offers starting points for the improvement of certain report features.

In the field study, the evaluations of the recipients regarding various content-related and formal design features of the monthly reports were inquired based on a scale ranging from 1 (very low) to 7 (very high) and then written into an importance/satisfaction matrix. **Figure 5** shows the importance/satisfaction matrix for company B as an example.

From the illustration follows that the managers of company B receiving the reports are primarily dissatisfied with the key figures presented in the monthly report. They assess the importance of comments as very high; their practical implementation however does not meet their expectations. The volume of the monthly report as well as the replies to questions are however adequate from the point of view of the recipients. The graphic design as a quality feature is even over-fulfilled (as related to its importance).

Based on this exemplary approach shown for company B, specific deviations between the actual design of the reports and ideal design derived from the subjective information need of the recipients could be found in each of the companies - a fact indicating potential for improvement. For instance do the monthly reports of companies C and F do not meet the needs of the managers, especially as far as their structural overview is concerned. Company D has complaints concerning both the content and the kind of data reported. Moreover, the members of the board of this company explicitly criticize that the reports as designed by the management accounting department, do only insufficiently consider their requirements. Moreover, the parallel interviews held with questionnaires given to the authors of the reports makes it clear that their assessment of the information need of the recipients is distinctly different from the assessment of the recipients themselves. The potentials for improvement deviated from the interviews with the recipients were largely unknown to the authors of the report, instead, the authors saw other potentials for improvement than the recipients.

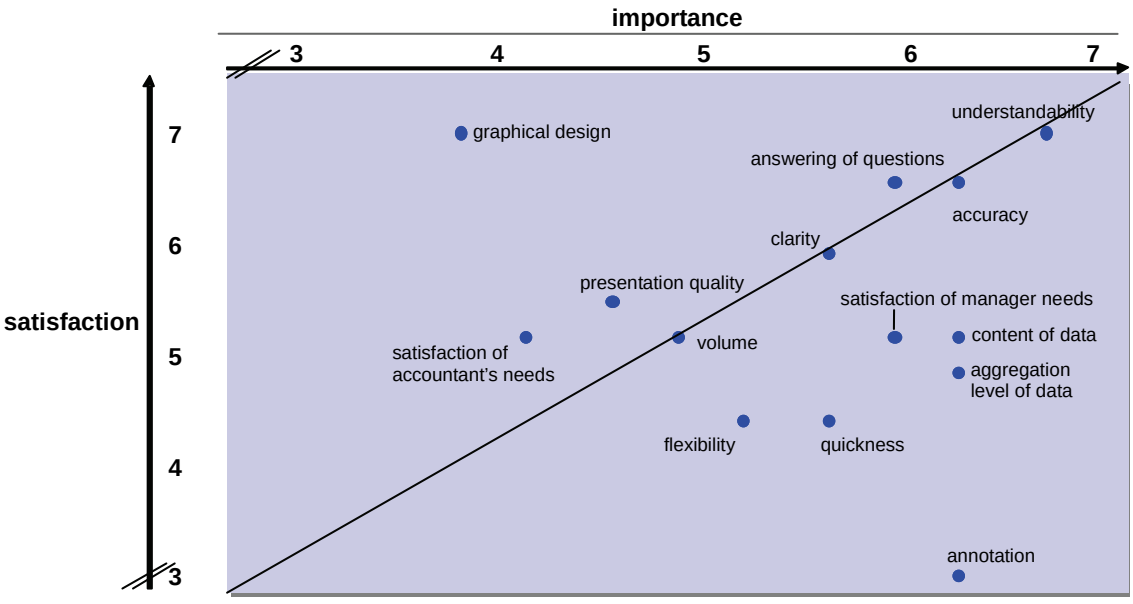

Figure 5. Importance/satisfaction matrix in relation to the monthly report of company B

Beyond the merely corporate-specific potentials for improvement some design aspects could be identified for which there is a need for improvement in all or at least most of the examined companies. This implies typical problems regarding the reporting systems in the examined companies. In all examined companies, the assessment of the annotation was "in the red" of the importance/satisfaction matrix. Further results from the questionnaires and the interviews indicate that on one hand, an increase of the proportion of comments is requested. On the other hand, the quality of the content of the comment needs to be improved, too. A first starting point for such improvement would be a more systematic use of comments; *i.e.* they should only be used for extraordinary facts or situations which are also of major economic relevance.

The features concerning the volume and graphic design, which were particularly positively evaluated in company B, also reached high satisfaction values in all other companies considering the importance attached to them. In spite of the broad diversification of the volume ranging from 5 to 295 pages, the volume seems to be well adjusted to the subjective need of the recipients. Also, the graphic design apparently is not an issue regarding the question if there should be a fixed portion of graphics, since this varies between 0 and 42%. The authors of the reports seem to have developed a good feeling for the needs of the recipients.

In winding up, it can be said that the examination of the subjective information need and in particular, the application of the importance/satisfaction matrix as a marketing instrument helped reveal potentials for improvement for the individual monthly reports that were examined within the framework of this field study. The results supports the assumption formulated in hypothesis two, *i.e.* that the product "Monthly Report" established by management accounting does not yet sufficiently consider the needs of managers as internal clients.

4. Conclusions

The existing field study provides an overview of the current situation of the internal monthly reporting to the management of some selected large German companies. The field study examined the monthly reports of seven companies. Additionally, interviews were held in these seven companies. Due to the limited scope of sample inspections no universally valid statements can be made based on these data. Nevertheless, in our opinion, the existing study bears a large heuristic potential which should be verified in future large-number studies. However, this approach is probably not easy to put into practice, due to the sensibility and complexity.

The field study could show that the monthly reports in the various companies do have different designs. Possible reasons for this variability in the design could be the orientation of the report design towards the situation-dependent environment, but also other factors, like a historical path-dependence of the design.

However, a consequent and systematic orientation of the report design towards the different information needs of the recipients does apparently not exist. Within the framework of the field study, the analysis of the subjective information need of the recipients showed that the current design of the monthly reports deviates from the ideal design which can be derived from the subjective information need. It was thus possible to show corporate-specific potentials for improvement for all companies examined in the field study.

Moreover, some potential for improvement applying to all companies could be ascertained for the reporting system. The current state of annotations and comments is particularly criticized in all examined companies. There are various reasons that may cause difficulties for controllers writing comments. It may be that controllers are more familiar with quantitative information in the form of numbers, thus having problems with a verbal presentation of qualitative information. Moreover, the interviews held during the field studies also revealed that both time pressure and a lack of insight into the operative business to be commented make it difficult to write clear annotations or comments.

As a resume, it can be said that the results of the studies show that the orientation of the design of management reports towards the subjective information need of the recipient seems to be a promising approach to reveal potentials for improvement within the reporting system. By means of this approach which has been derived from this theoretical basis it was possible to show that management reports are not well-adjusted to the requirements and needs of their recipients, and moreover, that this approach helps gaining specific clues as to how to improve the design of a report. Also, the interviews held with both the authors and recipients of such report made it clear that the conception of management reports is frequently characterized by a "trial and error" process. A systematic communication between the authors and users concerning the structure of the reports hardly takes place. Above said supports the findings that this would be a starting point for an improved structural design of management reports.

REFERENCES

[1] F. Hoffmann, "Merkmale der Führungsorganisation Amerikanischer Unternehmen," *Zeitschrift für Führung und Organisation*, Vol. 41, No. 3, 1972. pp. 3-8, 85-89, 145-148.

[2] A. Heigl, "Controlling - Interne Revision," The University of Texas at Brownsville, Brownsville, 1989.

[3] B. Huch, "Informationssysteme im Operativen Controlling – Rechnungswesen und Berichtswesen," *Kostenre-*

chnungsp Raxis, Vol. 28, No. 5, 1984, pp. 103-109.

[4] S. Neuhäuser-Metternich and F.-J. Witt, "Kommunikation und Berichtswesen," Beck Juristischer Verlag, München, 2000.

[5] T. Reichmann, "Controlling mit Kennzahlen und Managementberichten: Grundlagen Einer Systemgestützten Controlling Konzeption," Vahlen Verlag, Vahlen, 2001.

[6] Amshoff, "Controlling in Deutschen Unternehmungen: Realtypen, Kontext und Effizienz," Gabler, Wiesbaden, 1993.

[7] J. Weber, U. David and C. Prenzler, "Controller Excellence," Wearable Hemo-Ultrafiltratiin, Otto Beisheim, 2001.

[8] I. Göpfert, "Berichtswesen," In: H.-U. Küpper and A. Wagenhofer, *Handwörterbuch Unternehmensrechnung und Controlling*, 4th Edition, SchäfferPoeschel, 2002, pp. 143-155.

[9] E. Scheffler, "Das Konzerninterne Berichtswesen als Grun- dlage für ein Effizientes Konzern-Controlling," In: K. Küting and C.-P. Weber, *Konzernmanagement*: *Rechnung - Swesen und Controlling*, SchäfferPoeschel, 1993, pp. 303-317.

[10] M. Haberstroh and W. Papperitz, "Berichtswesen: Schnelligkeit als Wesentliche Anforderung des Controlling," *Controlling*, Vol. 4, 1992, pp. 12-19.

[11] G. Steinbichler, "Das Berichtswesen im Internationalen Unternehmen: Gestaltungsmöglichkeiten für das Controlling," *Controlling*, Vol. 2, No. 2, 1990, pp. 144-147.

[12] H.-U. Küpper and J. Weber, "Taschenlexikon Controlling," SchäfferPoeschel, Stuttgart, 2001.

[13] R. Koch, "Betriebliches Berichtswesen als Informations- und Steuerungsinstrument," Peter Lang, Wolfert, 1994.

[14] S. M. Stadler and B. E. Weißenberger, "Benchmarking des Berichtswesens," *Controlling*, Vol. 11, No. 4, 1999, pp. 5-11.

[15] J. Berthel, "Informationsbedarf," In: E. Frese, *Handwörterbuch der Organisation*, SchäfferPoeschel, 1992, pp. 872-886.

[16] F. Wall, "Planungs-und Kontrollsysteme," Gabler, Wiesbaden, 1999.

[17] T. Keller, "Enwicklung eines Anreizsystems zur Steigerung der Aufgabenbereitschaft von Informationen im Informationssystem der Unternehmung," Ph.D. Dissertation, Hamburg University, Hamburg, 1994.

[18] G. A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," *Psychological Review*, Vol. 63, No. 2, March 1956, pp. 81-97.

[19] J. Weber, B. Hirsch, S. Linder and E. Zayer, "Verhaltensorientiertes Controlling," Der Mensch im Mittelpunkt, WHU, 2003.

[20] H.-U. Küpper, "Controlling: Konzeption, Aufgaben und Instrumente," SchäfferPoeschel, 2003.

[21] C. Homburg, J. Weber, J. T. Karlshaus and R. Aust, "Interne Kundenorientierung der Kostenrechnung," Wearable Hemo-Ultrafiltratiin, 1998.

[22] C. Homburg, J. Weber, J. T. Karlshaus and R. Aust, "Interne Kundenorientierung der Kostenrechnung?" *Die Betriebswirtschaft*, Vol. 60, No. 2, pp. 241-256.

[23] J. Weber, "Einführung in das Controlling," SchäfferPoeschel, Stuttgart, 2004.

[24] A. Kieser and P. Walgenbach, "Organisation," SchäfferPoeschel, Stuttgart, 2003.

[25] R. S. Kaplan and D. Norton, "Translating Strategy into Action: The Balanced Scorecard," Harvard University Press, Cambridge, 1996.

[26] E. R. Babbie, "The Practice of Social Research," Wadsworth, Ohio, 2004.

[27] C. Homburg and H. Werner, "Kundenorientierung mit System – Mit Customer Orientation Management zu profitablem Wachstum," Frankfurt am Main *et al.*, 1998.

iBusiness, 2010, 2, 116-122
doi:10.4236/ib.2010.22014 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Inventories and Mixed Duopoly with State-Owned and Labor-Managed Firms

Kazuhiro Ohnishi

Institute for Basic Economic Science, Osaka, Japan.
Email: ohnishi@e.people.or.jp

Received February 25th, 2010; revised April 2nd, 2010; accepted May 8th, 2010.

ABSTRACT

This paper considers a two-period mixed market model in which a state-owned firm and a labor-managed firm are allowed to hold inventories as a strategic device. The paper then shows that the equilibrium in the second period occurs at the Stackelberg point where the state-owned firm is the leader.

***Keywords*:** *Inventory Investment, State-Owned Firm, Labor-Managed Firm*

1. Introduction

The analysis of mixed market models that incorporate state-owned public firms has been performed by many researchers, such as [1-16].[1] However, these studies consider mixed market models in which state-owned firms compete with profit-maximizing capitalist firms, and do not include labor-managed firms.

Mixed market models that incorporate labor-managed firms have also been studied by many researchers, such as [22-34].[2] However, these studies consider mixed market models in which labor-managed firms compete against profit-maximizing capitalist firms, and do not include state-owned firms.

Some studies examine mixed market models with state-owned and labor-managed firms. For example, Delbono and Rossini [40] explore the creation of 1) a duopoly formed by a labor-managed firm and a state-owned firm in a Cournot-Nash setting, and 2) a horizontal merger between the same agents. In addition, Ohnishi [41] investigates the behaviors of a state-owned firm and a labor-managed firm in a two-stage mixed market model with capacity investment as a strategic instrument. There are few studies that examine mixed market models with state-owned and labor-managed firms.

Therefore, we consider a two-period mixed market model in which a state-owned firm and a labor-managed firm can hold inventories as a strategic device.[3] In the first period, each firm simultaneously and independently chooses how much it sells in the current market and the level of inventory it holds for the second-period market. We analyze the equilibrium of the mixed duopoly model, and show that the equilibrium in the second period occurs at the Stackelberg point where the state-owned firm is the leader.

The remainder of this paper is organized as follows. In Section 2, we describe the model. Section 3 gives supplementary explanations of the model. Section 4 analyzes the equilibrium of the model. Section 5 concludes the paper. All proofs are given in the appendix.

2. The Model

Let us consider a mixed market with one state-owned welfare-maximizing firm (firm 1) and one labor-managed profit-per-worker-maximizing firm (firm 2), producing perfectly substitutable goods. There is no possibility of entry or exit. In the remainder of this paper, subscripts 1 and 2 refer to firms 1 and 2, respectively, and superscripts 1 and 2 refer to periods 1 and 2, respectively. In addition, when i and j are used to refer to firms in an expression, they should be understood to refer to 1 and 2 with $i \neq j$. The price of each period is determined by $P(S^t)$, where $S^t = \sum_{i=1}^{2} s_i^t$ is the aggregate sales of each period. We assume that $P' < 0$ and $P'' \leq 0$. The game runs as follows. In the first period, each firm simultaneously and independently chooses its first-period production $q_i^1 \in [0, \infty)$ and its first-period sales $s_i^1 \in [0, q_i^1]$.

[1] See [17-21] for excellent surveys.
[2] The pioneering work on a theoretical model of a labor-managed firm is conducted by Ward [35]. See also [36-39] for excellent surveys.
[3] For private market models with inventories as a strategic device, see Rotemberg and Saloner [42] and Matsumura [43].

Firm i's inventory I_i^1 becomes $q_i^1 - s_i^1$. At the end of the first period, firm i knows q_j^1 and s_j^1. In the second period, each firm simultaneously and independently chooses its second-period production $q_i^2 \in [0,\infty)$. At the end of the second period, each firm sells $s_i^2 = I_i^1 + q_i^2$ and holds no inventory. For notational simplicity, we consider the game without discounting.

Since $\sum_{t=1}^{2} q_i^t = \sum_{t=1}^{2} s_i^t$, social welfare is

$$W = \sum_{t=1}^{2}\left[\int_0^{S^t} P(x)dx - c_1 q_1^t - c_2 q_2^t\right] = \sum_{t=1}^{2}\left[\int_0^{S^t} P(x)dx - c_1 s_1^t - c_2 s_2^t\right], \quad (1)$$

where $c_i \in (0,\infty)$ denotes firm i's constant marginal cost. The demand and cost conditions that firms face remain unchanged over time. We assume that firm 1 is less efficient than firm 2, *i.e.* $c_1 > c_2$.[4] We define

$$w^t \equiv \int_0^{S^t} P(x)dx - c_1 s_1^t - c_2 s_2^t. \quad (2)$$

Furthermore, since $\sum_{t=1}^{2} q_2^t = \sum_{t=1}^{2} s_2^t$, firm 2's profit per worker is

$$\Phi_2 = \sum_{t=1}^{2}\left[\frac{P(S^t)s_2^t - c_2 q_2^t - f_2}{l_2(s_2^t)}\right] = \sum_{t=1}^{2}\left[\frac{P(S^t)s_2^t - c_2 s_2^t - f_2}{l_2(s_2^t)}\right] \quad (3)$$

where $f_2 \in (0,\infty)$ is firm 2's fixed cost, and l_2 is the amount of labor in firm 2. We assume that l_2 is the function of s_2^t with $l_2' > 0$ and $l_2'' > 0$. This assumption means that the marginal quantity of labor used is increasing. We define

$$\phi_2^t \equiv \frac{P(S^t)s_2^t - c_2 s_2^t - f_2}{l_2(s_2^t)}. \quad (4)$$

We analyze the subgame perfect Nash equilibrium of the mixed market model.

3. Supplementary Explanation

In this section, we give supplementary explanations of the model described in the previous section. First, we derive firm 1's reaction functions from (2). In the first period, since there is no inventory available, firm 1's reaction function is defined by

$$R_1^1(s_1^1) = \arg\max_{\{s_1^1 \geq 0\}}\left[\int_0^{S^1} P(x)dx - c_1 s_1^1 - c_2 s_2^1\right] \quad (5)$$

In the second period, firm 1's reaction function without inventory is defined by

$$R_1^2(s_1^2) = \arg\max_{\{s_1^2 \geq 0\}}\left[\int_0^{S^2} P(x)dx - c_1 s_1^2 - c_2 s_2^2\right] \quad (6)$$

and thus its best response is shown as follows:

$$\bar{R}_1^2(s_2^2) = \begin{cases} R_1^2(s_2^2) & \text{if } s_1^2 > I_1^1, \\ I_1^1 & \text{if } s_1^2 = I_1^1. \end{cases} \quad (7)$$

Firm 1 maximizes social welfare with respect to s_1^t, given s_2^t. When the inventory is zero, the first-order condition for firm 1 is

$$P - c_1 = 0. \quad (8)$$

Furthermore, we have

$$R_1^t{}'(s_2^t) = -\frac{P'}{P'}. \quad (9)$$

In the first period, the slope of the reaction function of firm 1 is –1. In the second period, the slope of the best response of firm 1 is –1 for $s_1^2 > I_1^1$, and it is zero for $s_1^2 = I_1^1$. This means that firm 1 treats s_1^t as strategic substitutes.[5]

Second, we derive firm 2's reaction functions from (4). In the first period, since there is no inventory available, firm 2's reaction function is defined by

$$R_2^1(s_1^1) = \arg\max_{\{s_2^1 \geq 0\}}\left[\frac{P(S^1)s_2^1 - c_2 s_2^1 - f_2}{l_2(s_2^1)}\right]. \quad (10)$$

In the second period, firm 2's reaction function without inventory is defined by

$$R_2^2(s_1^2) = \arg\max_{\{s_2^2 \geq 0\}}\left[\frac{P(S^2)s_2^2 - c_2 s_2^2 - f_2}{l_2(s_2^2)}\right], \quad (11)$$

and thus its best response is shown as follows:

$$\bar{R}_2^2(s_1^2) = \begin{cases} R_2^2(s_1^2) & \text{if } s_2^2 > I_2^1, \\ I_2^1 & \text{if } s_2^2 = I_2^1. \end{cases} \quad (12)$$

Firm 2 maximizes its profit per worker with respect to s_2^t, given s_1^t. The equilibrium must satisfy the following conditions: When the inventory is zero, the first-order condition for firm 2 is

[4]This assumption is justified in Nett [2,21] and Gunderson [44], and is often used in literature studying mixed markets. See, for instance, George and La Manna [5], Mujumdar and Pal [7], Pal [8], Nishimori and Ogawa [11], Matsumura [13], Ohnishi [14], and Fernández-Ruiz [16]. If firm 1 is equally or more efficient than firm 2, then firm 1 chooses q_1^t and s_1^t such that price equals marginal cost. Therefore, firm 2 has no incentive to operate in the market, and firm 1 supplies the entire market, resulting in a social-welfare-maximizing public monopoly. This assumption is made to eliminate such a trivial solution.

[5]The concepts of strategic substitutes and complements are due to Bulow, Geanakoplos, and Klemperer [45].

$$(P's_2^t + P - c_2)l_2 - (Ps_2^t - c_2 s_2^t - f_2)l_2' = 0, \quad (13)$$

and the second-order condition is

$$(P"s_2^t + 2P')l_2 - (Ps_2^t - c_2 s_2^t - f_2)l_2" < 0. \quad (14)$$

Furthermore, we have

$$R_2^t'(s_1^t) = -\frac{P"s_2^t l_2 + P'(l_2 - s_2^t l_2')}{(P"s_2^t + 2P')l_2 - (Ps_2^t - c_2 s_2^t - f_2)l_2"}. \quad (15)$$

Since $l_2" > 0$, $l_2 - s_2^t l_2' < 0$, so that $P"s_2^t l_2 + P'(l_2 - s_2^t l_2')$ is positive; that is, $R_2^t(s_1^t)$ is upward sloping. This means that firm 2 treats s_2^t as strategic complements.

Third, we consider Stackelberg games. If firm 1 is the Stackelberg leader, then firm 1 selects s_1^t, and firm 2 selects s_2^t after observing s_1^t. Firm 1 maximizes $w^t(s_1^t, R_2^t(s_1^t))$ with respect to s_1^t. On the other hand, if firm 2 is the Stackelberg leader, then firm 2 selects s_2^t, and firm 1 selects s_1^t after observing s_2^t. Firm 2 maximizes $\phi_2^t(s_2^t, R_1^t(s_2^t))$ with respect to s_2^t. We present the following lemma:

Lemma 1. Each firm's Stakelberg leader sales exceed its Cournot sales without inventory.

Lemma 1 means that each firm prefers sales higher than its Cournot sales without inventory.

4. Equilibrium

In this section, we analyze the equilibrium outcomes of the mixed market model. The equilibrium in the first period is stated by the following proposition:

Proposition 1. In the first-period of the mixed market model, the equilibrium coincides with the Cournot Nash solution without inventory (N_1, N_2).

The intuition behind Proposition 1 is as follows. There is no inventory available in the first period, and further s_i^1 does not affect s_i^2 and s_j^2. Since w^1 and ϕ_2^1 decrease by deviating from the Cournot Nash solution, each firm has no incentive to do so, and therefore the equilibrium is at (N_1, N_2).

We now consider the equilibrium of the second period. It is thought that the equilibrium of the second period is decided by the level of I_i^1. We discuss the following three cases:

1) The case in which only firm 1 can hold inventory
2) The case in which only firm 2 can hold inventory
3) The case in which each firm can hold inventory

We discuss these cases in order.

1) The case in which only firm 1 can hold inventory

First, consider **Figure 1**, where R_i^2 denotes firm i's second-period reaction curve without inventory. R_1^2 is downward sloping, whereas R_2^2 is upward sloping. Suppose that firm 1 holds I_1^{1A} in the second period. By holding inventory, firm 1's best response becomes (7). Firm 1's inventory investment thus creates a kink in its reaction curve at the level of I_1^{1A}. That is, firm 1's reaction curve becomes the kinked bold lines as drawn in the figure. The equilibrium is decided in a Cournot fashion, *i.e.*, the intersection of firm 1's and firm 2's reaction curves gives us the equilibrium of the game. **Figure 1** shows that the intersection of new reaction curves is not affected by the kink. Hence, the equilibrium occurs at N.

Next, consider **Figure 2**. Suppose that firm 1 holds I_1^{1B}. From (7), firm 1's reaction curve becomes the kinked bold lines. The intersection of firm 1's and firm 2's reaction curves gives us the equilibrium of the game.

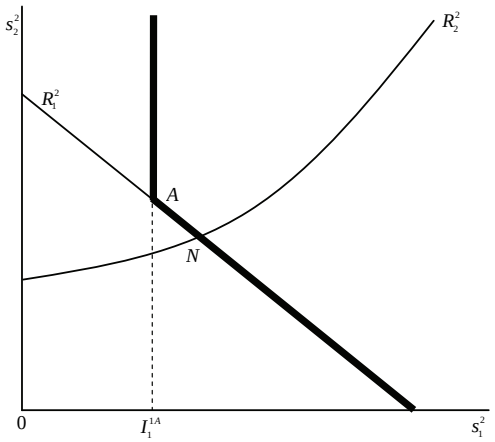

Figure 1. The equilibrium occurs at *N*

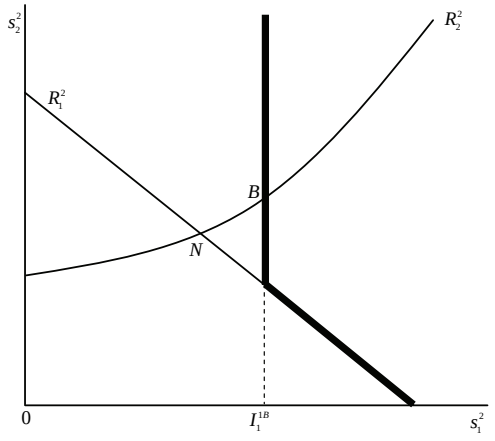

Figure 2. The equilibrium occurs at *B*

From **Figure 2**, we see that the inventory level of I_1^{1B} changes the equilibrium of the game. The intersection of the new reaction curves is the equilibrium sales in the second period. That is, if firm 1 holds I_1^{1B}, then the equilibrium occurs at B.

We can now state the following proposition:

Proposition 2. Suppose that only firm 1 can hold inventory. Then the equilibrium coincides with the Stackelberg solution where firm 1 is the leader.

2) The case in which only firm 2 can hold inventory

First, consider **Figure 3**. Suppose that firm 2 holds I_2^{1D}. From (12), firm 2's reaction curve becomes the kinked bold broken lines. In this figure, the reaction curves of both firms do not cross each other. That is, if firm 2 maintains the inventory level of I_2^{1D}, then there is no solution.

Next, consider **Figure 4**. Suppose that firm 2 holds I_2^{1E}. From (12), firm 2's reaction curve becomes the kinked bold broken lines. The reaction curves of both firms cross twice as in **Figure 4**. We can see easily that N and E are stable solutions. That is, there are two stable solutions. However, we see that firm 2's profit per worker is higher at N than at E.

We can now state the following proposition:

Proposition 3. Suppose that only firm 2 can hold inventory. Then the equilibrium coincides with the Cournot Nash solution without inventory (N_1, N_2).

3) The case in which each firm can hold inventory

First, consider **Figure 5**. Suppose that firms 1 and 2 hold I_1^{1F} and I_2^{1G}, respectively. In this figure, the reaction curves of both firms do not cross each other. That is, if firms 1 and 2 maintain the inventory levels of I_1^{1F} and I_2^{1G}, respectively, then there is no solution.

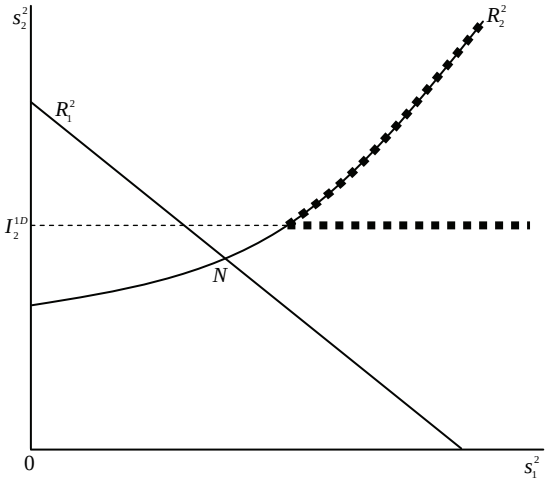

Figure 3. The reaction curves do not cross each other

Next, consider **Figure 6**. Suppose that each firm holds I_i^{1H}. Firm 1's reaction curve becomes the kinked bold

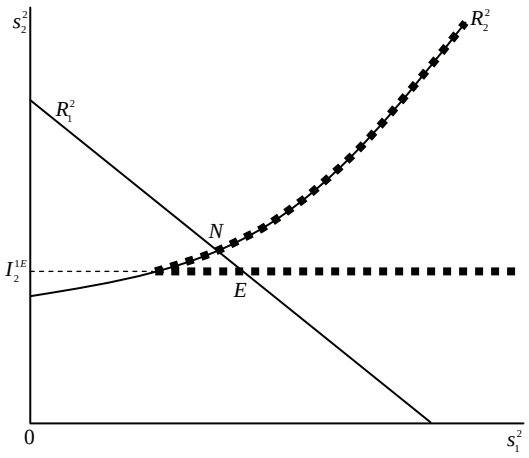

Figure 4. The reaction curves cross twice

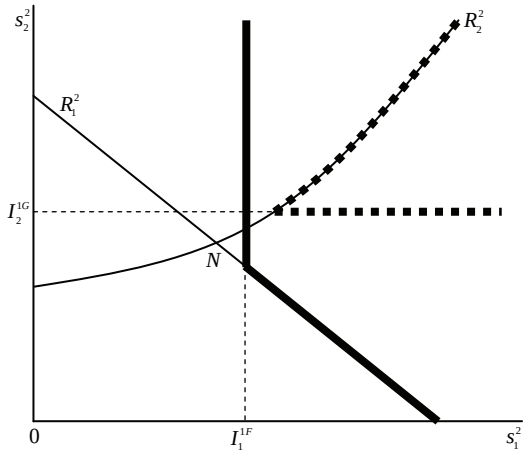

Figure 5. The new reaction curves do not cross each other

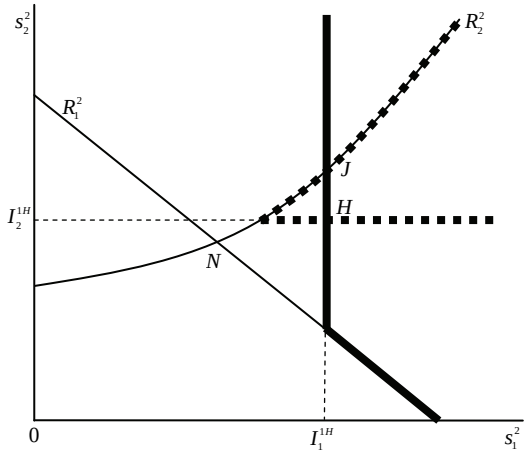

Figure 6. The new reaction curves cross twice

lines, and firm 2's reaction curve becomes the kinked bold broken lines. The new reaction curves of both firms cross twice. We see easily that H and J are stable solutions. That is, there are two stable solutions. However, we see that firm 2's profit per worker is higher at N than at these points.

The main result of this study is described by the following proposition:

Proposition 4. In the second period of the mixed market model, the equilibrium coincides with the Stackelberg solution where firm 1 is the leader. At equilibrium, firm 2's profit per worker is lower than in the Cournot mixed duopoly game without inventory.

5. Conclusions

We have considered a two-period mixed market model in which a state-owned firm and a labor-managed firm are allowed to hold inventories as a strategic device. We have then shown that the equilibrium in the second period occurs at the Stackelberg point where the state-owned firm is the leader and at equilibrium the labor-managed firm's profit per worker is lower than in the Cournot mixed duopoly game without inventory. As a result, we see that the introduction of inventory investment into the analysis of mixed market competition with state-owned and labor-managed firms is profitable for the state-owned firm while it is not profitable for the labor-managed firm.

REFERENCES

[1] F. Delbono and V. Denicolò, "Regulating Innovative Activity: The Role of Public Firm," *International Journal of Industrial Organization*, Vol. 11, No. 1, March 1993, pp. 35-48.

[2] L. Nett, "Why Private Firms are more Innovative than Public Firms," *European Journal of Political Economy*, Vol. 10, No. 4, December 1994, pp. 639-653.

[3] J. Willner, "Welfare Maximization with Endogenous Average Costs," *International Journal of Industrial Organization*, Vol. 12, No. 3, September 1994, pp. 373-386.

[4] K. Fjell and D. Pal, "A Mixed Oligopoly in the Presence of Foreign Private Firms," *Canadian Journal of Economics*, Vol. 29, No. 3, August 1996, pp. 737-743.

[5] K. George and M. La Manna, "Mixed Duopoly, Inefficiency, and Public Ownership," *Review of Industrial Organization*, Vol. 11, No. 6, December 1996, pp. 853-860.

[6] M. D. White, "Mixed Oligopoly, Privatization and Subsidization," *Economics Letters*, Vol. 53, No. 2, November 1996, pp. 189-195.

[7] S. Mujumdar and D. Pal, "Effects of Indirect Taxation in a Mixed Oligopoly," *Economics Letters*, Vol. 58, No. 2, February 1998, pp. 199-204.

[8] D. Pal, "Endogenous Timing in a Mixed Oligopoly," *Economics Letters*, Vol. 61, No. 2, November 1998, pp. 181-185.

[9] D. Pal and M. D. White, "Mixed Oligopoly, Privatization, and Strategic Trade Policy," *Southern Economic Journal*, Vol. 65, No. 2, April 1998, pp. 264-281.

[10] J. Poyago-Theotoky, "R & D Competition in a Mixed Duopoly under Uncertainty and Easy Imitation," *Journal of Comparative Economics*, Vol. 26, No. 3, September 1998, pp. 415-428.

[11] A. Nishimori and H. Ogawa, "Public Monopoly, Mixed Oligopoly and Productive Efficiency," *Australian Economic Papers*, Vol. 41, No. 2, June 2002, pp. 185-190.

[12] J. C. Bárcena-Ruiz and M. B. Garzón, "Mixed Duopoly, Merger and Multiproduct Firms," *Journal of Economics*, Vol. 80, No. 1, August 2003, pp. 27-42.

[13] T. Matsumura, "Stackelberg Mixed Duopoly with a Foreign Competitor," *Bulletin of Economic Research*, Vol. 55, No. 3, July 2003, pp. 275-287.

[14] K. Ohnishi, "A Mixed Duopoly with a Lifetime Employment Contract as a Strategic Commitment," *FinanzArchiv*, Vol. 62, No. 1, March 2006, pp. 108-123.

[15] J. C. Bárcena-Ruiz, "Endogenous Timing in a Mixed Duopoly: Price Competition," *Journal of Economics*, Vol. 91, No. 3, July 2007, pp. 263-272.

[16] J. Fernández-Ruiz, "Managerial Delegation in a Mixed Duopoly with a Foreign Competitor," *Economics Bulletin*, Vol. 29, No. 1, February 2009, pp. 90-99.

[17] D. Bös, "Public Enterprise Economics," Dieter Bos, North-Holland, 1986.

[18] D. Bös, "Privatization: A Theoretical Treatment," Clarendon Press, Oxford, 2001.

[19] J. Vickers and G. Yarrow, "Privatization: An Economic analysis," MIT Press, Cambridge, 1988.

[20] H. Cremer, M. Marchand and J.-F. Thisse, "The Public firm as an Instrument for Regulating an Oligopolistic Market," *Oxford Economic Papers*, Vol. 41, No. 1, January 1989, pp. 283-301.

[21] L. Nett, "Mixed Oligopoly with Homogeneous Goods," *Annals of Public and Cooperative Economics*, Vol. 64, No. 3, July 1993, pp. 367-393.

[22] C. Mai and H. Hwang, "Export Subsidies and Oligopolistic Rivalry between Labor-Managed and Capitalist Economies," *Journal of Comparative Economics*, Vol. 13, No. 3, September 1989, pp. 473-480.

[23] I. Horowitz, "On the Effects of Cournot Rivalry between Entrepreneurial and Cooperative Firms," *Journal of Comparative Economics*, Vol. 15, No. 1, March 1991, pp. 115-121.

[24] K. Okuguchi, "Labor-Managed and Capitalistic Firms in International Duopoly: The Effects of Export Subsidy," *Journal of Comparative Economics*, Vol. 15, No. 3, September 1991, pp. 476-484.

[25] H. Cremer and J. Crémer, "Duopoly with Employee-Controlled and Profit-Maximizing Firms: Bertrand vs. Cournot Competition," *Journal of Comparative Economics*, Vol. 16, No. 2, June 1992, pp. 241-258.

[26] G. Stewart, "Management Objectives and Strategic Interactions among Capitalist and Labour-Managed Firms," *Journal of Economic Behavior and Organization*, Vol. 17, No. 3, May 1992, pp. 423-431.

[27] E. Askildsen and N. J. Ireland, "Human Capital, Property right, and Labour Managed Firms," *Oxford Economic Papers*, Vol. 45, No. 2, April 1993, pp. 229-242.

[28] N. J. Ireland and G. Stewart, "On the Sale of Production Rights and Firm Organization," *Journal of Comparative Economics*, Vol. 21, No. 3, December 1995, pp. 289-307.

[29] K. Futagami and M. Okamura, "Strategic Investment: The Labor-Managed Firm and the Profit-Maximizing Firm," *Journal of Comparative Economics*, Vo. 23, No. 1, August 1996, pp. 73-91.

[30] H. M. Neary and D. Ulph, "Strategic Investment and the Co-Existence of Labour-Managed and Profit-Maximising Firms," *Canadian Journal of Economics*, Vol. 30, No. 2, May 1997, pp. 308-328.

[31] L. Lambertini and G. Rossini, "Capital Commitment and Cournot Competition with Labour-Managed and Profit-Max-Imising Firms," *Australian Economic Papers*, Vol. 37, No. 1, March 1998, pp. 14-21.

[32] L. Lambertini, "Spatial Competition with Profit-Maximising and Labour-Managed Firms," *Papers in Regional Science*, Vol. 80, No. 4, October 2001, pp. 499-507.

[33] K. Ohnishi, "Strategic Investment in a New Mixed Market with Labor-Managed and Profit-Maximizing Firms," *Meto-economica*, Vol. 59, No. 4, November 2008, pp. 594-607.

[34] T. Cuccia and R. Cellini, "Workers' Enterprises and the Taste for Production: The Arts, Sport and Other Cases," *Scottish Journal of Political Economy*, Vol. 56, No. 1, February 2009, pp. 123-137.

[35] B. Ward, "The Firm in Illyria: Market Syndicalism," *American Economic Review*, Vol. 48, No. 4, 1958, pp. 566-589.

[36] J. Ireland and P. J. Law, "The Economics of Labor-Managed Enterprises," St. Martin's Press, Macmillan, 1982.

[37] F. H. Stephan, Ed., "The Performance of Labour-Managed Firms," Macmillan Press, Macmillan, 1982.

[38] J. P. Bonin and L. Putterman, "Economics of Cooperation and the Labor-Managed Economy," Harwood Academic Publishers, Graubünden, 1987.

[39] L. Putterman, "Labour-Managed Firms," In: S. N. Durlauf and L. E. Blume, Eds., *The New Palgrave Dictionary of Economics*, Palgrave Macmillan, Vol. 4, No. 1, 2008, pp. 791-795.

[40] F. Delbono and G. Rossini, "Competition Policy vs. Horizontal Merger with Public, Entrepreneurial, and Labor-Managed Firms," *Journal of Comparative Economics*, Vol. 16, No. 2, June 1992, pp. 226-240.

[41] K. Ohnishi, "Capacity Investment and Mixed Duopoly with State-Owned and Labor-Managed Firms," *Annals of Economics and Finance*, Vol. 10, No. 1, May 2009, pp. 49-64.

[42] J. J. Rotemberg and G. Saloner, "The Cyclical Behavior of Strategic Inventories," *Quarterly Journal of Economics*, Vol. 104, No. 1, February 1989, pp. 73-97.

[43] T. Matsumura, "Cournot Duopoly with Multi-Period Competition: Inventory as a Coordination Device," *Australian Economic Papers*, Vol. 38, No. 3, September 1999, pp. 189-202.

[44] M. Gunderson, "Earnings Differentials between the Public and Private Sectors," *Canadian Journal of Economics*, Vol. 12, No. 2, May 1979, pp. 228-242.

[45] J. I. Bulow, J. D. Geanakoplos and P. D. Klemperer, "Multimarket Oligopoly: Strategic Substitutes and Complements," *Journal of Political Economy*, Vol. 93, No. 3, June 1985, pp. 488-511.

Appendix

Proof of Lemma 1

First, we prove that firm 1's Stakelberg leader sales are higher than its Cournot sales without inventory. Firm 1 maximizes $w^t(s_1^t, R_2^t(s_1^t))$ with respect to s_1^t. Therefore, firm 1's Stackelberg leader sales satisfy the first-order condition:

$$\frac{\partial w^t}{\partial s_1^t} + \frac{\partial w^t}{\partial s_2^t}\frac{\partial R_2^t}{\partial s_1^t}, \tag{16}$$

where $\partial w^t / \partial s_2^t = P - c_2$ is positive from (8) and $c_1 > c_2 > 0$, and $\partial R_2^t / \partial s_1^t$ is also positive from (10), (11) and (15). To satisfy (16), $\partial w^t / \partial s_1^t$ must be negative.

Second, we prove that firm 2's Stakelberg leader sales are higher than its Cournot sales without inventory. Firm 2 maximizes $\phi_2^t(s_2^t, R_1^t(s_2^t))$ with respect to s_2^t. Therefore, firm 2's Stackelberg leader sales satisfy the first-order condition:

$$\frac{\partial \phi_2^t}{\partial s_2^t} + \frac{\partial \phi_2^t}{\partial s_1^t}\frac{\partial R_1^t}{\partial s_2^t}, \tag{17}$$

where $\partial \phi_2^t / \partial s_1^t = P' s_1^t$ is negative from $P' < 0$, and $\partial R_1^t / \partial s_2^t$ is also negative from (5), (6) and (9). To satisfy (17), $\partial \phi_2^t / \partial s_2^t$ must be negative. Thus, the lemma follows. Q. E. D.

Proof of Proposition 1

Since s_i^1 does not affect s_i^2 and s_j^2, s_i^1 has no strategic value. Thus, the result follows easily from (5) and (10). Q. E. D.

Proof of Proposition 2

The equilibrium is decided in a Cournot fashion, *i.e.*, the intersection of firm 1's and firm 2's reaction functions gives us the equilibrium of the game. In R_2^2, social welfare is the highest at firm 1's Stakelberg leader point. Lemma 1 states that firm 1's Stakelberg leader sales exceed its Cournot sales without inventory. R_1^2 is downward sloping, whereas R_2^2 is upward sloping. From (7), we see that the equilibrium in the second period is decided by the value of I_1^1. I_1^1 can take values of zero and above. Our equilibrium concept is the subgame perfect equilibrium and all information in the model is common knowledge. In the first period, firm 1 chooses $\bar{I}_1^1 (= \bar{q}_1^1 - N_1)$ associated with its second-period Stackelberg leader solution. Thus, Proposition 2 follows. Q. E. D.

Proof of Proposition 3

Lemma 1 states that firm 2's Stakelberg leader sales exceed its Cournot sales without inventory. R_1^2 is downward sloping, whereas R_2^2 is upward sloping. From (12), if $I_2^1 \geq N_2$, then it is impossible for firm 2 to change s_2^2 in equilibrium. That is, if $I_2^1 \geq N_2$, then inventory does not function as a strategic device. Let ϕ_2^2 be assumed to be continuous and concave in s_2^2. The further a point on R_1^2 gets from firm 2's Stackelberg leader point, the more firm 2's profit per worker decreases. Thus, Proposition 3 follows Q. E. D.

Proof of Proposition 4

First, consider the possibility that firm 2 holds inventory as a strategic device. Lemma 1 states that firm 2's Stakelberg leader sales exceed its Cournot sales without inventory. R_1^2 is downward sloping, whereas R_2^2 is upward sloping. From (12), firm 2 cannot choose its Stackelberg leader point. Let ϕ_2^2 be assumed to be continuous and concave in s_2^2. The further a point on R_1^2 gets from firm 2's Stackelberg leader point, the more firm 2's profit per worker decreases. Hence, firm 2 does not choose $I_2^1 < N_2$. If $I_2^1 > N_2$ and $I_2^1 > R_2^2(I_1^1)$, then there is no solution. If $I_2^1 > N_2$ and $I_2^1 \leq R_2^2(I_1^1)$, then the solution becomes $R_2^2(I_1^1) > N_2$. However, at solution, firm 2's profit per worker is lower than in the Cournot mixed duopoly game without inventory. Hence, firm 2 does not hold inventory as a strategic device whether firm 1 holds inventory or not.

Next, consider the possibility that firm 1 holds inventory as a strategic device. Our equilibrium concept is the subgame perfect equilibrium and all information in the model is common knowledge. Hence, firm 1 knows that firm 2 does not hold inventory as a strategic device whether firm 1 holds inventory or not. Lemma 1 states that firm 1's Stakelberg leader sales exceed its Cournot sales without inventory. From (7), we see that the equilibrium in the second period is decided by the value of I_1^1. I_1^1 can take values of zero and above. In the first period, firm 1 chooses $\bar{I}_1^1 (= \bar{q}_1^1 - N_1)$ associated with its second-period Stackelberg leader solution. Thus, the equilibrium coincides with the Stackelberg solution where firm 1 is the leader.

From Lemma 1, we see that firm 1 increases s_1^2 by holding $\bar{I}_1^1 (= \bar{q}_1^1 - N_1)$ associated with its second-period Stackelberg leader solution. Since $\partial \phi_2^2 / \partial s_1^2 = P' s_2^2 < 0$, increasing s_1^2 decreases ϕ_2^2 given s_2^2, and thus Proposition 4 follows. Q. E. D.

iBusiness, 2010, 2, 123-127
doi:10.4236/ib.2010.22015 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Public Accountability: Implications of the Conspiratorial Relationship between Political Appointees and Civil Servants in Nigeria

Lanre Olu-Adeyemi[1], Tomola Marshal Obamuyi[2]

[1]Department of Political Science & Public Administration, Adekunle Ajasin University, Akungba Akoko, Nigeria; [2]Department of Banking & Finance, Adekunle Ajasin University, Akungba Akoko, Nigeria.
Email: lanreoluadeyemi@yahoo.co.uk, tomolaobamuyi@yahoo.co.uk

Received October 23rd, 2009; revised February 6th, 2010; accepted March 7th, 2010.

ABSTRACT

The paper focuses on the conspiratorial relationship between Accounting Officers and Political Appointees in Nigeria and how this merge has affected public accountability. The conspiratorial relationship has led to flagrant and deliberate abuse of best practices and due process all in a bid to steal public funds. The absence of public accountability has also increased the chances of corrupt practices by both the political appointees and civil servants. This paper advocates administrative reform and good governance, encompassing public accountability to ensure that the people are held accountable for their behaviours as a deterrent to corrupt practices.

***Keywords*:** *Accountability, Political Appointees, Civil Servants, Corruption*

1. Introduction

In contemporary Nigeria, government has ultimately become inseparable from the day to day life of the citizens. This is because government is now involved in the overall social and economic development as against its traditional role of mere maintaining law and order. Unfortunately, the resources at the disposal of governments continue to dwindle, meaning that governments have to reorder her priorities to meet the needs of the society. The implication is that both the civil servants and the political office holders must cooperate to ensure the achievement of sustainable financial and economic development. They must be responsive to the yearnings and aspirations of the people and be held accountable for their actions and inactions.

However, for some times, the influence of the political appointees has made the civil servants to neglect the issue of accountability in the work place. The World Development Report (2004) places accountability succinctly at the centre of public reform and public service delivery [1]. Public accountability measures the degree to which the community can control (hold accountable) the behaviour of public agents through political institutions [2]. Essentially, public accountability mainly regards matters in the public domain, such as the spending of public funds, the exercise of public authorities, or the conduct of public institutions [3]. Generally, the goals of all public accountability measures are to guarantee that public money is spent most judiciously to ensure that the public actually benefits from public finance. There are many dimensions of accountability found in literature. For instance, a distinction can be found between accountability and transparency [4], and between accountability and responsiveness and participation [5]. However, accountability and controllability may be equated, since an agent is accountable to a principal if the principal can exercise control over the agent [6]. Whatever the dimension from which accountability is seen, the importance is in forcing administrators to trace connections between the past, present and future [7].

In order to strengthen the accountability requirements of public sector spending in Nigeria, government had put in place many agencies to overcome the issues of corruption and wasteful spending. These anti-corruption agencies include the Independent Corrupt Practices and Other Related Offences Commission (ICPC), Economic and Financial Crimes Commission (EFCC) and the budget, due process monitoring unit, which are expected to serve as the watch dogs for public officers who may want to defraud the nation and enrich themselves illegally and hence hold them accountable to the public. For instance, the activities of EFCC have been summarized as follows [8]:

…about 350 *EFCC cases are at an advanced stage of prosecution. About* 5,000 *people have been arrested over the past three years. There have been about* 91 *convictions for various corruption crimes and assets worth over* $5 *billion have been seized, confiscated and refunded to the state and victims of crime.*

The activities of the anti-corruption agencies, notwithstanding, the basic questions in the minds of the people are: 1) To what extent has the concept of accountability be embedded in public services? 2) Has the introduction of the anti-corrupt agencies had any impact on corrupt practices in Nigeria? 3) Can the conspiratorial roles of the public appointees and civil servants be checkmated by the agencies? The paper, therefore, examined the issue of public accountability in Nigeria, and highlights the effects of the conspiratorial associations between civil servants and political appointees, which in most cases has led to opportunistic behaviours with the hope of corruptly enriching the individuals concerned.

2. Public Accountability and Corruption Control in Nigeria

Corruption is pandemic in Nigeria and it has certainly emerged as the major impediment to the development of democracy and the national economy. The scourge has grown to become a way of life of both the governor and the governed as it pervades all sectors of the state. A politician that 'succeeds' at the polls sees any office he/she occupies as a source of re-coupling his/her electoral expenses. Therefore, in most circumstances, public officers use their positions for private gains while long-term public interests are sacrificed.

Basically, corruption is described as efforts to secure wealth or power through illegal means – private gain at public expense; or a misuse of public power for private benefit [9]. It is a behavior, which violates rules against the exercise of certain types of [duties] for private [gains] - regarding influence [10]. This definition includes such behavior as bribery (use of a reward to pervert the judgment of a person in a position of trust); nepotism (bestowal of patronage by reason of ascribed relationship rather than merit); and misappropriation (illegal appropriation of public resources for private uses). Corrupt practices are so common and pervading in the Nigeria's public service to an extent that citizens find it difficult to develop an alternative to deal with it. Corruption is probably the main means to accumulate quick wealth in Nigeria. Corruption occurs in many forms, and it has contributed immensely to the poverty and misery of a large segment of the Nigerian population.

There are three reasons why corruption thrives in Nigeria [11]:

1) corrupt leadership lacked the desire and ability to change the moral tone of the country;

2) government domination of the economic sphere significantly enhances opportunities and ability to seek rents; and

3) civil society accepts or tolerate corruption

The high level of corruption in Nigeria has been aided by the conspiratorial relationship between political appointees and accounting officers. In this realm, there is flagrant and deliberate abuse of best practices and due process all in a bid to steal public funds. It is possible that either the political appointee or the career civil servant stands as the initiator of the dirty deals or ideas but the long and short of the matter is that both parties conspire against the State and the welfare of her citizens. The history of governance process in Nigeria reflects active connivance between political appointees and career officers at all levels of administration – Federal, State and Local. The situation is such that political appointees and career officers embark on a stealing spree and also use accounting techniques to cover up their tricks. This is evidenced by the blatant squandering of public resources by the past leaders in Nigeria. Reportedly, in 2005, Nigeria, with the assistance of the World Bank, began to recover US $458 million of illicit funds that had been deposited in Swiss bank by the late Sani Abacha, who ruled Nigeria from 1993 and 1998.

Honourable Ghali Na'Abba, Speaker of Nigerian House of Representatives (1999-2003), while commenting on the situation of corruption in Nigeria, posits that [12]:

While we cannot rule out the incidence of corruption and bribery in almost every facet of our society, it is particularly resident in the infrastructure areas in ministries or monopolistic parastatals saddled with the task of making infrastructure available to the public – water, telecommunications, electricity (*NEPA*), *roads and railways* (*NRC*) (2003).

The above is not only a confirmation of the malaise in the political economy by a top brass in government; it is also the placement of a national disaster in a well couched language. In the same way, the Nigerian National Petroleum Corporation has been accused of corrupt practices over the years. The corporation had been embroiled in one scandal or the other, ranging from issuance of pro forma invoices (PFIs) to customers and arbitrary product allocations to award of contracts to companies that grease the palms of some unscrupulous NNPC officials so as to secure offshore or downstream contracts [13]. Many corrupt practices have been associated with Public Officers in Nigeria's fourth republic [14].

All the financial gates and scandals unearthed in the Fourth Republic ran into several billions. For instance, the Police boss, Tafa Balogun's financial scam involved the laundering of billions of naira and dollars through different names in banks. Such was the method of gov-

ernment officials involved in 'Ikoyi-gate', a euphemism for the scam involving the sale of government property in Ikoyi, Lagos and other multiple and serial financial scandals that rocked the Fourth republic from the Local and State Governments to the Presidency.

However, corruption is a phenomenon that presents a paradox in Nigeria. This is because, while the number of cases was declining, the magnitudes in naira term were increasing. This position can be appreciated with the aid of **Figure 1** below.

Figure 1 indicates that the number of cases involved in corruption in Nigeria declines progressively since 1999. This period coincides with the introduction of the anti-corruption control measures in the country. But critics believed that the anti-corruption agencies were not effective at controlling corruption [15].

…It is now about four years since your administration embarked upon its anti-corruption crusade. Nevertheless, I regret to observe that the campaign has not yielded the desired result because it lacked focus and strong foundation ab initio…. In any case, the most preposterous and incredulous aspect of your anti-corruption campaign is that while the media is awash with stories on the activities of EFCC and ICPC, corruption is taking root daily in many federal establishments, also rock inclusive. I have said it several times that corruption is rife among senior officials of government, especially those at the federal level.... It is said that a few members of the leadership of the Senate could stoop so low as to drop your name with active connivance of some of your aides to collect large sums in oil and defense contract commissions. The ignominious activities of this cabal, including the foreign accounts of some of your aides, serving and former ministers, are also well known to the international community. I would be surprised if you feign ignorance of this unfortunate situation.

The truth of the matter is that the entire Nigerian political process is hampered by corruption. This also means that accountability has not been rooted in the Nigerian public service. Despite the activities of the ICPC and EFCC, corruption seems to be on the increase in the country. Most times, political appointees see public offices as an avenue to siphon public funds for private ends in spite of the jumbo salaries awarded to themselves by the public officers. For instance, **Table 1** shows the annual salaries of certain public officers in Nigeria.

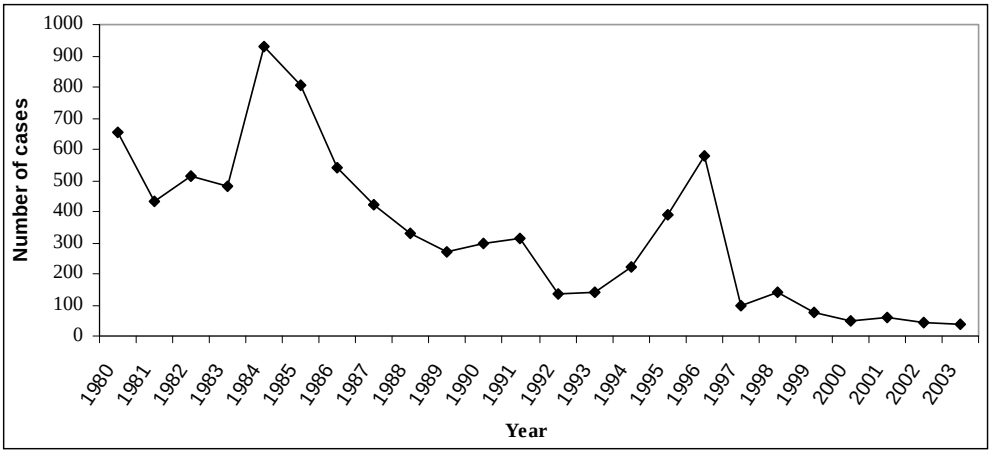

Figure 1. Summary statisticis of corruption in Nigeria (1980-2003)

Table 1. Annual salaries of certain public officers in Nigeria

	₦
Senator	36,677,840.00
Federal House Member	35,932,346.30
Federal High Court Judge	26,875,078.00
Permanent Secretaries, Executive Secretary, Chief Executive of Parastatal, Vice Chancellor	22,051,154.30
Local Government Chairman	13,865,895.30
Local Government Supervisory Councilor	12,746,875.00

Source: Culled from ASUU Open Letter to President Umaru Yar'Adua, *The Nation*, 3 September 2009

However, political appointees, most of the times, rely on the accounting officers to accomplish their nefarious activities. In actual fact, most of them are tutored in the act of stealing by accounting officers who possess the requisite knowledge on where public funds are kept and how public funds can be diverted into private pockets. This implies conspiracy between the Accounting Officers and Political Appointees. Therefore, the government must strengthen the corruption control mechanisms put in place to ensure good accountability system, free from any governmental interference, in order to sanitize the public service.

3. Administrative Reform, Good Governance and Public Accountability

The problems associated with the financial interactions of Accounting Officers and Political Appointees are not insurmountable. This paper advocates administrative reform and good governance for overcoming the conspiratorial relationship, which has affected public accountability.

1) *Administrative Reform*: Administrative reform is a political process designed to adjust the relationship between a bureaucrat and other elements in society or within the bureaucracy itself [16]. Succinctly put, administrative reform is:

Power politics in action; it contains ideological rationalization, fights for control of areas, services, and people, political participants and institutions… [17].

Administrative reform has a "moral content" in that it seeks to create a "better" system by removing faults and imperfections. It is usually undertaken to change the *status quo* for the better. It aims at making the administrative and political structures and procedures compatible with broader goals. Administrative reform sets additional political values to be used as yardsticks against which administrative performance may be judged. Administrative reform involves system diagnosis, that is, examination of administrative systems to detect what is wrong and what can be improved.

From the foregoing, it becomes imperative to emphasize the work of the audit department of every government office. This will discourage undue abuse of public privileges on the part of political appointees and ensure that the career of accounting officers is not at the mercy of Political Appointees. Consequently, external auditors appointed for government agencies and parastatals should ensure that accountability is enforced in the accounting system. This will go a long way in corroborating and safeguarding the judgements and actions of accounting officers and Internal Auditors. Thus, the fear that a politician could sack an un-cooperative accounting officer will be limited because sooner or later, the account profile will reveal the real facts behind the actions of the Accounting officers and the Political Appointees.

2) *Administrative Good Governance*: Good governance inter alias relates to the exercise of political power to manage a nation's affairs [18]. It also means an efficient, independent, accountable and open audited public service which has the bureaucratic competence to help design and implement appropriate policies and manage the public sector [19]. It also entails an independent judicial system to uphold the law and resolve disputes arising in a largely free market economy. The administrative aspect of good governance focuses on the following four main areas of public administration in general and public sector management in particular.

a) Accountability, which in essence means holding officials responsible for their actions;

b) Legal framework for development, which means a structure of rules and laws which provide clarity, predicttability and stability for the private sector, which are impartially and fairly applied to all, and which provide the basis for conflict resolution through an independent judicial system;

c) Information, by which is meant that information about economic conditions, budgets, markets and government intentions is reliable and accessible to all, something which is crucial for private sector calculations;

d) Insistence on transparency, which is basically a call for open government, to enhance accountability, limit corruption and stimulate consultative processes between government and private interests over policy development [20,21].

4. Conclusions

The paper focuses on the relationship between Accounting Officers and Political Appointees in Nigeria and how this merge has increased corruption. The relationship goes a long way in determining the success or failure of government policies and projects. The most desirable is a cooperative relationship as it enhances efficient service delivery. However, a conspiratorial or confrontational relationship is usually not in the best interest of the Public/Civil service. The conspiratorial relationship breeds corruption which retards national development. The situation was worsened by successive military regimes that institutionalized corruption in the country. Even, the anti-corruption measures put in place have received mixed reactions and their workability in achieving the desired objectives. This paper, therefore, advocates administrative reform and good governance, encompassing public accountability to ensure that the people are held accountable for their behaviour as a deterrent to corrupt practices.

5. Acknowledgements

The authors gratefully acknowledged all the anonymous

reviewers. The paper also benefited from the work of M. A. Khan and N. Chowdhury, accountability, corruption control and service delivery: governance challenges and future options

REFERENCES

[1] World Bank World Development Report, "Making Service Work for Poor People," The World Bank and Oxford University Press, Washington, DC, 2003.

[2] S. Eckardt, "Political Accountability, Fiscal Conditions and Local Government Performance – Cross-Sectional Evidence from Indonesia," *Public Administration Development*, Vol. 28, No.1, 2008, pp. 1-17.

[3] M. Bovens, "Analysing and Assessing Public Accountability: A Conceptual Framework," *European Government Papers*, Vol. 86, No. C-06-01, 2006.

[4] F. Fisher, "The European Union in the Age of Accountability," *Oxford Journal of Legal Studies*, Vol. 24, No. 1, 2004, pp. 495-515.

[5] R. Mulgan, "*Holding Power to Account: Accountability in Modern Democracies*," Pelgrave, Basingstoke, 2003.

[6] A. Lupia, "Delegation and its Perils," In K. Strom, *et al.*, Eds., *Delegation and Accountability in Parliamentary Democracies*, OUP, Oxford, 2003.

[7] P. T. Hart, "Verbroken Verbindingen. Over de politisering van het verleden en de opkomst van een inquisitiedemocratie," De balie, Amsterdam, 2001.

[8] N. Okonjo-Iweala and P. Osafo-Kwaakor, "Nigeria's Economic Reforms: Progress and Challenges," The Brookings Institutions, New York, Washington, DC, 2007.

[9] M. S. Lipset and G. Lenz, "Corruption, Culture and Markets," In L. E. Harrisson and S. P Huntington, Eds., *Culture Matters*, New York, 2000.

[10] J. S. Nye, "Corruption and Political Development: A Case-Benefit Analysis," *The American Political Science Review*, Vol. 3, No. 1, 1967.

[11] J. S. Guseh and E. Oritsejafor, "Government size, Political Freedom and Economic Growth in Nigeria, 1960-2000," *Journal of Third World Studies*, Vol. 24, No. 1, 22 March 2007.

[12] U. Na'Abba, "The Nigerian Problem and the Legislative Solution via the Legislative Agenda for Nigeria," *The Glitterati*, 4-10 May 2003.

[13] O. Bello, "Why Rilwan Lukman Needs to Tackle Corruption in NNPC," *Business Day*, Lagos, 13 January 2009.

[14] M. Dukor, "Corruption in Nigeria: The Moral Question of Statehood in Africa" In S. Hassan, A. Ebele, J. Fayeye and E. Oriola, Eds., *Democracy and Development in Nigeria*, Vol. 3, Ilorin, 2006.

[15] O. Kalu, "Working for Posterity to Judge us," *Open Letter to President Olusegun Obasanjo*, 22 August 2005.

[16] J. D. Montgomery, "Sources of Bureaucratic Reform: Problems of Power, Purpose and Politics," *Comparative Administrative Group Occasional Paper*, Bloomington, 1967.

[17] G. Caiden, "Administrative Reform," Chicago, 1969.

[18] World Bank, "Governance and Development," World Bank, Washington, DC, 1992.

[19] A. Leftwich, "Governance, Democracy and Development in the Third World," *Third World Quarterly*, Vol. 14, No. 3, 1993, pp. 605-624.

[20] World Bank World Development Report, "Making Service Work for Poor People," The World Bank and Oxford University Press, Washington, DC, 2003.

[21] A. Leftwich, "Governance, Democracy and Development in the Third World," *Third World Quarterly*, Vol. 14, No. 3, 1993, pp. 605-624.

iBusiness, 2010, 2, 128-138
doi:10.4236/ib.2010.22016 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

An Expert System Approach to Medical Region Selection for a New Hospital Using Data Envelopment Analysis

Chin-Tsai Lin*, Chuan Lee, Zhi-Jun Chen

Graduate School of Management, Ming Chuan University, Ming Chuan, Taiwan, China.
Email: ctlin@mail.ypu.edu.tw, clee@mcu.edu.tw, ivy.cute916@msa.hinet.net

Received February 22nd, 2010; revised March 27th, 2010; accepted May 1st, 2010.

ABSTRACT

An appropriate medical region must be selected before establishing a new hospital. Once established, a hospital may bring many medical doctors and facilities to the area. Not only can the distribution of medical resources in that area be influenced, but also competition among different hospitals can be enhanced. The government needs to consider the issue of medical resource distribution; therefore, medical region selection has important policy implications. This study uses data envelopment analysis (*DEA*) *to establish the effective indicators, and also uses an expert system on the equality of medical resource distribution to identify medical areas lacking medical resources and where there is relatively less competition. As a result, this study can provide the necessary information to facilitate the choice of region for a new hospital. This method not only avoids assigning a hospital to a medical region where there are surplus resources, but it can also reduce the risk of excessive competition.*

Keywords*: *Practice Location, Equality of Medical Resources Distribution, Data Envelopment Analysis, Effectiveness

1. Background

Prior to the establishment of the National Health Insurance system, there were 716 hospitals and 61,105 acute beds in Taiwan. However, by 2006, the number of hospitals was reduced by 193 to 523, whereas the number of acute beds had increased by 11,827 to 72,932 [1]. This development indicates the tendency for hospitals to continue to expand to obtain higher medical payments [2].

The government adopted a hands-off approach to physician training and hospital management until the establishment of the Department of Health, Executive Yuan, in 1971 [3]. Taiwan is divided into 17 different health-care districts, and relevant criteria for assessing medical resources are also established by the Department of Health [4]. According to the standard developed by the Department of Health for medical districts without sufficient medical resources (defined as districts with less than 20 general sickbeds per 10,000 population), no medical districts lacked medical resources as of 2006, except the medical area of Yulin County, which probably had 25 general sickbeds per 10,000 population. Thus, most districts have over 30 general sickbeds per 10,000 population; half of these have a sufficient amount of medical resources, with over 60 general sickbeds per 10,000 population. Hospitals established in districts with sufficient medical resources immediately suffer not only excessive competition in health-care markets, but also barriers to expansion or the establishment of new hospitals [3]. Moreover, the Department of Health has been developing a new project called the "Global Budget System" since 1998, in which annual total medical expenditure is calculated based on medical-care payments for each person and the actual number of medical insurance objects [5]. Besides the payment of total medical claims for general hospitals, payment for dentists, Chinese medicine doctors, and family doctors exists on a different basis. Therefore, if an inappropriate medical district is selected, one might simultaneously face several problems; for example, greater competition and a lower average payment value. Furthermore, since medical services are not mobile, and patients must attend hospitals in person, careful medical district selection has become a key issue for those establishing new hospitals. Once established, a hospital may bring many medical doctors and facilities to the area, which strongly influences the distribution of medical resources, and competition among different hospitals can be enhanced. Therefore, choice of the medical

area for a new hospital has important policy implications.

When the market is in balance, all doctors share the same effective demand. Similarly, it is wise for doctors to establish their practices in areas with a low density of doctors per capita to equalize distribution [6]. Additionally, Newhouse *et al.* [7] found that cities with smaller populations could be considered only after the number of doctors in urban areas reaches a certain ratio. Economic capability in the medical market may, therefore, profoundly affect doctors' choices of where to locate their practices. Chiang [8] noted that the reason remote areas have fewer doctors is not because of the unequal distribution of medical resources, but rather because considerable room remains in cities for new market entrants. Thus, more doctors are needed to ensure that remote areas have sufficient medical resources and services. The only way to solve the problem of insufficient numbers of doctors in remote areas is to increase the supply of doctors. In Taiwan, for example, the Taiwanese government is trying to provide more doctors to remote areas by increasing the quota for medical students and also promoting the Medical Group Practice Center [3]. Because of this successful medical policy, the number of doctors has increased from 24,399, before the implementation of the health-care project in 1994, to 34,864 in 2006; an increase of 10,465 (about 43%) in 12 years [9]. Intensifying competition among doctors in the medical market can be a problem; thus, doctors must seriously consider whether they should locate their practices in a medical district with a smaller number of doctors to avoid excessive competition.

In economics, the market concentration ratio is widely used to measure the degree of competition [10], particularly the Herfindahl index, which is used to calculate the square of the total occupancy rate of all hospitals in the market. Competition increases with decreasing Herfindahl index [11]. In a medical district with a population of 10,000 people, when the Herfindahl index drops to 100 (from 1000), the number of doctors increases from 10 to 100, but the occupancy rate of each doctor remains unchanged; *i.e.*, the degree of competition increases. Thus, capacity must be calculated before a new hospital is established. Furthermore, the capacity itself, the number of doctors, and the amount of additional medical resources in this market must also be considered.

The quantity of medical resources in a medical district can be measured by analyzing whether it has an equal distribution of medical resources when compared with other related medical districts. If a medical district suffers from an unfair distribution of medical resources, it might be a suitable location for establishing a new hospital. Two methods are commonly adopted for measuring equality, namely the proportional method and the index method [12]. Regardless of which method is used, numerous different metrics or criteria must be considered in the data. Furthermore, unless a medical district exists having its entire metrics superior to those of other districts, it will be extremely difficult to evaluate and justify districts which are superior to others, without using any weightings or transfer functions. Due to the limitations of traditional methods, the major purpose of this study was to establish a Performance Index using Data Envelopment Analysis (DEA), in which the Performance Index is adopted to evaluate the equality of distribution of medical resources in a medical district. The DEA model can provide an objective and fair solution to the above problem without requiring any presuppositions [13].

The function of the expert system lies in offering, judging, explaining, and making policy decisions to the specific field question [14], and compared with a human expert, the expert system has several beneficial characteristics: no time restrictions, low cost of operation, ease of distribution and duplication, consistency, ability to deal with time-consuming or complicated problems, and can be adapted to specific fields [15]. The question of medical region selection for new hospitals is complicated, and thus an expert system can perform better than a human expert.

This study used data envelopment analysis (DEA) to establish the effective indicators and to help choose the correct expert system. In particular, this study used the relevant medical care materials and the peoples' awareness of accessibility of medical treatment in 2006, and then applied the DEA method to identify the equality of medical resource distribution in Taiwan, to understand which medical areas lack medical resources, have relatively less competition, and in which, therefore, it is appropriate to add medical resources. This study may provide the necessary information to facilitate the choice of region for placement of a new hospital, avoiding placement in a medical region with a medical resource surplus, and reducing the risks associated with excessive competition.

2. Literature Review

Five definitions are most frequently quoted for equity of health-care distribution [16-21], as follows: equality of choice sets, equality of access, equality of expenditure, equality of needs, and equality of health.

2.1 Equality of Choice Sets

This means that all individuals should be provided with identical sets of choices [16,17]. This idea is similar to the theory of Penchansky and Thomas [22] regarding availability of enough doctors, hospitals, and equipment. This study measures choice set equality based on the percentage of doctors and acute beds; the number of choice sets increases with increasing percentage. When medical care facilities are established in districts with fewer choice sets, Phelps' spatial theory, which holds

that doctors would like to run their practices in sparsely populated areas, is demonstrated. Similarly, medical institutes face reduced competition as the number of choice sets decreases.

2.2 Equality of Access

This means that all individuals have equal access to medical care. Access not only indicates the convenience of obtaining medical care for all individuals, but also demonstrates the relationship between people and sites of medical care. For example, access involves distances and traffic problems [22]. Equality of access thus improves with decreasing distance. This study measures the equality of access based on the percentage of doctors, the length of road, and the percentage of the people able to obtain medical treatment within an acceptable time, with a higher value representing higher accessibility. Action [23], Coffey [24] and Cauley [25] indicated that the time taken to get medical treatment influences consumers' medical demand. When the distance and time to obtain medical treatment are long, then the demand for medical treatment is very low. Using a questionnaire survey, one can identify the time delay that consumers find acceptable for obtaining medical treatment. When a medical institute chooses a medical area with lower accessibility, it is in agreement with D'Aspremont *et al.* [26], who indicated that factory dealers try their best to be far away from each other, the so-called principle of maximum differentiation. In addition, by choosing a medical area with lower accessibility, consumer demand will also increase, and there will not be much competition for medical facilities.

2.3 Equality of Expenditures

This means medical care is distributed fairly among different individuals. Outpatient services and hospitalization charges are generally included in medical expenditures. Two indicators, average expenditure on outpatient services and average expenditure on hospitalization, are used to measure expenditure equality. A higher value indicates that each person's expenditure is higher. One does not use the percentage of doctors (western medicine) as an indicator of expenditure on outpatient services or the percentage of acute beds as an indicator of expenditure on inpatient services because these two indicators cannot tell us the differences that arise from regional differences in the number of people seeking medical treatment or differences in each person's hospitalization cost. On the other hand, the average of each person's outpatient expenditures and the average of each person's inpatient expenditures can account for the difference in the number of people. In addition, after Taiwan implemented the Global Budget System, patient's expenditures after seeking medical advice were paid by the Bureau of National Health Insurance [27], so the relationship with the number of patients is diminished [28]. Furthermore, in a medical region with a large number of doctors, more doctors' increasing demand, thus increasing outpatient numbers, which increases each person's average expenditure on medical treatment [29]. Thus, in medical regions with higher average individual expenditures on medical treatment, the number of doctors will be higher, resulting in relatively high competition.

2.4 Equality of Needs

Equality of needs means that medical resources should be distributed based on public need. Sometimes, necessity can be defined as obtaining or maintaining high-level medical services. Generally, medical treatment can be considered as health-care provided based on the medical knowledge of doctors and professionals [30,31]. In fact, when the unit of medical service is used to assess the need for medical treatment, the commonly applied methods include times of outpatient service, hospitalization, or surgery. Two indicators, percentage of doctors providing outpatient services and percentage of acute beds, are used to measure equality of needs. A higher value represents a greater amount of medical resources that the medical demands obtain each time. When a hospital chooses an area with lower medical resources, and the difference in the amount of medical treatment is considered, the effective demand should be the same for each doctor [12]. Similarly, when a medical institute is established in a region with lower medical resources, the competition is relatively low for the medical demands of each person.

2.5 Equality of Health

This means that the distribution of medical resources must result in all persons having equal health status, as reflected by life expectancies, death rates, infant death rates, and rates of injury and sickness. Owing to the elements of care that influence health status, numerous other relevant physiological and social factors can be identified [32]. Male and female survival rates are two indicators used to measure health equality. A higher value represents better health status in a medical area. Since nonprofit hospitals do not consider maximizing profit their main purpose, and they obtain their funds through charitable contributions or government subsidies, nonprofit hospitals can always manage [12]. The nonprofit hospital exists, as stated by Weisbrod [33], because there are some unmet demands for medical treatment; when the service provided is less than that required by society, people will organize a nonprofit hospital in order to offer services to provide the needed services. Thus, nonprofit hospitals must consider health equality as one of the standards used to determine where they should be established. A medical region that has a worse health status needs a nonprofit hospital.

The definition of the equality of distribution for medical resources indicates that non-profit hospitals should consider all five dimensions. Since for-profit hospitals do not always have to assume a major social responsibility, they only need to consider the first four dimensions.

3. Methods

The proportional and index methods are the most common methods of measuring equity. When the proportional method is used to distribute health care, the medical insurance expenditures among different groups can be adopted to compensate for the percentage differences [34]. The index method is the most frequently quoted method to measure equality; for example Van Doorslaer *et al.* [35] and Schalick *et al.* [36]. Wagstaff *et al.* [37] discuss three indices: "the disease centralization index, the centralization index of medical treatment expenditures, and the index of fairness." This permits us to measure the degree of inequity in medical resources in advance. However, regardless of the method used, both methods (proportional and index) are only capable of dealing with single targets. When several indices are measured simultaneously, as in the present study, one weighted set or alternatively a transfer function must be provided. Additionally, the weighted set and the function choice are considered subjective.

The DEA model provides a single objective and fair method that does not require setting default weights to solve problems involving multiple objectives. Furthermore, the proposed method has good unit invariance. The earliest DEA model uses efficiency as the evaluation basis [38]. n decision management units (DMUs) ($j = 1,\cdots,n$) are accessed, and m types of input $X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T$ and p types of output $Y_j = (y_{1j}, y_{2j}, \cdots, y_{pj})^T$ are produced. The model for assessing the o^{th} DMU is as follows:

$$\begin{aligned} &\text{Min}\ \ \theta_o - \varepsilon(\sum_{r=1}^{p} s_{ro}^- + \sum_{i=1}^{m} s_{io}^+) \\ &s.t. \sum_{j=1}^{n} r_j x_{ij} + s_{io}^+ = \theta_o x_{io},\ i \in \{1,\cdots,m\} \\ &\quad \sum_{j=1}^{n} r_j y_{rj} - s_{ro}^- = y_{ro},\ r \in \{1,\cdots,p\} \\ &\quad \theta_o,\ r_j,\ s_{ro}^-,\ s_{io}^+ \geq 0 \end{aligned} \tag{1}$$

where θ_o represents technical efficiency, and Equation (1) is the input-oriented CCR model. Consequently, the efficiency of this equation is also known as "input based efficiency." Furthermore, output can also be taken as the output-oriented CCR model, which can be presented as follows:

$$\text{Max}\ \ \phi_o + \varepsilon(\sum_{r=1}^{p} s_{ro}^- + \sum_{i=1}^{m} s_{io}^+) = \frac{1}{\theta_o} + \varepsilon(\sum_{r=1}^{p} s_{ro}^- + \sum_{i=1}^{m} s_{io}^+)$$

$$\begin{aligned} &s.t. \sum_{j=1}^{n} r_j y_{rj} - s_{ro}^- = \phi_o y_{ro},\ r \in \{1,\cdots,p\} \\ &\quad \sum_{j=1}^{n} r_j x_{ij} + s_{io}^+ = x_{io},\ i \in \{1,\cdots,m\} \\ &\quad \phi_o,\ r_j,\ s_{ro}^-,\ s_{io}^+ \geq 0 \end{aligned} \tag{2}$$

where the value of ϕ_o is termed the "output based efficiency." The relation between input and output based efficiency can be represented as $\theta_o = \frac{1}{\phi_o}$.

Chang *et al.* (1995) explained measurement effectiveness by implementing the CCR model. When the input in Equation (2) is set to $X_j = 1$, the output-oriented CCR model with a constant input should be:

$$\begin{aligned} &\text{Max}\ \ \phi_o + \varepsilon(\sum_{r=1}^{p} s_{ro}^- + \sum_{i=1}^{m} s_{io}^+) \\ &s.t. \sum_{j=1}^{n} r_j y_{rj} - s_{ro}^- = \phi_o y_{ro},\ r \in \{1,\cdots,p\} \\ &\quad \sum_{j=1}^{n} r_j + s_{io}^+ = 1,\ i \in \{1,\ \cdots,m\} \\ &\quad \phi_o,\ r_j,\ s_{ro}^-,\ s_{io}^+ \geq 0 \end{aligned} \tag{3}$$

The effectiveness is the reciprocal of efficiency, ϕ_o, by calculating Equation (3) namely $\theta_o = \frac{1}{\phi_o}$. That is, when all DMU inputs are constants, the output-oriented DEA model equals the relative efficiency measured based on outputs. According to its meaning in management, it can be explained as "value the target unscrupulously". Unscrupulousness here does not mean ignoring efficiency but instead stresses the macro-perception for measuring environmental change and developing a strategy for seeking long-term efficiency [39].

4. Research Process

This study implemented the DEA method by analyzing the equality of distribution of medical resources using four (for-profit hospitals) and five (nonprofit hospitals) dimensions, respectively. Furthermore, to avoid losing the meaning of performance value, in which too many DMUs, resulting from performance assessment, contribute to a performance value of 1, every effort should be made to ensure that the relationship between the number of DMUs and the number of input-output items meets the experience principle: namely, the number of DMUs is three times that of input-output items [40].

However, in this study, the DMU contains 16 medical districts (with Keelung City belonging to the same medical district as Taipei City and Taipei County), and the evaluation index contains eight items for for-profit

hospitals and ten items for nonprofit hospitals. Therefore, the ratio index can be considered the criterion for evaluating the development of each medical district, where **Table 1** illustrates the definition of each index. Although the experience principle is not always met, the major goal of this study was still to determine which medical districts have insufficient medical resources. It is extremely satisfying to obtain an analysis result in which few DMUs have a performance value of 1. This study used the DEA to build the structure for an expert system of assessment, as in **Figure 1**.

The relevant data from the "Health and Vital Statistics", "Statistical Yearbook of the Highway Bureau", and "National Health Insurance Statistics" for 2006 were gathered [1,41]. The percentage of people who can obtain medical treatment within an acceptable time, which is part of the equality of access indicator, was determined from a questionnaire survey conducted by the Department of Health, which identified the time delay that consumers find acceptable for obtaining medical treatment.

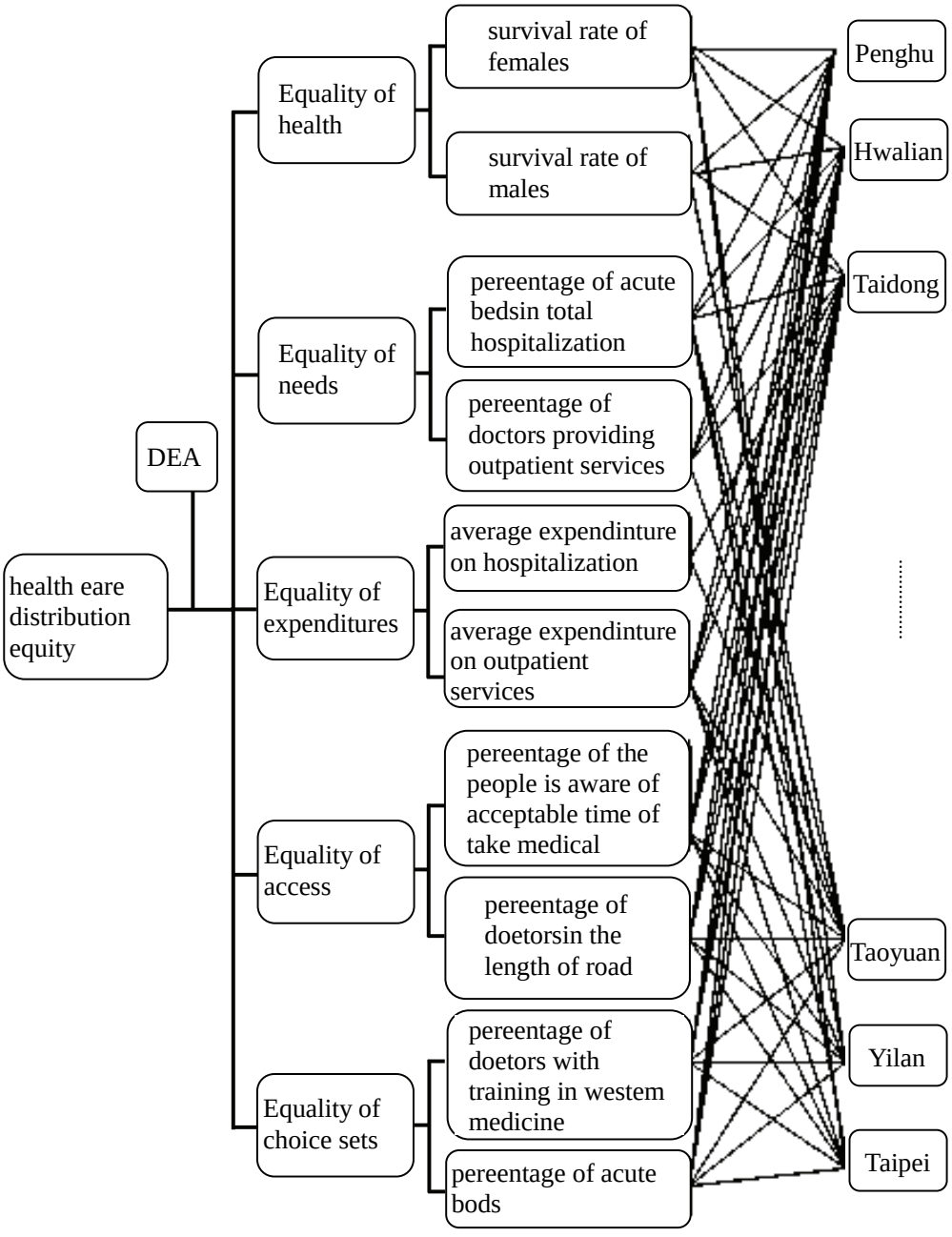

Figure 1. Structure of the equality of medical resources distribution

Table 1. Index for measuring health care distribution equity

Dimension	Index	Formula
Equality of choice sets	Percentage of doctors with training in western medicine (ten thousands)	The number of doctors ÷ population (person) × 1000
	Percentage of acute beds (ten thousands)	The number of acute beds ÷ population (person) × 1000
Equality of access	Percentage of doctors along a 10-km length of road	The number of doctors ÷ the length of the road (km) × 10
	Percentage of people who can obtain medical treatment within an acceptable time	Percentage of people who can obtain medical treatment within an acceptable time ÷ the number of people studied (persons) × 100
Equality of expenditures	Average expenditure on outpatient services (thousand dollars)	Man-time in outpatient services × the average expenditure on outpatient services (dollars) ÷ 1000 ÷ population (persons)
	Average expenditure on hospitalization (hundred dollars)	The number of hospitalizations × the average expenditure of hospitalization ÷ 100 ÷ population (persons)
Equality of needs	Percentage of doctors providing outpatient services	The number of doctors ÷ man-time in health insurance × 1000
	Percentage of acute beds in total hospitalization	The number of acute beds ÷ the number of hospitalizations × 1000
Equality of health	Male survival rate	(1–death rate of male) × 100
	Female survival rate	(1–death rate of female) × 100

Source: Department of Health, Health and Vital Statistics [1]

A telephone questionnaire survey was conducted, using stratified percentage systematic sampling; 3,269 people were included in the sample. The equality index of the distribution of medical resources for each medical district was calculated based on the formula in **Table 1**, and the observed values are listed in **Table 2**.

The Department of Health currently divides Taiwan into 17 medical areas and 63 medical sub-areas. This division is based on the principle of regarding adjacent counties and cities as single areas [4]. For example, Taipei city and Taipei County are included in the same area. However, given that Keelung City is geographically surrounded by Taipei County, it seems sensible to also include it in the Taipei city and county medical area. Thus, this study analyzed 16 medical areas rather than 17.

The Department of Health directly signs insurance contracts with hospitals/clinics, but not with individual doctors. Doctors are allowed to simultaneously work for hospitals/clinics both within and outside the NHS system, so it is extremely reasonable to use the Department of Health figure for the number of hospitals. However, individuals who participate in the National Health Insurance system in specific areas are not necessarily residents of those areas, so a significant difference exists between the number of individuals insured under the NHS and the number of residents in an area. Thus, to avoid misunderstanding, data gathered by the Department of Health shows a rather high ratio of the insured.

5. Discussions

Based on Equation (3) in this study, **Table 3** shows the analysis for the 16 medical districts. The closer the performance value calculated using Equation (3) is to 1, the fairer is the distribution of medical resources in that district, resulting in more sufficient medical resources. However, when the performance value is less than one, including situations where it is much less than 1, that district has an unfair distribution of medical resources, leading to greater insufficiency. Therefore, if the efficiency value of all medical districts is near 1, the distribution of medical resources in each district is fair. **Table 3** shows that, whether from the perspective of for-profit or nonprofit hospitals, medical districts with fair distribution of (*i.e.*, sufficient) medical resources in 2006 included Taipei (Taipei City, Taipei County, and Keelung City), Yilan County, Taichung (Taichung City, Taichung County) and Peng-hu County. Based on the results of this study, it is not wise to establish a new hospital in a district with sufficient medical resources, regardless of whether it is a for-profit or nonprofit hospital. Establishing a new hospital in such an area means that it will face excessive competition.

Table 2. Index of equity of medical areas in Taiwan in 2006

Dimension	Medical area Index	Taipei	Yilan	Taoyuan	Hsinchu	Miaoli	Taichung	Changhua	Nantou	Yunlin	Jiayi	Tainan	Kaoshong	Pingdong	Taidong	Hwalian	Penghu
Equality of choice sets	Percentage of doctors per 10,000 people	28.175	19.594	9.486	12.234	16.010	8.101	9.286	11.356	12.619	10.425	9.440	10.838	11.370	13.961	11.229	10.192
	Percentage of acute beds per 10,000 people	49.647	44.398	14.430	39.479	38.049	18.749	24.519	28.353	28.211	22.399	20.687	31.973	24.576	27.955	33.742	32.638
Equality of access	Percentage of doctors along a 10-km length of road	48.079	21.247	28.597	6.767	28.316	4.641	4.901	13.446	10.689	3.985	3.931	3.497	6.853	13.844	5.739	2.620
	Percentage of people who can obtain medical treatment within an acceptable time	91.028	98.361	90.847	92.143	93.846	93.743	93.069	92.000	96.970	95.574	91.330	92.673	93.878	93.548	90.741	90.000
Equality of expenditures	Average expenditure on outpatient services	16.190	11.952	6.057	9.725	10.897	5.808	7.102	8.054	9.501	7.958	7.300	7.707	8.509	9.494	7.991	8.057
	Average expenditure on hospitalization	125.23	77.403	24.932	69.034	78.125	27.073	40.406	45.178	52.018	34.045	30.188	66.940	56.337	63.369	48.024	48.844
Equality of needs	Percentage of doctors providing outpatient services	20.315	14.045	10.094	10.760	13.721	9.460	9.617	10.196	11.028	10.076	8.373	12.360	10.790	12.508	10.191	10.378
	Percentage of acute beds of total hospital beds	24.845	28.084	26.715	21.101	25.705	30.242	25.530	25.985	24.415	20.053	26.454	26.540	22.293	22.793	25.520	29.509
Equality of health	Male survival rate	99.345	99.293	99.438	99.151	99.367	99.266	99.108	99.335	99.244	99.124	98.999	99.044	99.109	99.206	99.047	98.833
	Female survival rate	99.591	99.573	99.689	99.468	99.671	99.533	99.412	99.598	99.462	99.378	99.277	99.322	99.404	99.519	99.362	99.280

Source: Department of Health, Health and Vital Statistics [1]

Table 3. Efficiency values and their ranks of distribution in medical treatment of each medical area in Taiwan

Medical region	For-profit hospital		Nonprofit hospital	
	2006 Efficiency value	2006 Rank of Medical resources	2006 Efficiency value	2006 Rank of Medical resources
Taipei (Taipei City, Taipei County and Keelung City)	1.0000	1	1.0000	1
Yilan County	1.0000	1	1.0000	1
Tyoyuan County	0.9823	6	1.0000	1
Hsinchu (Hsinchu City and Hsinchu County)	0.9368	13	0.9981	10
Miaoli County	0.9752	7	1.0000	1
Taichung (Taichung City and Taichung County)	1.0000	1	1.0000	1
Changhua County	0.9462	11	0.9974	13
Nantou County	0.9353	14	0.9994	7
Yunlin County	0.9859	5	0.9993	8
Jiayi (Jiayi City and Jiayi County)	0.9717	8	0.9978	11
Tainan (Tainan City and Tainan County)	0.9336	15	0.9960	16
Kaoshong (Kaoshong City and Kaoshong County)	0.9433	12	0.9968	15
Pingdong County	0.9544	9	0.9974	12
Taidong County	0.9511	10	0.9985	9
Hwalian County	0.9225	16	0.9969	14
Penghu County	1.0000	1	1.0000	1

Additionally, if the performance values of individual medical districts are all close to 1, from the perspective of nonprofit hospitals, the distribution of medical resources in each medical district will be abundant, which seems clearly different from the perspective of for-profit hospitals. This situation applies because, regardless of the differences between medical districts in terms of medical resources, these differences have almost no effect on their survival rate. The Department of Health defines districts with less than 20 sickbeds per 10,000 people as having insufficient medical resources. The present study found that, of the 16 medical areas, the fewest acute beds were found in YunLin County (20.76 beds per 10,000 people) in 2006. Thus, no medical district in Taiwan has insufficient medical resources.

Notably, although Jiayi and Penghu Counties were assessed as having insufficient medical resources, the performance values of PengHu Counties in 2006 were 1.00, suggesting that the medical resources in Penghu Counties are sufficient. The government has regarded Jiayi county as seriously lacking medical resources, but if one examines Jiayi (Jiayi City and Jiayi County) medical area, the medical resources have already been improved. Careful investigation shows that the number of doctors in Jiayi County increased 54% from 1997 to 2006, while the number of emergency sickbeds increased 66%. Therefore, upgrading the number of doctors and hospital facilities appears highly effective in maintaining sufficient medical resources. Particularly after "God's Help Hospital" was expanded and the Buddhist Tzu-Chi Dalin General Hospital and Chang Gung Memorial Hospital were established, Jiayi County appears to have already achieved sufficient medical resources. Penghu County is a separate island located off the coast of Taiwan, and the local government has been continuously and progressively promoting and implementing the "Integration Medical Service Outsourcing Project for Off-shore Islands Area of Penghu County," which provides integrated medical services, including outpatient services, emergency treatment, health-care planning, home health-care interviewing services, health education programs, and a patient referral system based on outsourcing and multiple solutions, thus helping maintain sufficient medical resources. In Penghu County, from 1997 to 2006, increases were achieved of 30% in the number of doctors, 30% in the number of outpatients, and 65% in the average outpatient service fee.

From the perspective of for-profit hospitals, the ranks of medical districts with the greatest insufficiency of medical resources in 2006 were Hwalian County, Tainan (Tainan City and Tainan County), Nantou County, Hsinchu (Hsinchu City, Hsinchu County), Kaoshong (Kaoshong City and Kaoshong County), Changhua County, Taidong County, Pingdong County, Jiayi (Jiayi City and

Jiayi County), Miaoli County, Tyoyuan County, and Yilan County. From **Figure 2**, according to the first quartile (Q1 = 0.9384), second quartile (Q2 = 0.9631), and third quartile (Q3 = 0.9965) of relative efficiency value, the 16 regions can be grouped into four areas. In the first group are those areas with sufficient medical resources (Taipei (Taipei City, Taipei County, Keelung City), Yilan County, Taichung (Taichung City, Taichung County) and Penghu County). The second group is those areas of insufficient medical resources (Jiayi (Jiayi City, Jiayi County), Miaoli County, Taoyuan County and Yunlin County) with a relative efficiency value between the second quartile (Q2, 50%) and the third quartile (Q3, 75%). The third group is those areas of scant medical resources (Kaoshong (Kaoshong City, Kaoshong County), Changhua County, Taidong County and Pingdong County) with a relative efficiency value between the first quartile (Q1, 25%) and the second quartile (Q2, 50%). The fourth group is those areas with serious insufficiency of medical resources (Hwalian County, Tainan (Tainan City, Tainan County), Nantou County, and Hsinchu (Hsinchu City, Hsinchu County)), with a relative efficiency value less than the first quartile (Q1, 25%).

Using non-parametric methods, the Mann-Whitney test and the Kruskal-Wallis test, it was found that the medical efficiency values among the four groups was significantly different, (Mann-Whitney P = 0.001; Kruskal-Wallis P = 0.002), which implies an unfair medical resource distribution among the four groups. Though the second group ((Jiayi (Jiayi City, Jiayi County), Miaoli County, Taoyuan County, and Yunlin County) has an acceptable level of medical resources, they are not sufficient. The third group (Kaoshong (Kaoshong City, Kaoshong County), Changhua County, Taidong County and Pingdong County) has scant medical resources – less than the average level – and needs to improve as quickly as possible. The fourth group has a serious insufficiency of medical resources (Hwalian County, Tainan (Tainan City, Tainan County), Nantou County and Hsinchu (Hsinchu City, Hsinchu County)), and also needs to improve as quickly as possible. Thus, for-profit hospitals should regard this area of very poor medical resources as a priority area to establish new medical facilities where they will not face excessive competition.

In fact, it is difficult to consider Hsinchu medical district as a place with insufficient medical resources, because of its high-tech industry image. But the "biomedical garden" of Hsinchu County has already been classified as 1 of 12 construction projects in the Loving Taiwan plan in 2008, and building is to commence in 2009, which should improve the medical resources of the Hsinchu area in the future. Other areas with insufficient medical resource include Nantou County, Hwalian County, Taidong County, and Pingdong County. In particular, Nantou County, Hwalian County, Taidong County, and Pingdong County have poor medical resources in remote areas of all four counties; the hospital centers are in the city, which results in large differences in accessibility to medical treatment. The government always classifies Jiayi County, Penghu County, and Yunlin County as areas that need early improvement, but only the medical resources in Penghu County have been effectively improved, suggesting that the government has not been successful in improving the medical resources in every medical area. When selecting an appropriate

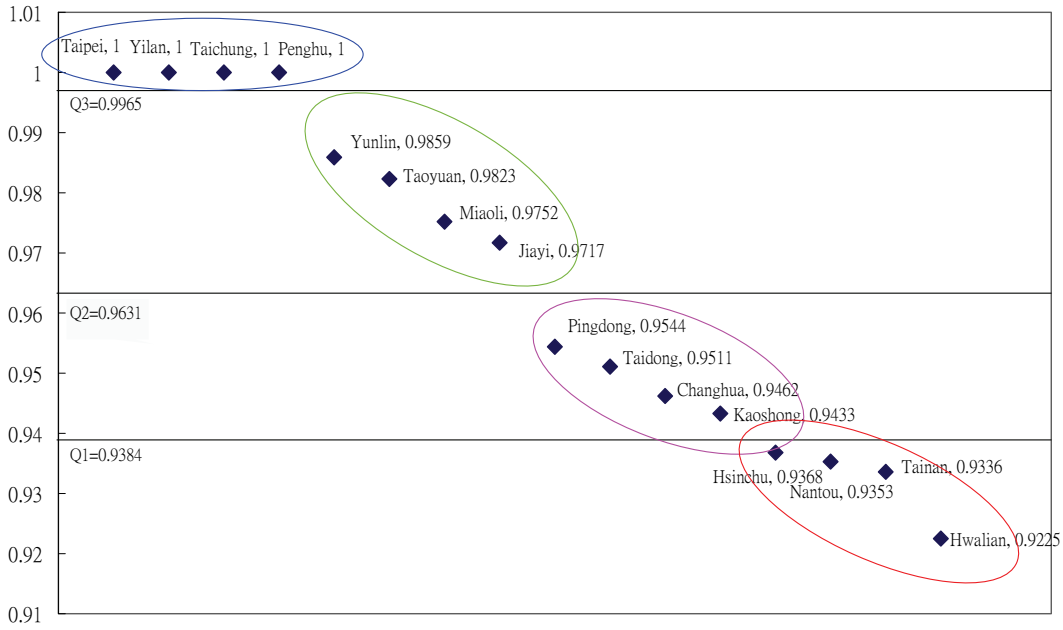

Figure 2. The relative efficiency of the distribution of medical treatment in every medical area of Taiwan

resources and the local traffic situation, which are disadvantages faced by distant counties such Nantou, Ping location for a new hospital, the sufficiency of medical dong, Hwalian and Taidong County, should be the main considerations. Thus, the government should encourage the establishment of new private hospitals in Hsinchu (Hisnchu City, Hsinchu County), Miaoli County, Changhua County, Yunlin County, Jiayi (Jiayi City, Jiayi County), Tainan (Tainan City, Tainan County), and Kaoshong (Kaoshong City, Kaoshong County). In the cases of Nantou County, Pingdong County, Hwalian County, and Taidong County, the government still needs to offer sufficient incentives, for example, by providing government scholarships to medical students, promoting expansion projects for local public hospitals, and providing subsidies.

6. Conclusions

The value of this paper lies in evaluating the equality of the distribution of medical resources using the DEA model, while also setting up an assessment model using an expert system that measures many indicators while avoiding subjective comparisons. This study is extremely helpful in expanding the theory of DEA modeling into a practical application related to medical economics and management policies.

The medical regions in Taiwan with the greatest need to improve medical resources were listed individually based on the results of the DEA method. This study also illustrates how the DEA method may be implemented to assist decision-makers in avoiding risk and avoiding the establishment of new hospitals in medical districts with an excess supply of medical resources. These results may then provide a reference point for for-profit and nonprofit hospitals when selecting new hospital locations; and, for the government, these results are a guideline for developing future medical policies. In particular, this study assessed the equality of access indicator (percentage of people who can obtain medical treatment within an acceptable time) using a questionnaire survey. The purpose of the survey was to identify the time it took to obtain medical treatment that people found acceptable, which can more clearly reflect people's perception of the accessibility of medical care, and serve as a convincing indicator of accessibility. Finally, this study proposes the following:

1) Both the DEA method and the process mentioned in this study should be applicable when private medical institutes are seeking locations for new hospitals. These findings not only help to evaluate the actual differences before establishing new hospitals, but also to reduce unnecessary risks resulting from excessive competition.

2) The first priority for improvement are those areas with a serious insufficiency of medical resources, including Hwalian County, Tainan (Tainan City, Tainal County), Nantou County, and Hsinchu (Hsinchu City, Hsinchu County). Next, those areas with scant medical resources, including Kaoshong (Kaoshong City, Kaoshong County), Changhua County, Taidong County and Pingdong County), need improvement. Finally, areas with insufficient medical resources, including Jiayi (Jiayi City, Jiayi County), Miaoli County, Taoyuan County and Yunlin County, need to be addressed.

3) Based on the study conducted here, the government should encourage private medical institutes to establish new hospitals in medical regions such as Taoyuan County, Hsinchu (Hsinchu City, Hsinchu County), Miaoli County, Changhua County, Yunlin County, Jiayi (Jiayi City, Jiayi County), Tainan (Tainan City, Tainan County), or Kaoshong (Kaoshong City, Kaoshong County), where they can benefit from relatively low competition and a reasonable traffic situation.

4) For regions in which traffic adversely affects accessibility to medical treatment, such as Nantou County, Pingdong County, Hwalian County, and Taidong County, the government should continue providing incentives, such as scholarships to students, expanding the local public hospital, and offering suitable subsidies.

5) For medical regions with sufficient medical resources, including Taipei (Taipei City, Taipei County and Keelung City), Yilan County, Taichung (Taichung City, Taichung County), and Penghu County, the government should consider delaying the establishment of new public hospitals and transferring public hospitals to private organizations, which would also reduce the government's financial burden.

REFERENCES

[1] Department of Health, "Health and Vital Statistics," Department of Health, Taiwan, 2006.

[2] T. C. Liu and P. C. Wu, "The Choice of Medical Institutions under NHI-An Example of Pediatric Patients in Taipei," *Journal of Healthcare Management*, Vol. 2, No. 2, 2002, pp. 87-108.

[3] D. L. Jiang, "Health Policy: Taiwan Experience," ChuLiu, Taipei, 1999.

[4] W. C. Hsiao, C. L. Yang and J. R. Lu, "Health Care Financing and Delivery in the ROC: Current Conditions and Future Challenges," *Industry of Free China*, 1990, pp. 1-19.

[5] Y. C. Lee, M. S. Lai and P. C. Sheng, "The Development and the Implication of Annual Health Care Expenditure Target for Global Budget Payment System of National Health Insurance in Taiwan," *Journal of Healthcare Management*, Vol. 2, No. 2, 2001, pp. 72-86.

[6] C. E. Phelps, "Health Economics," Addison Wesley Educational Publishers Inc, New York, 1997.

[7] J. P. Newhouse, A. P. Williams, B. W. Bennett and W. B. Schwartz, "Does the Geographical Distribution of Physicians Reflect Market Failure," *Bell Journal of Economics*, Vol. 13, No. 2, 1982, pp. 493-505.

[8] T. L. Chiang, "Deviation from the Carrying Capacity for Physicians and Growth Rate of Physician Supply: The Taiwan Case," *Social Science and Medicine*, Vol. 40, No. 3, 1995, pp. 371-377.

[9] Department of Health, "Health and Vital Statistics," Department of Health, Taiwan, 2001.

[10] F. X. Xiao, "Industrial Economics," Root International Information Co., Ltd., 2002.

[11] R. E. Santerre and S. P. Neun, "Health Economics: Theories, Insights, and Industry Studies," Harcourt Brace and Company, Fort Worth, 2002.

[12] R. F. Lu and Q. R. Xie, "Health Economics," Taipei, 2000.

[13] L. M. Seiford, "Data Envelopment Analysis: The Evolution of the State of the Art (1978-1996)," *Journal of Productivity Analysis*, Vol. 7, No. 2-3, 1996, pp. 99-137.

[14] L. G. Xue, "Expert System in Library," *Index of NCL Taiwan Branch Bulletin*, Vol. 5, No. 1, 1991, p. a10.

[15] B. K. Duval and L. Main, "Expert Systems: What is an Expert System?" *Library Software Review*, Vol. 13, No. 1, 1994, pp. 44-46.

[16] J. Le Grand, "Equity and Choice," Harper Collins, London, 1991.

[17] J. Le Grand, "Health and Health Care," *Social Justice Research*, Vol. 1, 1987, pp. 257-274.

[18] G. Mooney, "Equity in Health Care: Confronting the Confusion," *Effective Health Care*, Vol. 1, No.4, 1983, pp. 179 -185.

[19] G. Mooney, J. Hall, C. Donaldson and K. Gerard, "Utilization as a Measure of Equity: Weighing Heat?" *Journal of Health Economics*, Vol. 10, No.4, 1991, pp. 475-480.

[20] G. Mooney, J. Hall, C. Donaldson and K. Gerard, "Reweighing Heat: Response to Culyer, Van Doorslaer and Wagstaff," *Journal of Health Economics*, Vol. 11, No.2, 1992, pp. 199-205.

[21] A. J. Culyer and A. Wagstaff, "Equity and Inequity in Health and Health Care," *Journal of Health Economics*, Vol. 12, No. 4, 1993, pp. 431-457.

[22] R. Penchansky and J. W. Thomas, "The Concept of Access: Definition and Relationship to Consumer Satisfaction," *Medical Care*, Vol. 19, No. 2, 1981, pp. 127-140.

[23] J. P. Action, "Nonmonetary Factors in the Demand for Medical Services: Some Empirical Evidence," *Journal of Political Economy*, Vol. 83, No. 3, 1975, pp. 595-614.

[24] R. M. Coffey, "The Effect of Time Price on the Demand for Medical Care Services," *Journal of Human Resources*, Vol. 18, No. 3, 1983, pp. 407-424.

[25] S. D. Cauley, "The Time Price of Medical Care," *Review of Economics and Statistics*, Vol. 69, No. 1, 1987, pp. 59-66.

[26] C. D'Aspremont, J. J. Gabszewicz and J. F. Thisse, "On Hotelling's Stability in Competition," *Econometrical*, Vol. 47, No. 5, 1979, pp. 1145-1150.

[27] Bureau of National Health Insurance, "The National Health Insurance Statistics," Taiwan, 2006.

[28] T. E. Getzen, "Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Model to the Analysis of Health Care Expenditures," *Journal of Health Economics*, Vol. 19, No. 2, 2000, pp. 259-270.

[29] L. F. Rossiter and G. R. Wilensky, "Identification of Physician-Induced Demand," *Journal of Human Resources*, Vol. 19, No. 2, 1984, pp. 231-244.

[30] R. M. Anderson and J. F. Newman, "Societal and Individual Determinates of Medical Care Utilization in the United States," *Milbank Mem Fund Quarterly*, Vol. 51, No. 1, 1973, pp. 95-124.

[31] C. Cox, "Physician Utilization by Three Groups of Ethnic Elderly," *Medical Care*, Vol. 24, No. 8, 1986, pp. 667-676.

[32] C. Donaldson and K. Gerard, "Economics of Health Care Financing: The Visible Hand," St. Martin's Press, New York, 1993.

[33] B. A. Weisbrod, "Toward a Theory of the Voluntary Non-Profit Sector in a Three-Sector Economy". In E. Phelps, Ed., *Altruism, Mortality and Economic Theory*, Rusell Sage Foundation, New York, 1975.

[34] S. W. H. Cheng and J. R. Su, "The Incidence of Expenditures and Revenues in Taiwan's National Health Insurance," *Taipei International Conference on Health Economics*, Taipei, 1999.

[35] E. Van Doorslaer, A. Wagstaff, H. Van Der Burg, T. Christiansen, D. D. Graeve, I. Duchesne, U. G. Gerdtham, M. Gerfin, J. Geurts, L. Gross, U. Hakinen, J. John, J. Klavus, R. E Leu, B. Nolan, O. O'Donnell, C. Propper, F. Puffer, M. Schellhorn, G. Sundberg and O. Winkelhake, "Equity in the Delivery of Health Care in Europe and the US," *Journal of Health Economics*, Vol. 19, No.5, 2000, pp. 553-583.

[36] L. M. Schalick, W. C. Hadden, E. Pamuk, V. Navarro and G. Pappas, "The Widening Gap in Death Rates among Income Groups in the United States From 1967 to 1986," *International Journal of Health Services*, Vol. 30, No. 11, 2000, pp. 13-26.

[37] A. Wagstaff, E. Doorslaer and P. P. Van, "Equity in the Finance and Delivery of Health Care: Some Tentative Cross -Country Comparison," *Oxford Review of Economic Policy*, Vol. 5, No. 1, 1989, pp. 89-112.

[38] A. Charnes, W. W. Cooper and E. Rhodes, "Measuring the Efficiency of Decision Making Units," *European Journal of Operational Research*, Vol. 2, No. 6, 1978, pp. 429-444.

[39] P. L. Chang, S. N. Hwang and W. Y. Cheng, "Using Data Envelopment Analysis to Measure the Achievement and Change of Regional Development in Taiwan," *Journal of Environmental Management*, Vol. 43, No.1, 1995, pp. 49-66.

[40] F. Pedraja-Chaparro, J. Salinas-Jimenez and P. Smith, "On the Quality of the Data Envelopment Analysis Model," *Journal of the Operational Research Society*, Vol. 50, No. 6, 1999, pp. 636-644.

[41] Highway Bureau, "Statistical Yearbook of Highway Bureau," M. O. T. C., Ministry of Transportation and Communications, Taiwan, 2006

iBusiness, 2010, 2, 139-144
doi:10.4236/ib.2010.22017 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Using Analytical Hierarchy Process in Decision Analysis - The Case of Vietnam State Securities Commission

Hoang Linh Nguyen[1], Cher-Min Fong[1], Cheng-Ter Ho[2]

[1]Department of Business Management, National Sun Yat-Sen University, Kaohsiung, Taiwan, China; [2]Department of Industrial Engineering and Management, National Kaohsiung University of Applied Sciences, Kaohsiung, Taiwan, China.
Email: linhmc@hotmail.com

Received January 5th, 2010; revised February 25th, 2010; accepted April 3rd, 2010.

ABSTRACT

This paper uses Saaty's Analytical Hierarchy Process (*AHP*) *to formulate the strategy framework for Vietnam's State Securities Commission* (*SSC*). *In the first step, a questionnaire was designed to find Key Success Factors* (*KSFs*) *of the strategy of Taiwan Financial Supervisory Commission* (*FSC*) *by using the benchmarking technique. Criteria for questionnaire are carefully selected based on the Principles for securities market regulation set forth by the International Organization of Securities Commissions* (*IOSCO*). *The KSFs of FSC were then used to conduct a survey in the State Securities Commission of Vietnam* (*SSC*). *The data collected by AHP-structured pair wise comparisons were constructed into a computer-based program called Expert Choice. The result shows that top priority choice for SSC is to build up financial and operational capacity for securities firms, which in turn, will best support other alternatives. Another finding shows useful techniques in strategic management widely applicable in the business world can perfectly fit into the not-for-profit contexts in a way that it can help SSC reassessing and remodeling current flows of work in developing the nascent securities market to be the market that protect investors, insure fair, effective, transparent environment and reduce market systemic risk.*

Keywords*: *Decision Analysis, Analytical Hierarchy Process, Benchmarking

1. Introduction

The securities and derivatives markets are vital to the growth, development and strength of market economies. They support corporate initiatives, finance the exploitation of new ideas and facilitate the management of financial risk. Since retail investors are placing an increasing proportion of their money in mutual funds and other collective investments, securities markets have become central to individual wealth and retirement planning. Sound and effective regulation and market confidence are important for the integrity, growth and development of securities markets. Hence, it is important to develop suitable strategy for securities market regulation - a common task for many securities market regulators while still at nascent stage in Vietnam. Accordingly, the need to develop a well functioning securities market in Vietnam has been at government's top agenda through recent years. However, since it is emerging and lack of synchronous market development policy, it has been foreseen a considerable task for the State Securities Commission of Vietnam (SSC) in using its scarce resources in working out the best strategies.

This study aims to analyze and design a formulation framework that used Analytical Hierarchy Process (AHP), one of the most common used methods in prioritizing the elementary issues in a complex problem. A questionnaire was designed to find Key Success Factors (KSFs) by benchmarking FSC's strategies. Criteria for questionnaire are carefully selected based on the Principles for Securities Market Regulation set forth by the IOSCO. The achieved KSFs were then used to conduct a survey in SSC. The data collected by AHP-structured pair wise comparisons were constructed into a computer-based program capable of running AHP. The result shows that top priority choice for SSC is to build up financial and operational capacity for securities firms, which in turn, will best support other alternatives. In this research, the authors' work has also shown that useful techniques in strategic management widely applicable in the business

world can perfectly fit into the government or not-for-profit contexts. It has helped to create a strategy formulation model for the SSC to make better decisions.

2. Methodology

2.1 The AHP Approach

The AHP is a comprehensive framework, which is designed to cope with the intuitive, the rational, and the irrational when we make multi-objective, multi-criterion and multifactor decisions with and without certainty for any number of alternatives [1]. The AHP has been applied to many complex problems with various decision analyses, which enable decision-makers to derive ratio scale priorities or weights as opposed to arbitrarily assigning them [2]. Many others recognize a very important feature that AHP supports decision-makers by allowing them to structure complexity, to exercise judgment, and to incorporate both objective and subjective considerations in the decision process [3-5]. The AHP is also a novel decision analyzing approach that structures a problem using a hierarchy. It enables us to make effective decision on complex issues by simplifying and expediting human natural decision-making processes. Some other sees the AHP is the theory of measurement for dealing with quantifiable or tangible criteria that has found rich applications in decision theory, conflict resolution and in models of the brain [1,6,7]. To illustrate this process in an easy way, Bagchi and Rao [8] define that this hierarchy starts with a top level containing the ultimate objective of the problem. The sub-objectives, if any, constitute the next level, followed by the criterion variable affecting the higher-level objectives. The bottom level of the hierarchy contains the options or alternatives. Therefore, each hierarchical level can be seen as being made up of elements (or criterion variables) that in turn, are decomposed into sub-elements that make up the next level of the hierarchy.

Over the years, AHP has become one of the most widely used multiple criteria decision-making tools for researchers and decision makers. Many outstanding works have been published based on AHP in different fields such as planning, selecting best alternative, resource allocations, resolving conflict, optimization, etc., and numerical extensions of AHP [6-8]. The specialty of AHP is its flexibility to be integrated with different techniques like Linear Programming, Quality Function Deployment, Fuzzy Logic, etc. This enables the user to extract benefits from all the combined methods, and hence, achieve the desired goal in a better way [9].

2.2 Benchmarking for Strategy Choice

Using a benchmarking technique, the viability of various objectives and sub-objectives is evaluated for alternatives. In this paper, the benchmarking technique is based on the IOSCO's principles for securities market regulation. The eight Core Principles are shown in the first column of **Table 1**. Each of these Core Principles has a number of criteria that are in the second column. Since it would be an enormous task to consider all the criteria, the only most significant criteria of each Core Principle are selected by the Questionnaire surveyed in FSC.

2.3 Strategy Formulation for SSC

The various steps in the application of AHP for securities market regulation strategy choice will now be based on the data obtained from surveys in the SSC and constructed into computer program.

2.3.1 SSC's Mission and Values as Goals for Strategy Choice Model

Extensive discussion and consultation with SSC management board has been done and IOSCO's objective requirements have been carefully considered. For any securities market regulator, it is necessary to achieve these goals in order to fulfill the task of securities market regulation. The α-level objectives are as follows:

1) Protection of Investors;
2) Fair, Efficient, and Transparent Market;
3) Reduction of Systemic Risk.

2.3.2 Alternative Strategies for SSC

The alternative strategies for SSC's securities market regulation are:

1) Increase Securities Supply;
2) Increase Securities Demand;
3) Build up Financial and Operational Capacity for Securities Companies;
4) Strengthen Legal and Regulatory Framework;
5) Improve Market Infrastructure;

Table 1. The selected criteria corresponding to core principles are assigned to level β in the hierarchy

Core Principles	Criteria
(a) Principles Relating to the Regulator	Independence and Accountability
(b) Principles for Self-Regulation	SROs subjected to authorization and oversight
(c) Principles for the Enforcement of Securities Regulation	Comprehensive enforcement powers
(d) Principles for Cooperation in Regulation	Effective information sharing mechanisms
(e) Principles for Issuers	Full, timely and accurate disclosure of information
(f) Principles for Collective Investment Schemes	Proper and disclosed basis for asset valuation, pricing, and unit redemption.
(g) Principles for Market Intermediaries	Standard conduct of business rules
(h) Principles for the Secondary Market	Securities exchanges and trading systems subject to regulation and oversight

6) Develop Human Resource and Capacity.

The rationales of the Alternatives are as follows:

Rationale for Alternative 1 and 2: Inadequate securities supplies and demands: supplies are qualitatively and quantitatively weak. There are not any securities issued by potentially large corporations like joint stock commercial banks, joint venture companies or general corporations but most are shares of privatized stated-own enterprises. Securities supplies are limited also due to the fact that depository shares which are qualified for trading accounts for only 40 percent of the listed stocks. On the other hand, bonds trading are so constrained even tradable volume is potentially large. In addition, listed companies are in good financial positions but most do not have adequate capitals. Government owned rate is high in most of the companies further making the tradable shares in the stock exchange low.

Rationale for Alternative 3: Limited intermediaries operations due to lack of professional and capable human resources of the securities companies. Most of securities companies exercise dealing and brokerage mainly. Other advanced services like underwriting and investment advisory are limited in few companies. The services provided for investors are not yet in superior quality and mainly in the two biggest cities of Hanoi and Ho Chi Minh City. This does not support attraction of investors in other cities and regions throughout the country. Low public confidence: inadequate accounting and auditing systems in place together with limited perception of information disclosure causes low degree of public confidence in the securities companies.

Rationale for Alternative 4: Asynchronous securities market management: lack of comprehensive securities laws system revealed limitation and constraints in regulating and administering the securities market in Vietnam.

Rationale for Alternative 5: Ineffective structure of regulatory body and stock exchange operation model: current model of the exchange is under SSC. Depository, registration, settlement and clearing are operations of the exchange and not effectively managing and controlling the securities market in the long run. Above-mention systems are done manually or semi-automatically, thus it has caused low efficiencies in the supervisory function of the securities market.

Rationale for Alternative 6: A pool of technically trained and professionally competent human resource is perhaps the single most important requirement for the development of Vietnam capital market. The scope of human resource development in capital market is wide, ranging from market participants in both public and private sectors, from top policy makers and frontline regulators to intermediaries and investors. Thus, it is important for all stakeholders to collaborate in designing and delivering training programs with proper division of labor.

2.3.3 Details of Analysis Procedure of AHP

The AHP allows the decision maker to evaluate the criteria and their alternatives. The scale of importance must be set up prior to the questionnaire in order to enable correct evaluation of the criteria. In this research, the scale of 1 to 9 adopted is given earlier.

The designed questionnaire was delivered to key persons in SSC management with strict emphasis on relative importance of the pairwise judgments. These pairwise comparisons are made in accordance with the computer program format and corresponding the choice of SSC key personnel in relation to how they think the criteria's importance taking part in selecting the strategy for securities market regulation in SSC.

The ten sets of pairwise comparisons questionnaire made from interviewing ten top management personnel were assembled into three groups, each of which having similar judgments. The represented pairwise comparison values were the average value of the group. The Participating Group 1 consists of three personnel at highest level of management level, the Participating Group 2 consists of three personnel from middle management level, and the Participating Group 3 consists of four personnel from lower management level. The then average values are entered into the computer program. The result was combined automatically by the program to produce the result of the strategy model.

The Hierarchy Model for the strategy formulation is shown in **Figure 1**.

3. Results

The decision-making methodology has been validated in the State Securities Commission of Vietnam. This was done by the structured pair wise comparison survey conducted directly with leadership of the SSC. The data then was fed into the model and the results were analyzed using AHP method incorporated in the computer program. The result shows that the top choice priority strategy for SSC is to *build up financial and operational capacity for securities companies*.

It is found out that the inconsistency ratio, which is a weighted average of the inconsistency ratios of Participating Group 1, Participating Group 2, Participating Group 3, and combined results are .05, .06, .05, and .02, respectively. This matches the requirement by AHP methodology in constructing strategy formulation model that requires inconsistency of less than 1. The inconsistency measure is useful for identifying possible errors in judgments as well as actual inconsistencies in the judgments themselves. Inconsistency measures the logical inconsistency of judgments. This has shown the capability and knowledge of top management at SSC in providing judgments and has contributed to the successfulness of this research.

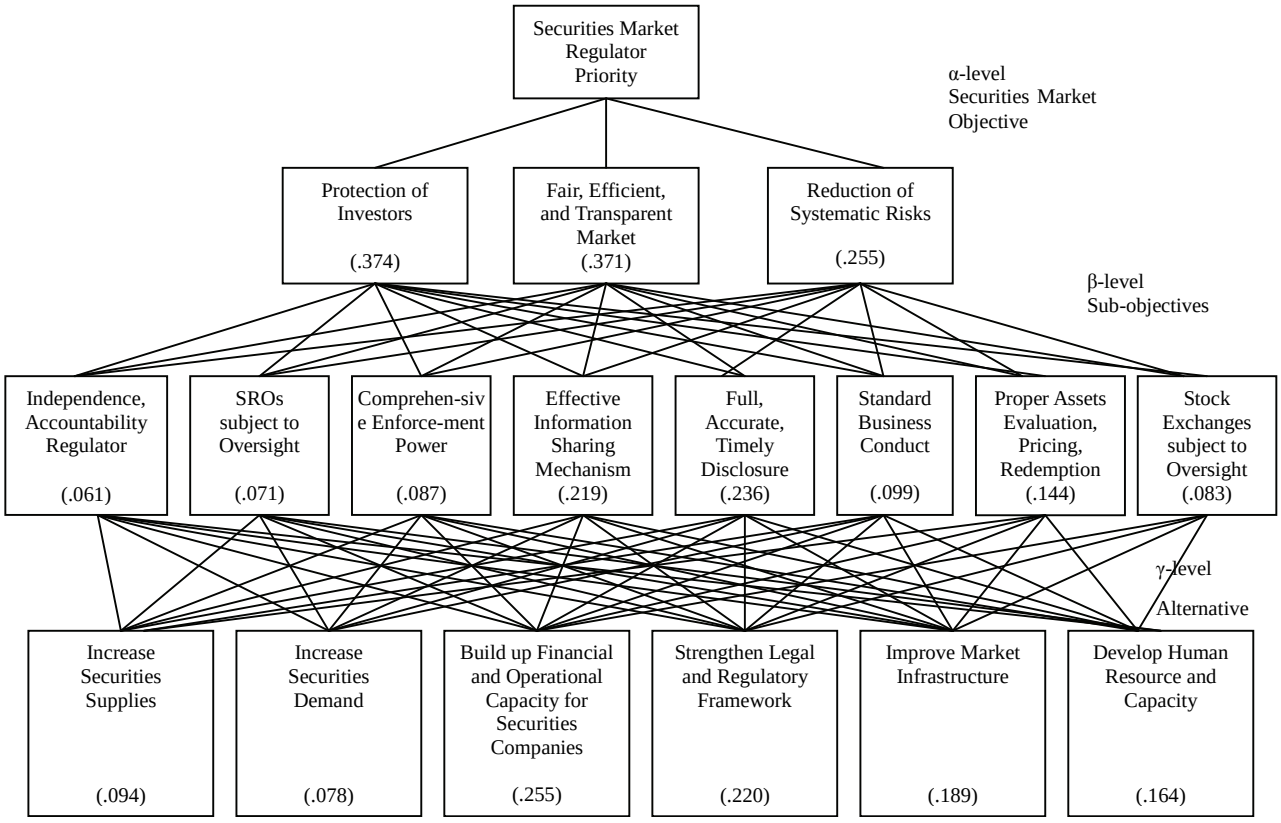

Figure 1. The hierarchy model for the strategy formulation

The main objective of this study is to design, develop and formulate a strategy model for securities market regulation using the analytical hierarchy process has been realized. First, the study has shown that strategy formulation procedure in strategic management originally established and mainly applied in business world could be well employed to establish formulation models in public/government/not-for-profit organization context even in securities market industry, which has the most complex nature in the world. Secondly, a strategic decision making procedure for securities market regulators based on various studies of decision-making analysis has been created. In addition, KSFs of FSC in relation to securities market regulation strategy have been successfully established. The KSFs have been utilized as a benchmark to create a strategy formulation model for SSC. The strategy choice model has been validated in the SSC through AHP-structured questionnaire.

4. Discussion and Conclusions

It has been a demanding task of the State Securities Commission of Vietnam to increase the number of qualified listed stocks in the Stock Exchange. Everyday, both the regulator and market participants can easily see small number of listed companies that represent a far too small percentage of GDP. Everybody for sure thinks about how to increase such a small number in order to have a larger-size securities market, which will truly be an alternative channel of equity capital procurement in the economy, and consequently, will boost privatization process and contribute to economic development of Vietnam.

Currently, there are so many deficiencies in the regulatory environment and these create obstacles in increasing number of listed firms as well as developing the securities market. However, the authors view these deficiencies are normal since securities market in Vietnam has been around since 2000. Even though a majority of judges in the survey gave favorable scores toward regulatory framework strengthening but the result came at a different focus – the securities companies. The synthesis with respect to goal: Securities Market Regulation Strategy Priorities Choice is shown in **Figure 2**.

After implementing the model in SSC for two years period with strategy focus on development of securities companies, a number of policies favor the healthy operations of securities companies has resulted in an increase from 13 companies in 2004 to 56 companies in 2008 and to 104 companies as of December 31st, 2008. In turn, the market has developed to a stage no one could ever expect. In respond to the new incentives, number of listed shares

in both exchanges has gone up to over 390 by end of

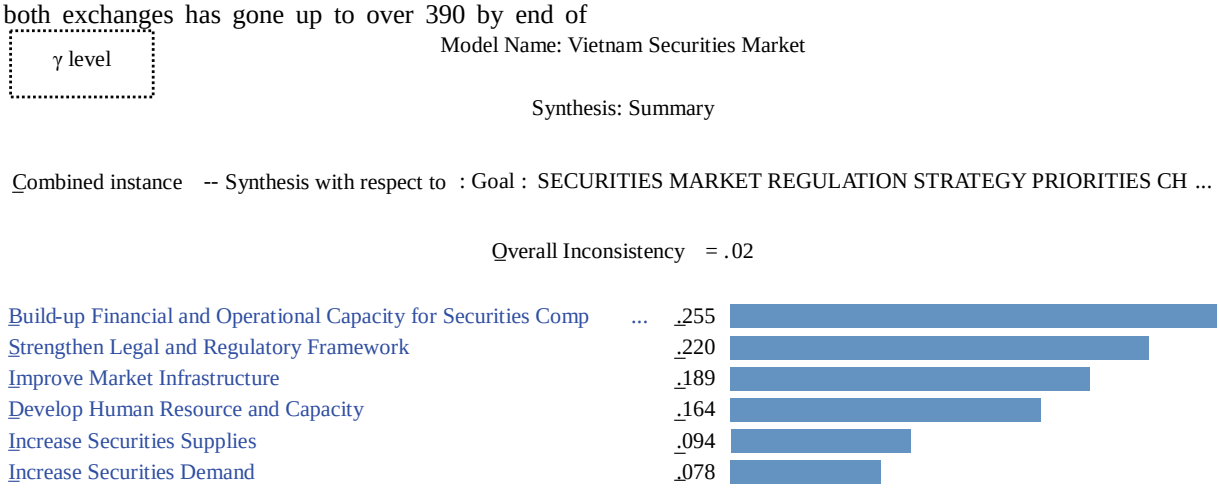

Figure 2. The synthesis with respect to goal: securities market regulation strategy priorities choice

2008 from around 50 in early 2005 (exclusive of non-listed public firms); market capitalization increased from 3% in 2005 to over 46% of GDP by end of 2008 (exclusive of bond market).

Joint stock and equitized companies lacked interest to go public because they did not appreciate capital mobilization through securities market as compared with the traditional banking and government channels. In advanced market, intermediaries play a critical role in making market participants understand the tradeoffs by going public through consultancy and other services. In other words, with strong and active securities companies in place, good linkages between securities firms and customers will be established which market confidence will be built upon. As a result, more companies will be likely going public, and more trading accounts will be open. A good securities firm system will better contribute to solve the problem for both securities supplies and demand. Once a more effective securities market has been realized, both in size and scope, relevant government authorities will better support the course of regulating the market as discussed later. This is how the strategy formulation model constructed in this study gives out the prevailing choice of "Building up Financial and Operational Capacity for Securities Companies".

For AHP methodology, strategic management should utilize the analytical hierarchy process approach based on scientific principles and human judgment that can address the complexity nature of the issues. A very critical stance is that in performing the survey at SSC and in constructing the model, the authors have observed that most SSC's top management in making their pairwise comparisons with respect to different objectives in AHP structure emphasized much on the legal aspect. They argued that an incomplete legal framework could not support any activity in the market that could in turn help positively foster the securities market. However, truly from their point of views that the ever-important concept for securities market regulators is to protect investors' rights and benefits, their consolidated decisions has turned out to be improving the quality of the market intermediaries – the securities firms as discussed earlier. By this way, the AHP approach using in strategy formulation could have helped SSC management to arrive at a priority choice in a more persuadable manner while well managing their scarce resources.

Through out this research, AHP appeared to have some limitation with regard to ambiguity in the selection of ratio in the inverse reciprocal matrix and in relation to determining consensus among a panel, each of which has selected a set of score in the pairwise comparisons. Given the case that all inconsistency ratios were over .1 or the model would have to use more than fifteen voters in a panel of decision makers, then it would be a massive task for the researcher in possible readjustment of the scores in pairwise comparisons. In such a situation, of course, the decision making finally would have incurred inaccuracy of priority weighting. Accordingly, it is desirable to further study of AHP to overcome its weakness. Once this task is accomplished, non-consensus among panels can be solved to help arriving at decisions that are more precise.

REFERENCES

[1] P. T. Harker and L. G. Vargas, "The Theory of Ratio Scale Estimation: Saaty's Analytic Hierarchy Process," *Management Science*, Vol. 33, No. 11, November 1987, pp. 1383-1403.

[2] T. L. Saaty, "Modeling Unstructured Decision Problems: A Theory of Analytical Hierarchy," *Proceedings of the First International Conference on Mathematical Modeling*, University of Missouri-Rolla, Rolla, Vol. 1, 1997, pp.

59-77.

[3] E. H. Forman, "The Analytic Hierarchy Process as a Decision Support System," *Proceedings of the IEEE Computer Society*, Salt Lake, 1983.

[4] T. L. Saaty, "Multicriteria Decision Making: The Analytic Hierarchy Process," WS Publication, Pittsburgh, 1990.

[5] Y. Wind and T. L. Saaty, "Marketing Applications of the Analytic Hierarchy Process," *Management Science*, Vol. 26, No. 7, 1980, pp. 641-658.

[6] L. G. Vargas, "An Overview of the Analytic Hierarchy Process and its Applications," *European Journal of Operational Research*, Vol. 48, No. 11, 1990, pp. 2-8.

[7] F. Zahedi, "The Analytic Hierarchy Process: A Survey of Methods and its Applications," *Interfaces*, Vol. 16, No. 4, 1986, pp. 96-108.

[8] P. Bagchi, R. P. Rao, "Decision Making in Mergers: An Application of the Analytic Hierarchy Process," *Managerial and Decision Economics*, Vol. 13, No. 2, March - April 1992, pp. 91-99.

[9] O. S. Vaidya and S. Kumar, "Analytic Hierarchy Process: An Overview of Applications," *European Journal of Operational Research*, Vol. 169, No. 1, 2006, pp. 1-29.

iBusiness, 2010, 2, 145-155
doi:10.4236/ib.2010.22018 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Customer Care Management Model for Service Industry

Muthuswamy Shanmugaraja[1], Muthusamy Nataraj[1], Nallasamy Gunasekaran[2]

[1]Department of Mechanical Engineering, Government College of Technology, Coimbatore, India; [2]Principal, Angel College of Engineering and Technology, Tirupur, India.
Email: raja8011@yahoo.co.in

Received January 12th, 2010; revised February 23rd, 2010; accepted April 11th, 2010.

ABSTRACT

Purpose *– This paper describes a model for Customer care management in an automotive service industry.* ***Design/ methodology/approach*** *– Customer care management (CCM) model is developed using TQM techniques, Quality Function Deployment (QFD) and Six Sigma. The matrix structure in QFD is used to transform customer complaints into Critical-to-Quality (CTQ) parameters. By using Six Sigma DMAIC approach, the customer complaint parameters are analyzed for improvement.* ***Findings*** *– The application of CCM model in an automobile service industry has determined that the workload planning is the chronic problem for customer complaint. Further analysis through this model leads to restructuring of existing workload planning practice through a set of algorithms.* ***Research limitations/implications*** *– CCM model lacks to accommodate the effect of relationship between rectification factors. Also competitor technical contemplation is not possible in this model.* ***Originality/value*** *– Customer is the focal point and early response to their complaint is the key to success of every business. This paper has developed a structured complaint management practice which warrants the timely response to customer complaints and speedy resolution for survival in today's customer driven market.*

Keywords**:** *Customer Complaint, CCM Model, TQM, Six Sigma, QFD, Critical-to-Quality, DMAIC, Service Industry*

1. Introduction

Customer is the focal point of every business [1]. The very existence of business depends on customer satisfaction. Customer expects high quality services, even willing to pay premium for better service [2]. From a customer perspective, good service quality leads to long-term customer relationships measured by re-patronage and cross sales, also customer recommend the service to others [3]. Services are fundamentally different from manufacturing; this difference contributes to the increased complexity of service quality [4]. Firms therefore make all efforts for providing high quality services to please customers. But in spite of best efforts an occasional complaint is inevitable [5]. However a good recovery can turn angry, dissatisfied customers into loyal ones, again [6]. The key to success lies in recognizing the importance of responding fairly and effectively to customer complaints [7]. Complaints are often a treasuring trove of information leading to constructive ideas for improving and upgrading services in the future [8]. Researches indicates that only a small number of dissatisfied customers actually complain and give the company an opportunity to correct itself. Others simply shift loyalties [9]. Hence it is become important to resolve complaints in a fair manner at the earliest instead of taking a defensive approach [10]. Structured customer complaint management is one of the tenets for problem prevention in long term [11]. This paper attempts to develop one such customer care management [CCM] model. In this model, speedy complaint resolution is aimed through Quality Function Deployment [QFD], a customer voice processing technique and Six Sigma, a zero complaint process approach. This CCM model is introduced in an automotive service centre to retain existing customers than to go scouting new ones.

2. Quality Function Deployment

Quality Function Deployment [QFD] is a technique to process customer complaints and translate them into possible factors for rectification [12]. The House of Quality matrix [HOQ] is the main component in QFD. It comprises customer information matrix [Horizontal portion] and technical information matrix [Vertical portion] as shown in **Figure 1**. In HOQ, customer complaints (WHATs) are plotted in horizontal and the rectification factors (HOWs)

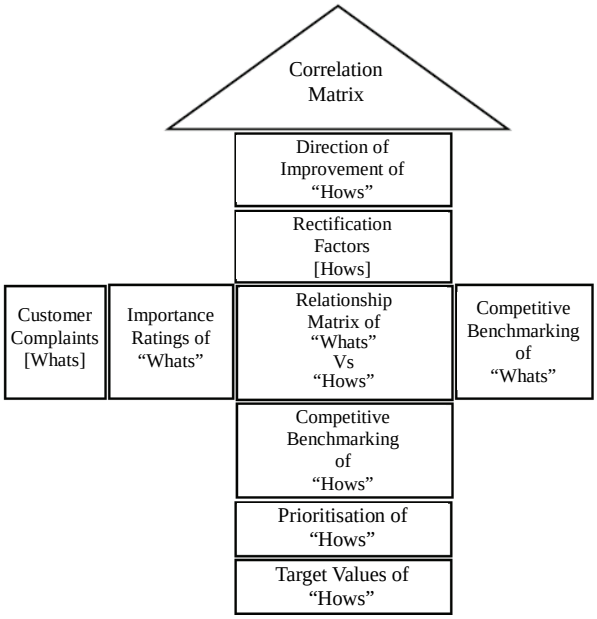

Figure 1. House of quality matrix

are correlated in the vertical. This matrix format felicitates examination, cross checking, analysis of information, helps organization to set competitive targets and to determine the priority action issues [13].

3. Six Sigma

In as early as 1987, Motorola initiated the Six Sigma program with a focus on the design of products and processes so that defects would almost never occur [14]. Six Sigma is a rating that signifies "best in class", with only 3.4 complaints per million [15]. Six Sigma examines quality, as defined by the customer, in order to focus on the requirements and expectations that are truly critical and measurable [16,17]. The most important methodology in Six Sigma program is DMAIC (Define-Measure-Analyze-Improve-Control) as illustrated in **Figure 2**.

In the Define phase, the problem to be solved is defined, evaluated and selected based on a cost/benefit analysis and a set of criteria determined by the upper management. Subsequently, in the Measure phase, the problem is translated into a measurable form by means of Critical-To-Quality (CTQ) characteristics. The data pertinent to the problem is assembled and a baseline study is conducted. In the Analyze phase, a thorough diagnosis of the current situation is carried out to identify the major factors that may potentially influence the CTQs. In this phase, statistical tools, ranging from simple to advanced, play a key role. In the Improve phase, the project team designs and implements the solutions or adjustments to the process to improve the performance of the CTQs. Finally, in the Control phase, process management and the control systems are developed and adjusted to assure that the improvements are sustainable [18].

4. Customer Care Management Model

Six Sigma basically operates on Critical to Quality Characteristics [CTQs] which represents the customer's complaints. Since the customer expectations are qualitative in nature, in CCM model, QFD is used to convert them into quantitative CTQ for the ease of complaint rec- tification and service improvement through Six Sigma. This model includes five distinct phases as shown in **Figure 3** for managing complaints in sequence. In this model, QFD serves two purposes; one to transform the customer complaints into attainable factor and two to define and develop a problem statement. Hence in the DMAIC methodology of Six Sigma, the define phase is overlapped with QFD. The output of QFD matrix analysis is directly fed to measure phase.

The activities involved in each phase are:

- In QFD phase, the customer and their complaints are identified through a structured survey method. Then it is processed against the possible rectification factors to determine the CTQ.
- In measure phase, the CTQ is expressed in terms of sigma quality value for comparing the performance before and after improvement.
- In analysis phase, the present performance gap is analyzed and suitable solution direction is indicated.
- In improve phase, the present system is improved with identified solution as expected by customers.
- In control phase, to sustain improvement, suitable control measure are identified and put in place.

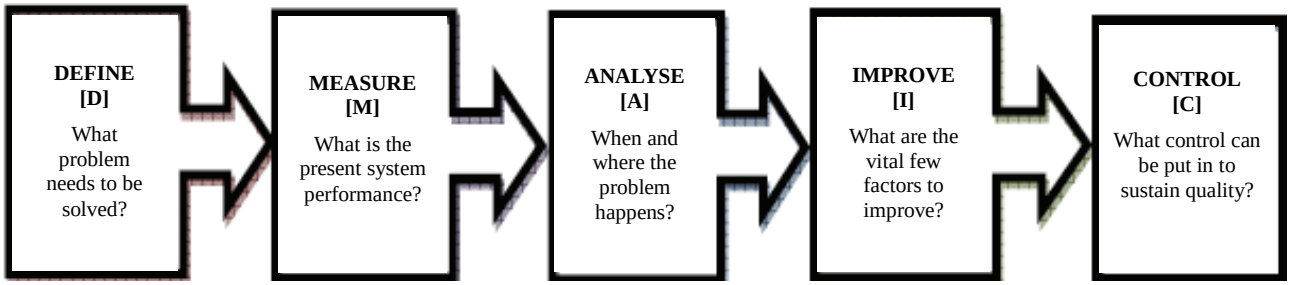

Figure 2. DMAIC methodology

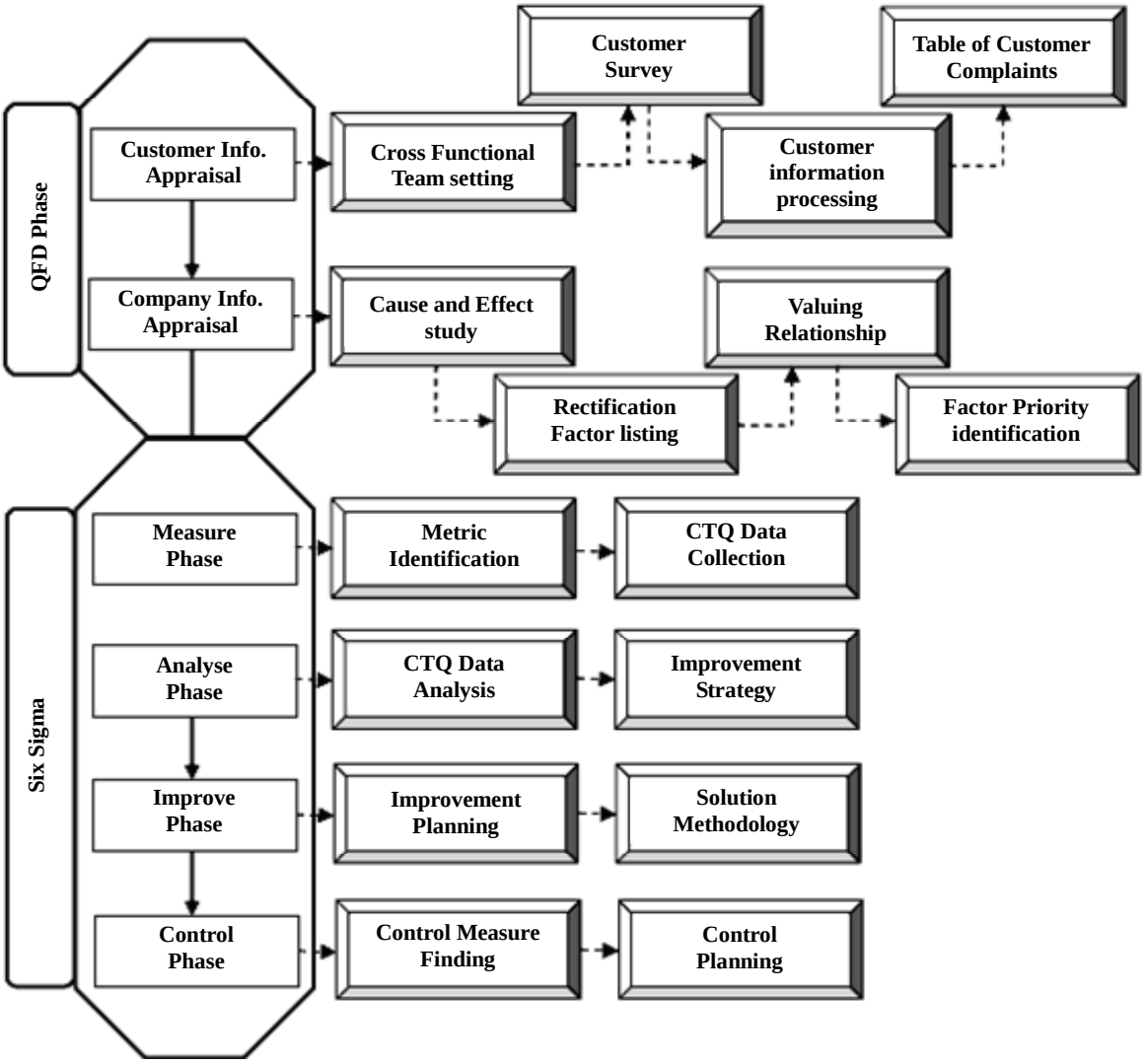

Figure 3. CCM model

The possible achievements of this CCM model are;

- It serves as good complaint recording technique.
- Well organized system of sorting and recording complaint data assures customer concerns effectively.
- It provides policy and procedural review to top management for complaint revival.
- It empowers the front line staff in the organization to handle customer complaints in the most appropriate manner.
- It avoids the misunderstanding of complaints.
- Payback is greater than the cost of customer dissatisfaction.

5. Case Study

A case study is done in an automobile service industry engaged in passenger car care process with principle authorization. The company is highly sensitive to customer satisfaction issues and reacts quickly to the complaints they consider to be CTQ. This practice allows them to keep ahead of the competition though there is rapid growth in vehicle population in recent days. The customer complaints also rose up in the vertical axis which put the company into hurdle. Even though the customized approaches are in-force for addressing the customer problems within the company, they struggle to address grievances. The CCM model is proposed for customer complaint management and service recovery. The further sections explain the case study analysis with CCM model in phase wise.

5.1 QFD Phase

This phase comprises two sub processes namely *Customer information appraisal* and *Company information appraisal a*s depicted in **Figure 3**.

***Customer information appraisal*:** This process involves the following steps as illustrated in **Figure 4**.

Cross Functional Team [*CFT*] *Setting*: CFT comprising all department personals is constituted to identify the customers and their complaints.

Customer Survey: With prior management approval, the customers are surveyed with questioner formats in such a way that every customer is being asked about what is the present complaint/reason for dissatisfaction, what they expect, how best the competitors are performing than the company and overall performance of the company.

***Customer Information Processing*:** From customer feedbacks, the customer complaints are processed with their importance level. Importance Level [IL] is a scale value in which 1 indicates least importance where as 9 indicates most important complaint. IL is a useful measure to prioritize the qualitative customer complaints based on the reported frequency and their impact on customer satisfaction. Since the customer survey includes performance evaluation of the competitors, it is rated against each of the customer complaints. The rating varies from 1 for poor performance to 5 for better performance. The ratings are obtained directly from the customers during the initial survey.

Table of Customer Complaints: All the complaints are tabulated with their IL value and Competitor ratings as shown in **Table 1** and followings findings are consolidated.

Competitor rating indicates:

- With respect to late vehicle delivery, the competitor X and the company are rated equal where as the competitor Y is rated poorer than them.
- Regarding the cost of service, the competitor Y and the company are rated equally and competitor X is given rating 2 which indicates service cost of competitor A is higher than the rest.
- In hospitality complaint, the competitor X is rated good where as competitor Y and the company are rated poorer equally than X.
- For poor off-road service, all the three companies are rated equally with rating 4. For poor accident assistance, the surveying company is rated as good than competitor Y, poor than competitor X.
- The surveying company is rated as good than others for Annual Maintenance Contract [AMC] problems.
- Also as for as concerned with service quality, the company is rated as good than competitors with rating 4.

The unique feature in this model is that the Importance Level and competitor rating not only helps to prioritize the qualitative customer complaints, but also used to converge further analysis in such a way that;

- With respect to the level of importance, the complaints, late vehicle delivery, high cost of service and poor service quality are found more precedence and needs further attention to enhance customer satisfaction.
- Even the complaints with IL below 5 has certain impact on customer satisfaction, it is given least attention in CCM model than complaints with IL more than 5.
- With respect to competitor rating, the company is rated equally with both competitors for late vehicle delivery and high service cost problems. In the view of leading the market competition, the company has to strive

Table 1. Table of customer complaints

Complaints	Importance Level [1 to 9]	Competitor Rating [1 – poor 5 - good]		
		X	Y	Ours
Late vehicle delivery	9	3	2	3
High cost of service	7	2	4	4
Poor Hospitality	4	5	2	2
Poor off-road Assistance	4	4	4	4
Poor accident assistance	5	5	3	4
Unfair AMC	2	3	3	5
Poor service Quality	8	3	3	4

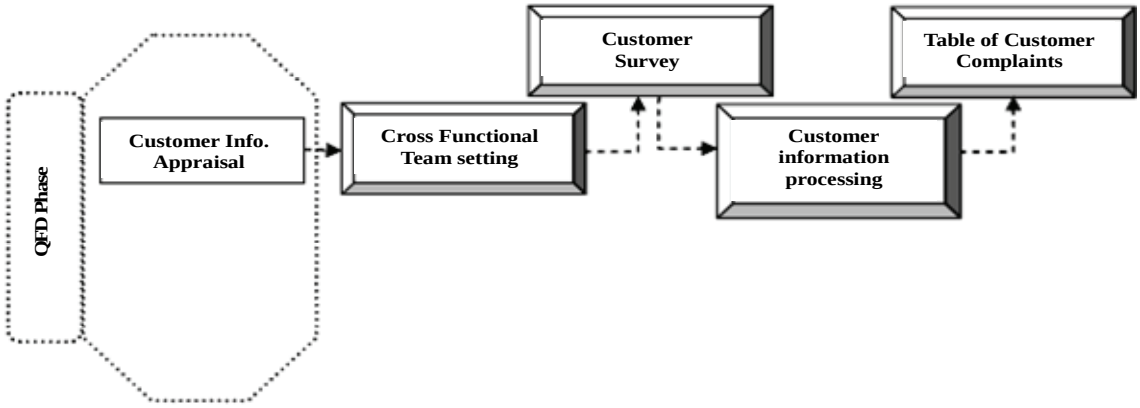

Figure 4. Customer information appraisal

immediately before the competitors. But in case of service quality complaint, even though the company does well than competitors, the customer expects still more. Hence any little improvement in service quality may have large impact in customer satisfaction.

Hence the further analysis is focused with complaints as altered in **Table 2**.

***Company Information Appraisal*:** This process is aimed to identify the rectification factors pertaining to short-listed customer complaints listed in **Table 2**. This process involves the following steps as shown in **Figure 5**.

Cause and Effect Study: This study determines the measurable factors which influences customer satisfaction. The rectification factors are identified by using cause and effect diagram as shown in **Table 3**.

Rectification factors listing: After identifying the possible rectification factors, it is arranged across the top portion of the HOQ matrix as depicted in **Figure 6**.

Value Relationship: In order to know the value judgment of impact of the identified factors, the inter relationship between factor and complaint is assessed. The rectification factors are assigned weight age; 5 for strong relationship, 3 for moderate relationship and 1 for weak relationship. Each factor is assessed its relationship nature with every complaints and awarded weight age accordingly.

Table 2. Altered table of customer complaints

Complaints	Importance Level [1 to 9]	Competitor Rating [1 – poor 5 - good]		
		X	Y	Ours
Late vehicle delivery	9	3	2	3
High cost of service	7	2	4	4
Poor service Quality	8	3	3	4

Table 3. Cause and effect study

Effect		
Customer Complaint		
Level 1 Causes		
Late vehicle delivery	High service cost	Poor service quality
Level 2 Causes		
Insufficient man power		
Poor sub contracting		
Lack of resources		
Poor workload planning and scheduling		
Material cost (Direct and indirect)		
Labour cost (Direct and indirect)		
Overheads		
Pricing policy		
Unskilled labour		
Poor job training		
Quality of spare parts		
Knowledge of work and technical expertise		

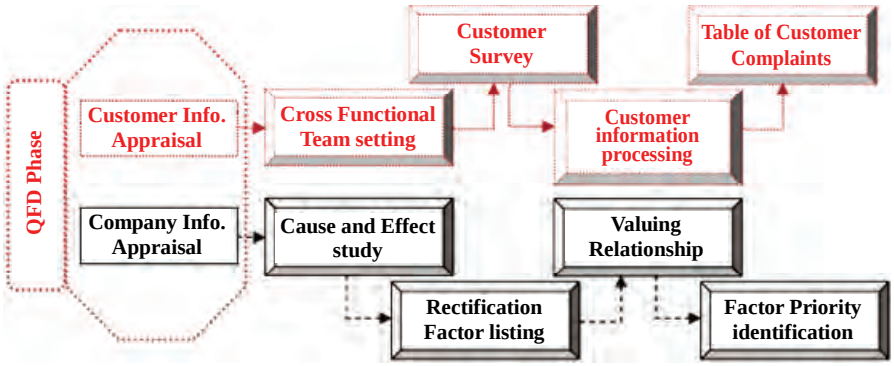

Figure 5. Company information appraisal

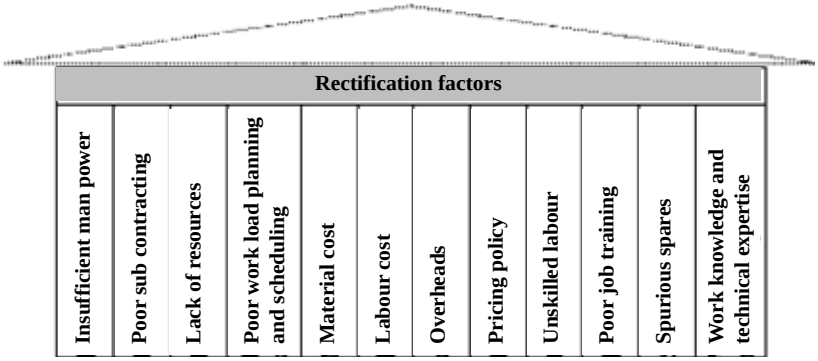

Figure 6. Rectification factors in HOQ matrix

Thus the relationship value is filled in the matrix as shown in **Figure 7**.

Factor Priority Identification: In order to spot out the most influencing factor for customer satisfaction, priority is established to rectification factors. The priority weight age is calculated using factor relationship value and complaint IL value. For rectification factor "Insufficient man power" the relationship values are (5, 1, 3) and complaint IL values are (9, 7, 8) respectively. The priority weight age is (5 × 9) + (1 × 7) + (3 × 8) = 76. Similarly the priority weight is calculated and recorded at the bottom of the matrix as shown in **Figure 8**. The factor 'Poor work load planning and scheduling' is identified as CTQ since it scores highest priority weight 106. The CTQ identified has strong influence in customer vehicle delivery commitment and service quality, has moderate influence in service cost.

As summarized in **Table 2**, the competitor rating clearly indicates that the surveying company and competitor X are doing equally well than competitor B in maintaining delivery schedules, whereas, with respect to service quality, the company is already rated well than competitors. Since the CTQ has strong influence in delivery schedules and service cost, any small extent of improvement in CTQ may have greater influence on customer requirements and in turns makes the company to lead competition well in advance than others.

5.2 Six Sigma

The output of QFD phase is taken as input to Six Sigma measure phase in CCM model.

Measure Phase: After identifying the CTQ factor through QFD process, further analysis is carried through Six Sigma process. Measure phase is the initial phase in which quantifying the factor is sought. This objective is done through the following steps as shown in **Figure 9**.

	Rectification factors											
	Insufficient man power	Poor sub contracting	Lack of resources	Poor work load planning and scheduling	Material cost	Labour cost	Overheads	Pricing policy	Unskilled labour	Poor job training	Spurious spares	Work knowledge and technical expertise
Late vehicle delivery	5	5	3	5	1	1	1	1	3	3	1	1
High cost of service	1	5	1	3	5	5	5	5	3	3	3	3
Poor service quality	3	1	5	5	3	3	3	1	5	5	5	5

Figure 7. Rectification factors with relationship value

		Rectification factors											
Complaints	IL	Insufficient man power	Poor sub contracting	Lack of resources	Poor work load Planning and scheduling	Material cost	Labour cost	Overheads	Pricing policy	Unskilled labour	Poor job training	Spurious spares	Work knowledge and technical expertise
Late vehicle delivery	9	5	5	3	5	1	1	1	1	3	3	1	1
High cost of service	7	1	5	1	3	5	5	5	5	3	3	3	3
Poor service quality	8	3	1	5	5	3	3	3	1	5	5	5	5
Priority Weight		76	85	104	106	68	68	68	52	88	88	70	70

Figure 8. Priority weight for rectification factors

***Metric Identification & Data Collection*:** The present work load planning and scheduling activity is measured in terms of work force and No. of days respectively. The workforce hierarchy in the company comprises section supervisors provided with skilled and semi skilled labours. The available labour force in car servicing centre is 6 section supervisors with 24 skilled and 40 semi skilled labours. Presently the work is scheduled on FCFS (First Come First Serve) basis. The incoming car ranges from 25 to 30 per day. The time taken by a car from the arrival to delivery after service inside the company includes time taken by supervisor to attend first, time taken to prepare job card, time taken to prepare estimate, time taken for repair work and time taken to pay for service. Any delay in time taken for any one or more of above mentioned tasks results in customer complaints. Time taken to service the car is associated in either ways to delay in delivery and service quality, if the repair time is more, then the delivery may not at the committed time where as if the service time is less, then the quality of service may not be assured.

Analyze Phase: with available information regarding work load and labour force availability, this phase works out to determine the solution possibilities. It involves analysis of workload planning, scheduling, and developing improvement strategy as shown in **Figure 10**.

***CTQ Data Analysis*:** The overall workload to the company comprises of free service, paid service, body work and accident repairs. Since the company is an authorized dealer, many of the service requests from the customers belong to free service category (under warranty). Having a check, the incoming vehicle mixture for a period of past 3 months, it seemed that the 50% was occupied by free service vehicles out of an average incoming of 30 cars. As the free service request is comparatively more, it becomes obvious to look into the labour structure of free service department. In the company, the free service department is equipped with one service supervisor and four teams of labour; each team contains a skilled mechanic and two semi skilled helpers. The supervisor accepted the car for service work and allots it to any one the four teams depending upon the workload already assigned to that team.

***Improvement Strategy*:** The reason for poor workload

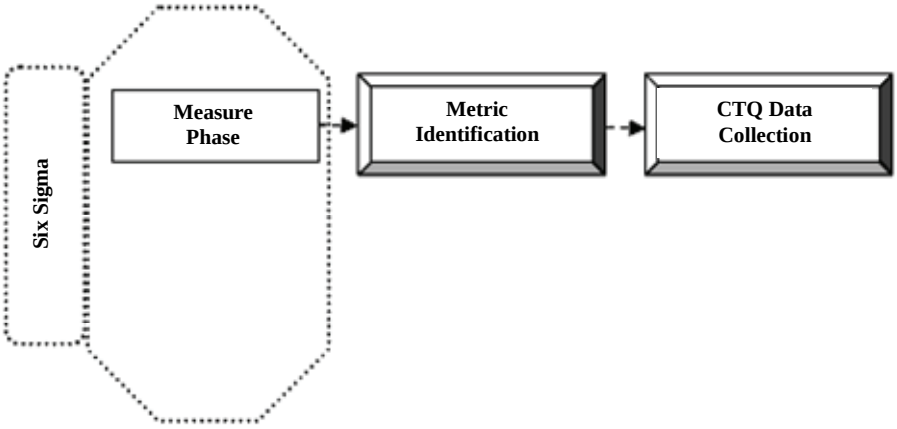

Figure 9. Six sigma measure phase

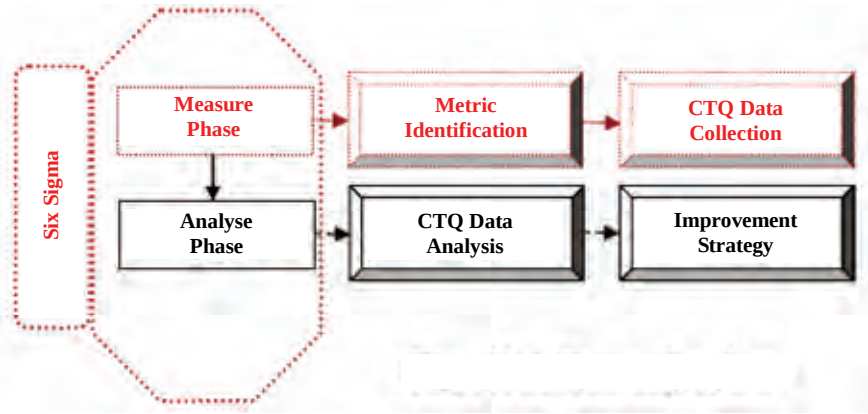

Figure 10. Six sigma analyses phase

sharing in this practice is that it is purely depends on the judgment of the respective supervisor. Even though the authorizing principle has provided standard labour schedules for service requests, the supervisor may not be in position to work out the total workload of each car when it arrives because of unknown pattern of car incoming and non standard works. This results in both overloading and under loading of teams, finally ends with customer complaints.

Improve Phase: In this phase, the strategy for improving performance is planned as shown in **Figure 11** and executed in the following steps.

***Improvement Planning*:** To improve the workload planning of free service department, an algorithm is developed for calculating the incoming workload. This algorithm felicitates the determination of incoming work load and department level workload of the company. The workload calculation aids the supervisors to commit the positive due date. It is also equally important to develop a solution for the problem of worker loading in the fleet. To handle work assigning task in a systematic way, an algorithm is developed to assist the work assigning task of section supervisors.

***Solution Methodology*:** It is proposed to calculate the work load of the incoming car on receipt. Work load is expressed in terms of hours required to perform. For regular and routine service related enquiries, the company is already supplied the time standards by their principles. For non standard works, the approximate time required to complete is estimated with the help of experience of service personals.

***Work Load Planning Algorithm*:**

Let

N = Number of incoming cars per day.

n = Number of jobs reported in a car.

T_j = Time to complete job 'j' in terms of Hours

W_i = Workload of car 'i' in terms of hours.

W_d = Total workload per day per department in terms hours.

On receipt of a car into to service centre, the information related to jobs are collected through work order form by the section in-charge. Then the workload is calculated with available standard time schedules as follows;

$$W_i = \sum_{j=1}^{n} [[T]_j] \quad (1)$$

where W_i = workload of car 'i'

j = repair job

n = Total jobs reported

T_j = time to do job 'j'

$$W_d = \sum_{i=1}^{N} [[W]_i] \quad (2)$$

where W_d = workload of the department

W_i = workload of car 'i'

N = Total incoming cars per day

The company begins its day to day work at 08.30 am with lunch break for 1 hr and tea break for 15 mins in either sessions and closes works at evening 6.00 pm. The available labour time per day is 8 hrs per team. Hence the total work time available for free service department is 8hrs × 4 teams = 32 hrs. With the available work time, the free service department can service cars with maximum workload of 32 hrs per day with four teams. But in practice, time spent for non-work activities like tool search, power failure, work hazards, time to procure spares from store etc not allows to complete maximum workload of a day. Hence, whiling calculating the workload of car, some standard allowance is added at the rate of 10% of the workload of the car to accommodate above said non-work events. Also for the vehicle arriving just before the tea break or lunch break, the break time is added with service time to obtain actual workload of the car.

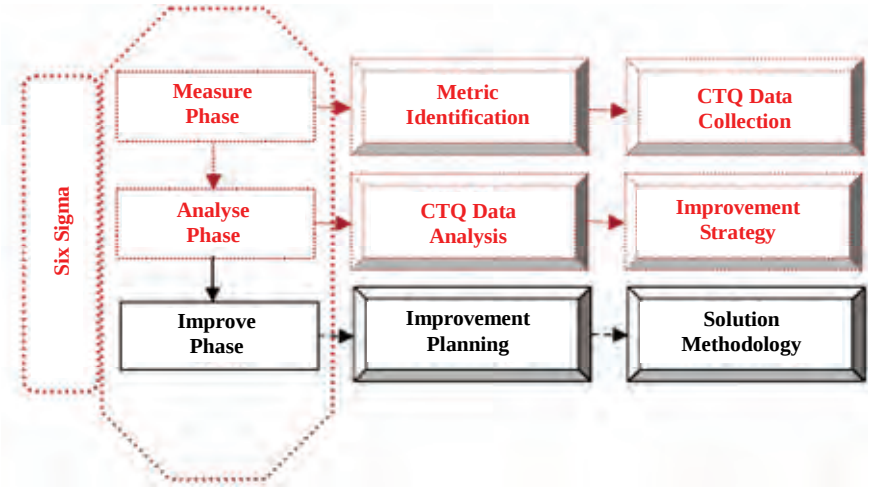

Figure 11. Six sigma improve phase

Hence Equation (1) becomes

$$W_i = \sum_{j=1}^{n} \left[\left[\mathrm{T} \right]_{\mathrm{j}} \right] + T_a + T_b \qquad (3)$$

where T_a = Allowance time

T_b = Break time

Calculating the actual workload of incoming car by using above Equation (3) enables the section supervisor to calculate total workload of the department on that day, so that he can commit the delivery schedule to the customer easily and preciously. If any previous day's work kept pending and to be carried out on next day, the same may be suitably added with the total workload of the department before committing the delivery time to the fresh customers.

***Work Load Scheduling*:**

Calculating the workload and committing the delivery time accordingly is very tough to increase the effectiveness of the workload scheduling of the department or company, but effective and efficient work assigning to team is important to achieve the delivery commitments with work quality. To develop an effective assigning method, it is assumed that each team can handle one car at a time. With this assumption, the following algorithm is developed.

Let

M = number of teams

Wx = workload assigned to team 'x'

With assumption that all the teams are free, the following sample work assigning illustrates how to schedule workloads among team in a systematic way as depicted in **Figure 12**.

- Assign workload W1 = 2 hours to team 1. Now team 1 is loaded until 10.30 am.
- Assign workload W2 = 1.5 hours to team 2. Now team 2 is loaded until 10.00 am.
- Assign workload W3 = 3 hours to team 3. Now team 3 is loaded until 11.30 am.
- Assign workload W4 = 6 hours to team 4. Now team 4 is loaded until 02.00 pm.

Now all the teams are given work and team 2 is in the position to complete earlier than team1. Next workload should be assigned to team 2. Hence

- Assign workload W5 = 4 hours to team 2. No team 2 is loaded until 02.00 pm.

Now team 1 is in the position to complete earlier than team 3. Any next workload should be assigned to team 1. In this way, the available teams are equally shared with incoming workloads. This approach felicitates the workload sharing process as well as helps to identify the teams which can take up with fresh work after the execution of the existing service works. Further it helps to obtain the delivery schedules by using the time scale. Strictly adhering to workload norms and effective work assigning practice leads to improvement in overall efforts.

***Control Phase*:** To sustain the improvement activities for ever, good monitoring system is important to control the workload determination process and workload assigning activity of each department in the company. In this phase, the control measures are identified and a control plan is devised to achieve the objective as shown in **Figure 13**.

***Control Measure Finding*:** the customer complaints are highly dynamic in nature and require continuous knowledge update to solve then and there. To sustain the advantage of this model, the following control measures are identified and put in force for result;

- Periodic brainstorming sessions to share difficulties faced in this new approach.
- Continuous watch on customer complaint.
- Top management involvement.
- Regular motivational and technical training for supervisors to promote their skill and work involvement.

***Control Planning*:** The approved thump rule of 50% improvement in the first effort of new Six Sigma drive is applied here to set the target which should result from the improve phase.

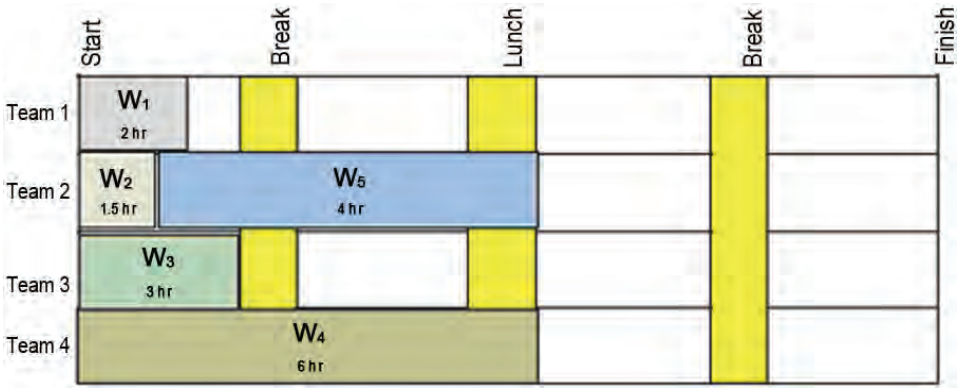

Figure 12. Work load scheduling

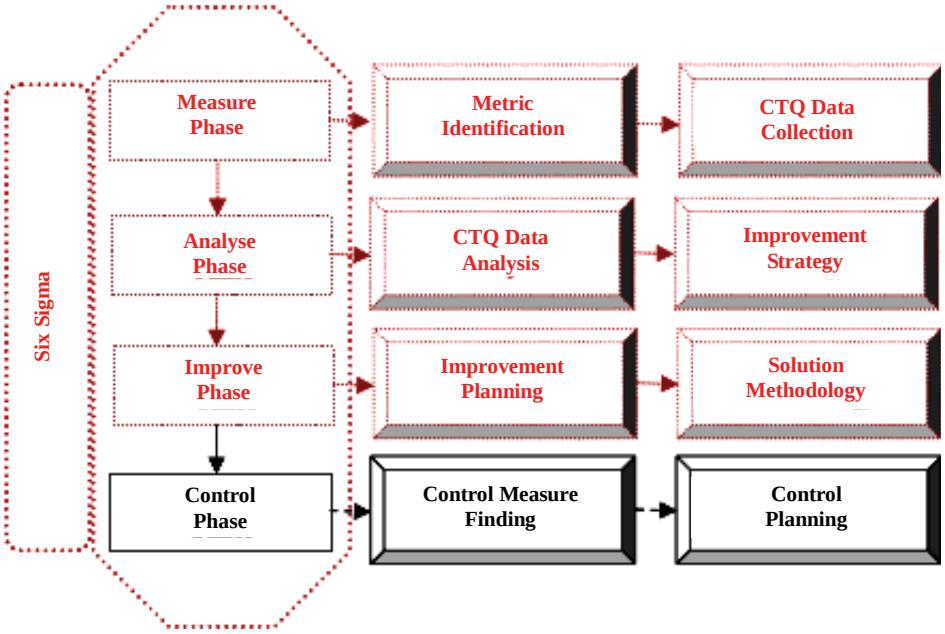

Figure 13. Six sigma control phase

6. Concluding Remarks

This study has developed a customer care management [CCM] model by using the conceptual features of QFD and Six Sigma. This model is proposed in an automotive service company to manage customer complaints. At the end of QFD phase, the 'work load planning and scheduling' was identified as CTQ. Through the four sub phases of Six Sigma, the CTQ is analyzed. In this improvement drive, work load calculation algorithm and work load assigning practice were developed to solve predominant customer complaints. In this new approach, the inter relationships between solution factors are not considered. Naturally in some cases improvement of one factor may have impact on another factor either to improve or to worse. Also, in the QFD analysis, the rectification factors are not evaluated against competitors as done for customer complaints. But it is one of the important analyses for companies to keep competitive edge. Since it is practically not possible to do competitive analysis for rectification factors, instead of that is may be advisable to look for innovative solution possibilities. This may be accomplished by adding the features of an innovative technique like TRIZ in CCM model. Further research exertion may please be extended to study the possibilities for accommodating the nature of relationship between the solution factors and innovative features in the CCM model.

REFERENCES

[1] Chakrabarty and K. C. Tan, "The Current State of Six Sigma Application in Services," *Managing Service Quality*, Vol. 17, No. 2, 2007, pp. 194-208.

[2] R. Sousa and C. Voss, "Quality Management Revisited: A Reflective Review and Agenda for Future Research," *Journal of Operations Management*, Vol. 20, No. 1, 2002, pp. 91-109.

[3] Gronroos, "Service Management and Marketing," *Lexington Books*, Lexington, Massachusetts, 1990.

[4] R. L. Hensley and K. Dobie, "Assessing Readiness for Six Sigma in a Service Setting," Managing Service Quality, Vol. 15, No. 1, 2005, pp. 82-101.

[5] A. Desai, "Improving Customer Delivery Commitments the Six Sigma Way: Case Study of an Indian Small Scale Industry," *International Journal of Six Sigma and Competitive Advantage*, Vol. 2, No. 1, 2006, pp. 23-47.

[6] V. Zeithamal, A. Parasuraman and L. Berry, "Delivering Service Quality," The Free Press, New York, 1990.

[7] Collier, "The Service/Quality Solution Suing Service Management to Gain Competitive Advantage," Irwin, Milwaukee, 1994.

[8] K. Yoo and J. A. Park, "Perceived Service Quality, Analyzing Relationships Among Employees, Customers and Financial Performance," *International Journal of Quality & Reliability Management*, Vol. 24, No. 9, pp. 908-926, 2007.

[9] M. Kumar, J. Antony, C. N. Madu, D. C. Montgomery and S. H. Park, "Common Myths of Six Sigma Demystified," *International Journal of Quality & Reliability Management*, Vol. 25, No. 8, 2008, pp. 878-895.

[10] C. Fornell and B. Wernerfelt, "Defensive Marketing Strategy by Customer Complain Management," *Journal of Marketing research*, Vol. 24, No. 4, 1987, pp. 337-346.

[11] J. Antony, "Six Sigma for Service Processes," *Business Process Management Journal*, Vol. 12, No. 2, 2006, pp. 234-248.

[12] R. B. Coronado and J. Antony, "Critical Success Factors for the Successful Implementation of Six Sigma Projects in Organizations," *The TQM Magazine*, Vol. 14, No. 2, 2002, pp. 92-99.

[13] R. G. Day, "Quality Function Deployment," Tata McGraw-Hill Publishing Company Limited, New Delhi, 1995.

[14] Y. Hong and T. N. Goh, "Six Sigma in Software Quality," *The TQM Magazine*, Vol. 15, No. 6, 2003, pp. 364-373.

[15] J. Goding and M. Hammer, "Putting Six Sigma in Perspective," *Quality*, Vol. 40, No. 10, 2001, pp. 58-62.

[16] S. H. Park, "Six Sigma for Quality and Productivity Promotion," Asian Productivity Organization, Tokyo, 2003.

[17] J. Antony, K. Downey-Ennis, F. Antony and C. Seow, "Can Six Sigma Be the "Cure" for our "Ailing" NHS?" *Leadership in Health Services*, Vol. 20, No. 4, 2007, pp. 242-253.

[18] M. Finster, "From Continuous Improvement to Continuous Innovation," *Quality Management Journal*, Vol. 8, No. 4, 2001, pp. 7-33.

iBusiness, 2010, 2, 156-167
doi:10.4236/ib.2010.22019 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Comparison of GA Based Heuristic and GRASP Based Heuristic for Total Covering Problem

Chandragiri Narashimhamurthy Vijeyamurthy[1], Ramasamy Panneerselvam[2]

[1]Network Coordination, BSNL, Chennai, India; [2]Department of Management Studies, School of Management, Pondicherry University, Pondicherry, India.
Email: vijeyamurthy@gmail.com, Panneer_dms@yahoo.co.in

Received January 25th, 2010; revised March 3rd, 2010; accepted April 9th, 2010.

ABSTRACT

This paper discusses the comparison of two different heuristics for total covering problem. The total covering problem is a facility location problem in which the objective is to identify the minimum number of sites among the potential sites to locate facilities to cover all the customers. This problem is a combinatorial problem. Hence, heuristic development to provide solution for such problem is inevitable. In this paper, two different heuristics, viz., GA based heuristic and GRASP based heuristic are compared and the best is suggested for implementation.

***Keywords*:** *Genetic Algorithm, GRASP, Total Covering Problem, Boolean Operators, Care and Share Operator*

1. Introduction

Consider a sales region of a product, which in turn has different customer regions. The company selling the product should fix necessary number of dealer points such that the customers in that sales region are fully served. The company may fix a maximum of say 5 km of distance for the customers to reach a given dealer point from his/her region (customer region). In this process, a given customer may be covered by more than one dealer point. The objective is to locate the minimum number of dealer points in the sales region under consideration such that those dealer points cover all the customers regions.

Here, the process of serving a customer region by a dealer point is called as covering that customer region by that dealer point. The word "cover" means that the location of a customer is well within the given upper limit for the distance from a facility-location from where that customer will be served. Here, the objective is to locate facilities at minimum number of sites to cover all the customers. Such problem is known as *total covering problem* [1].

Consider a problem in which dealer points are to be located to serve the customers in a sales region. Assume that there are six customer regions, which are to be covered by dealer points. In this problem, five potential locations are identified for locating dealer points. The distance matrix between the customer regions is as shown in **Table 1**.

Now, a distance criterion of say, 5 km is assumed. This means that no region in the sales region is beyond 5 km from a site where a dealer is located. Based on this assumption, a covering coefficient is defined as shown below.

Let, $c_{ij} = 1, \; if \;\; d_{ij} \le 5\,km$

$= 0$, otherwise

where, c_{ij} is the covering coefficient for the customer region i and the potential dealer point j and d_{ij} is the distance between the customer region i and the potential dealer point j. Based on this definition of covering coefficient, the corresponding covering coefficient matrix is shown in **Table 2**.

A careful examination of the **Table 2** reveals that if the potential site 1 and the potential site 3 are assigned with dealers, all the six customer regions in the sales regions will be fully covered. As per this coverage, the potential site 1 will cover the customer regions 1, 2 and 4 and the potential site 3 will cover the customer regions

Table 1. Distance matrix of locating dealer points (distance in km)

		Potential Dealer site j				
		1	2	3	4	5
Customer Region i	1	3	6	4	6	12
	2	5	7	2	3	7
	3	11	4	3	15	6
	4	4	5	6	11	4
	5	15	9	5	5	9
	6	14	12	2	16	13

Table 2. Covering coefficients matrix of locating dealer points

		Potential Dealer site j				
		1	2	3	4	5
Customer Region i	1	1	0	1	0	0
	2	1	0	1	1	0
	3	0	1	1	0	0
	4	1	1	0	0	1
	5	0	0	1	1	0
	6	0	0	1	0	0

1, 2, 3, 5 and 6. The customer regions 1 and 2 are covered by the facilities from both the selected potential sites. This is an example of multiple-coverage of some customers by a set of facilities. The different examples of total covering problem are shown in **Table 3**. The total covering problem falls under combinatorial category. Hence, it is inevitable to design an efficient heuristic to obtain near optimal solution. In this paper, an attempt has been made to develop and compare a genetic algorithm based heuristic and a GRASP based heuristic for the total covering problem.

2. Review of Literature

The covering problem comes under the facilities location problem. The covering problem can be classified into total covering problem and partial covering problem. The objective of the total covering problem is to cover all the customers with the minimum number of facilities whereas the objective of the partial covering problem is to cover as many customers as possible with the minimum number of facilities without exceeding the limit on the utmost number of facilities to be operated as suggested by the management. In this research, the total covering problem is considered.

Toregas *et al*. [2] have developed a liner programming model to solve the traditional set covering problem with equal cost in the objective function. Patel [3] has used dynamic programming approach for locating rural social service centers for the Dharampur taluka in South Gujarat in India. Klastorin [4] has solved the conventional set-covering problem by mapping it into an assignment problem. Saatcioglu [5] has used a mathematical model for airport site selection based on Turkish data. Neebe [6]

Table 3. Examples of total covering problem

S.No.	Problem	Customers	Facilities assigned to potential sites	Criterion	Objective
1	Location of schools	Residential regions	Schools	Maximum distance of 5 kilometers	To locate minimum number of schools to cover all the residential regions
2	Location of raw material warehouses	Muti-plant in an organization	Raw material warehouses	Maximum of 30 kilometers	To locate minimum number of warehouses in a state to cover all the plants
3	Location of dealers of automobiles	Residential regions	Dealer locations for automobiles of a company	Maximum of 10 kilometers	To locate minimum number of dealers to cover all the residential regions
4	Location of emergency food grain stations	Residential regions	Emergency food grain stations	Maximum of 150 kilometers	To locate minimum number of emergency food grain stations to cover all the residential regions in the event of a disaster.
5	Location of emergency relief vehicle station	Railway subdivisions	Emergency relief vehicle station	Maximum of 100 kilometers	To locate minimum number of emergency relief vehicle stations to cover all railway subdivisions in a division.
6	Variety reduction in a fasteners producing company	Actual required diameters of steel rod for making fasteners	Available diameters of steel rods at raw material stage	If the required diameter of a fastener is less than or equal to an available diameter of steel rod, then the fastener of the required diameter can be made using that available diameter of steel rod	To determine minimum number of sizes (diameters) of available steel rods to make all the fasteners.

has developed a procedure for locating emergency-service facilities for all possible response distances. Panneerselvam [7] has developed a heuristic procedure for the total covering problem. Rajkumar and Panneerselvam [8] have improved the work of Panneerselvam [7]. Later, Panneerselvam [9] has developed an efficient heuristic for the total covering problem. O'kelly [10] demonstrated the use of covering problem for locating interacting hub facilities. Hubs are central facilities, which act as switching points in networks connecting a set of interacting nodes. Boffey [11] has discussed the location problems arising in computer networks.

Chan *et al*. [12] have developed a branch and bound algorithm with multiplier adjustment for the traditional set-covering problem. Chaovalitwongse, Berger-Wolf, Dasgupta and Ashley [13] have conducted a simulation study of their proposed algorithm to demonstrate that their combinatorial approach is reasonably accurate. The results suggests the proposed algorithm would pave a way to a new approach in computational populations genetics as it does not require any a priori knowledge about allele frequency, population size, mating system or family size distributions to reconstruct sibling relationships. To extract the minimum number of biologically consistent sibling groups, the proposed combinatorial approach is employed to formulate this minimization problem as a set covering problem.

Pelegrin, Redondo, Fernandez, Garcia and Ortigosa [14] have proposed genetic like algorithm, GASUB for finding the global optima to discrete location problems. The authors claim that the algorithm finds the predetermined number of global optima, if they exist, for a variety of discrete location problems. GASUB has been compared to MSH, the multi start substitution method and found that it gave better solutions than MSH. Alumur, Kara and Karasan [15] have classified and surveyed the hub location models, including the recent trends on hub location and provided a synthesis of the literature. The hub location problem is concerned with locating hub facilities and allocating demand nodes to hubs in order to route the traffic between origin-destination pairs. Hubs are special facilities that serve as switching, transshipment and sorting points in many—to—many distribution systems.

Marianov, Mizumori and Re Velle [16] proposed a new heuristic, called heuristic concentration—integer (HCI). The authors have applied the algorithm to the maximal availability location problem (MALP) and the solutions are compared to those obtained using linear programming with branch and bound. They claim that HCI could find good solutions to the problems in a reasonable time compared to LP-IP solutions. Francisco, Antonio and Glaydston [17] have presented a solution procedure for probabilistic model using column generation having constraint in waiting time, queue length for congested system with one or more servers per service center for the maximal covering location—allocation problems. The authors claim that the results were obtained in reasonable time. Batanovic, D. Petrovic and R. Petrovic [18] have considered the maximum covering location problems in networks in uncertain environments. They have proposed three new algorithms for choosing the best facility locations assuming that the demands at all nodes are equally important, the relative weights of demands at nodes are deterministic and weights of demand at nodes are imprecise. The algorithms are based on searching among potential facility nodes by applying comparison operations on discrete fuzzy sets.

The review of literature indicates that the researchers have developed mathematical models, branch and bound algorithms and heuristics. Since, the total covering problem comes under combinatorial category, the development of an efficient heuristic is inevitable. In this paper, the researchers have proposed a genetic algorithm based heuristic and a GRASP based heuristic for total covering problem and compared their performances.

3. Mathematical Model of Total Covering Problem

In general, all emergency/ essential service related situations are formulated as total covering problems.

A mathematical model of the total covering problem is presented below.

Let, m be the number of customers;

n be the number of potential sites;

c_{ij} be the covering coefficient for the customer i and potential site j

Minimize $Z = \sum x_j$

Subject to

$$\sum_{j=1}^{n} c_{ij}\, x_j \geq 1 \quad \text{for i = 1 to } m.$$

where,

$x_j = 1$, if the potential site j is assigned with a facility;

$= 0$, otherwise, for j = 1, 2, 3,…, n.

The objective function minimizes the total number of sites selected for assigning facilities. The constraint i ensures that each customer is served/covered by at least one selected potential site which is assigned with a facility.

4. Development of Heuristics

The total covering problem falls under combinatorial category. Hence, it is inevitable to design an efficient heuristic to get near optimal solution. In this paper, the authors have made an attempt to develop a *Genetic Algorithm* (GA) based heuristic and a *Greedy Randomized Adaptive Search Procedure* (GRASP) based heuristic to obtain global optimum solution for the total covering problem.

4.1 GA Based Heuristic

Genetic algorithm is a meta-heuristic, which is used to find the solution to any combinatorial problem. It mimics the mechanism of selection and evolution. In order to achieve the objective, GA generates successive population of alternate solutions until obtaining a solution, which yields acceptable result. Within the generation of each successive operation, an improvement in the quality of the individual solution is achieved. Hence, GA can quickly move to a successful outcome without determining every possible solution to the problem. The procedure used in the genetic algorithm is based on the fundamental processes that control the evolution of biological organisms, namely, natural selection and reproduction.

Organism's ability to survive within its environment is improved by the two processes as explained below.

1) Natural selection determines which organism has the opportunity of reproduction and survival within a population.

2) Reproduction involves genes from two separate individuals combining to form offspring that inherit the survival characteristics of their parents.

This section presents a genetic algorithm based heuristic for total covering problem. The genetic algorithm has two major operations, viz. crossover operation and mutation. Consider the covering coefficient matrix, which is already shown in **Table 2** and the same is reproduced in **Table 4**.

4.1.1 Crossover Operation

In this section, the crossover operation which is performed on two chromosomes to produce offspring is presented. To explain this operation, the encoding of the given covering coefficient data into chromosomes is as presented below.

The 0-1 entries in each of the rows of the covering coefficient matrix are treated as a chromosome. A zero entry in a chromosome represents non-allocation of facility to the respective potential site and one entry in that chromosome represents allocation of facility to the respective potential site. So, the sequence of 0-1 entries in each chromosome represents the values of the decision variable x_j, for j = 1, 2, 3, …, n, where $x_j = 1$ if the potential site j is assigned with a facility; otherwise, it is equal to 0 and n is the total number of potential sites. So, entries in each chromosome give one possible solution to the total covering problem.

Table 4. Covering Coefficients Matrix of Locating Dealers

		Potential site j				
		1	2	3	4	5
Region i	1	1	0	1	0	0
	2	1	0	1	1	0
	3	0	1	1	0	0
	4	1	1	0	0	1
	5	0	0	1	1	0
	6	0	0	1	0	0

If the given problem has m customers, then the initial population will have m chromosomes. For the given problem, the chromosomes of the initial population are as listed below and each chromosome is treated as a binary number.

Chromosome 1: 1 0 1 0 0
Chromosome 2: 1 0 1 1 0
Chromosome 3: 0 1 1 0 0
Chromosome 4: 1 1 0 0 1
Chromosome 5: 0 0 1 1 0
Chromosome 6: 0 0 1 0 0

The crossover operation is done using the following pairs of Boolean operators:

1) Logic OR and Logic AND
2) Odd shift before Logic OR and Logic AND
3) Even shift before Logic OR and Logic AND
4) Logic OR and odd shift before Logic OR
5) Logic OR and even shift before Logic OR
6) Logic AND and odd shift before Logic AND
7) Logic AND and even shift before Logic AND

While the offspring are created using the above pairs of crossover operators, if any one offspring is infeasible, then it is replaced with a feasible offspring, which will be created by *Care and Share* crossover operation.

4.1.2 Evaluation of Offspring

Consider an offspring "1 0 1 0 0". Its evaluation is done as presented in **Figure 1**. The genes of the offspring are positioned in the respective order just above the columns corresponding to potential sites. The regions which are covered by each site, which is assigned with a facility are shown by marking squares around the respective "1" entries in the covering coefficient matrix. In **Figure 1**, the site 1, which is assigned with a facility, covers the regions 1, 2 and 4. The facility assigned at the site 3 covers the regions 1, 2, 3, 5 and 6. The union of the subsets of regions, which are covered by the site 1 and the site 3 are {1, 2, 3, 4, 5, 6}. This means that all the six regions are covered by the facilities that are assigned at the site 1 and the site 3. Hence, the offspring is a feasible offspring. The corresponding fitness function value (number of sites which are assigned with facilities) is 2.

4.1.3 Care and Share Crossover Operation

Consider another offspring, whose genes are "0 1 0 0 0". As explained in section 4.1.2, the coverage of the regions by the only site 2 in this offspring, which is assigned with a facility, is shown in **Figure 2**. In **Figure 2**, the facility which is assigned at the site 2 covers only the regions 3 and 4. So, the solution of this offspring is infeasible. Now, the

set of selected sites for assigning facility = {2}. Then, another sub-covering coefficient matrix with the remaining potential sites (1, 3, 4 and 5) and remaining regions (1, 2, 5 and 6) is shown in **Figure 3**. Now find the maximum number of regions that can be covered by any unselected potential site from **Figure 3**. The corresponding value in **Figure 3** is 4, which occurs for the potential site 3. So, include it in the set of selected sites for assigning facilities as shown: Set of selected sites for assigning facilities = {2, 3}.

Genes of Offspring		1	0	1	0	0
		Potential sites j				
		1	2	3	4	5
Region i	1	[1]	0	[1]	0	0
	2	[1]	0	[1]	1	0
	3	0	1	[1]	0	0
	4	[1]	1	0	0	1
	5	0	0	[1]	1	0
	6	0	0	[1]	0	0

Figure 1. Coverage of regions by Offspring "1 0 1 0 0 "

Genes of Offspring		0	1	0	0	0
		Potential sites j				
		1	2	3	4	5
Region i	1	1	0	1	0	0
	2	1	0	1	1	0
	3	0	[1]	1	0	0
	4	1	[1]	0	0	1
	5	0	0	1	1	0
	6	0	0	1	0	0

Figure 2. Coverage of regions by Offspring " 0 1 0 0 0"

From **Figure 3**, it is visible that the facility, which is assigned at the potential site 3 can cover all the regions (1, 2, 4 and 5) in it. So, there is no more uncovered region. The modified offspring for the given offspring is constructed by having 1 in the position 2 and position 3 and 0 in the remaining positions as shown below.

Modified offspring = {0 1 1 0 0}

Now, the earlier offspring, {0 1 0 0 0} is to be substituted with the modified offspring, {0 1 1 0 0}. The process of constructing a feasible offspring for an infeasible offspring is called *"Care and Share"* crossover operation. In this example, **Figure 3** itself gives the feasible offspring. In general, the process of forming sub-covering coefficient matrices is to be continued until all the regions are covered.

4.1.5 Mutation

Mutation is a process of randomizing the genes in each chromosome. In a chromosome, this can be done by randomly selecting any two genes in it and swapping them. Since, the usage of Logic AND makes many zeros in offspring, some of the offspring will become infeasible. Hence, "Care and Share" operation is used to find a feasible offspring for each of the infeasible offspring. As per the requirement of Genetic algorithm, if mutation on an offspring is performed, there is a possibility of making that offspring as an infeasible offspring. *Hence, for this total covering problem, mutation is not performed.*

4.1.6 Steps of GA Based Heuristic

Step 1: Input the following:

- Number of iterations N = 10
- Covering coefficient Matrix, C(I, J), where m is the number of customers and n is the number of potential sites.

Step 2: Set the iteration number I to 1.

Step 3: Find the number of ones in each of the rows of the covering coefficient matrix.

Step 4: Arrange the rows of the covering coefficient matrix in the ascending order of the number of ones in the rows and store the sorted rows in another matrix, called chromosome matrix, CM(I,J), I = 1, 2, 3, …, m and j =1, 2, 3, …, n.

		Potential sites j			
		1	3	4	5
Region i	1	1	1	0	0
	2	1	1	1	0
	5	0	1	1	0
	6	0	1	0	0
No. of regions that can be covered		2	4	2	0

Figure 3. Sub-covering coefficient matrix after deleting Site 2

Step 5: Set the size of the population to the number of customers (m) in the Chromosome matrix (Each row of the matrix is treated as a chromosome).

Step 6: Find the fitness values of each chromosome in the initial population.

Step 7: Crossover Operation

Step 7.1: Perform crossover operation by taking two chromosomes in succession starting from the chromosome 1 for each of the following pairs of logical operators.

(a) Logic OR and Logic AND
(b) Odd shift before Logic OR and Logic AND
(c) Even shift before Logic OR and Logic AND
(d) Logic OR and odd shift before Logic OR
(e) Logic OR and even shift before Logic OR
(f) Logic AND and odd shift before Logic AND
(g) Logic AND and even shift before Logic AND

[For example, if the number of rows of the chromosome matrix is 10 and Logic OR and Logic AND crossover operations are to be carried out, the first five offspring will be due to Logic OR crossover operation and the last five offspring will be due to Logic AND crossover operation. One should note that the number of offspring after performing crossover operation using a pair of logic operators will always be equal to the number of rows of the chromosome matrix (m)].

Step 7.2 In each case of *Step* 7.1, for each of the infeasible offspring, perform "*Care and Share*" operation and obtain a feasible offspring. Then replace that infeasible offspring with the feasible offspring, which is constructed using the "*Care and Share*" operation.

Step 8: In each case [from (a) to (g))] of the previous step, for each offspring, find the fitness function value.

Step 9: Club all the offspring of all the cases from (a) to (g) and sort them in the ascending order of their fitness function values.

Step 10: Store the top most offspring of the clubbed population of *Step* 9 as the current best chromosome along with its fitness function value.

Step 11: Choose the top m offspring from the clubbed population of *Step 9* and store them in the chromosome matrix CM(I,J), for I = 1, 2, 3, …, m and J = 1, 2, 3, …, n.

Step 12: Increment the iteration number by 1 (I = I + 1).

Step 13: If I ≤ N, then go to *Step 7*; else go to *Step 14*.

Step 14: Print the current best chromosome along with its fitness function value.

Also print the customers, which are covered by each potential site that is assigned with a facility.

Step 15: Stop.

5. GRASP Heuristc

In this section, another heuristic based on Greedy Randomized Adaptive Search Procedure (GRASP) for the total covering problem is presented. The GRASP is an iterative procedure, which has two phases, namely con-

struction phase and local search phase. In the construction phase, a feasible solution is constructed by choosing the next element randomly from the Candidate List (CL) [19]. The candidate list contains only the best elements selected by greedy function.

The Candidate List technique makes it possible to obtain different solution in each of the iterations. Since the solutions generated by the GRASP construction phase are not guaranteed to be the local optimum, it is recommended to apply the local search phase, which is the second phase of the GRASP. In this paper, a greedy heuristic is applied for the local search phase. At the end of each GRASP iteration, the better solution is updated. The latest best solution becomes the final solution, when the given termination criterion is reached.

The steps of GRASP based heuristic to locate the minimum number of facilities to cover all the customers are presented below.

Steps of GRASP Based Heuristic

Step 1: Input the covering co-efficient matrix, which is a square matrix of size *m*.

Step 2: Set the candidate = Null Set.

Step 3: Use the following ***Greedy heuristic*** to find the feasible solutions and add it to the *Candidate List* (CL).

Step 3.1: Find the number of ones in each column j of the Matrix C.

Let it be CS_j

Step 3.2: Select the column (site) with the maximum CS_j for assigning Facility.

Store the selected site number in the array Q.

Store the elements in the column corresponding to the selected site of the matrix C in an array F.

Set the actual number of sites selected [kk] to 1

Step 3.3: If Maximum $CS_j = m$, then go to Step 3.8; otherwise go to Step 3.4.

Step 3.4: For each unselected site j (for j not in the array Q), find the total number of customers covered by the sites in the array Q after it is tentatively included in that array Q. Let it be TC_j.

Step 3.5: Find the maximum TC_j values.

Step 3.6: If there is no tie for the maximum TC_j, then select the site with maximum TC_j and place it in the array Q.

Otherwise find the number of ones in the each of the columns of the matrix C, corresponding to the maximum TC_j.

Then select the column with maximum number of ones among such columns and place it in the array Q.

Increment the actual number of sites selected by 1 (kk = kk + 1).

Step 3.7: If Maximum $TC_j = m$, then go to Step 3.8; otherwise go to Step 3.4.

Step 3.8: Treat the array Q as the Candidate List CL.

Step 4: Select the lone member of the *Candidate List* (CL), Let it be M.

Step 5: Set I = 1.

Step 6: Set the criterion Index, $k = 0$.

Step 7: Randomly select the position from the member M of CL and change it from 0-1 or 1–0.

Step 8: If the solution is feasible, do the following, or else go to step 9.

Step 8.1: Evaluate the solution and count the number of ones in the solution.

Step 8.2: Add the solution to the Candidate List.

Step 8.3: Up date $k = 1$.

Step 9: I = I + 1.

Step 10: If $I \leq 10$ then go to step 7, or else go to step 11.

Step 11: if $k = 0$ then go to step 14, or else go to step 12.

Step 12: Find best solution from the *Candidate List* and let it be M.

Step 13: Go to step 5.

Step 14: Print the lastly used best solution (M), between steps 5 to step 10.

Step 15: Stop.

6. Factorial Experiment

In this section, first, the performance of the GA based heuristic is compared with that of the GRASP based heuristic and then it is compared with that of a model.

6.1 Comparison of GA Based Heuristic and GRASP Based Heuristic

This section presents the experimentation to compare the performance in terms of solution (number of potential sites selected for assigning facilities) of the proposed GA based heuristic (Alg_1) and the GRASP based heuristic (Alg_2) through a factorial experiment by considering three factors, viz. Percentage Sparsity of the covering coefficient matrix (percentage of number of 1s), Problem Size and Algorithm. Let the percentage sparsity be the Factor A, the Problem Size be the Factor B and the Algorithm be the Factor C. The Factor A is assumed with 5 levels (treatments), which are viz. 16%, 18%, 20%, 22% and 24%. The Factor B is assumed with 6 levels (treatments), which are, viz. 30 × 30, 40 × 40, 50 × 50, 60 × 60, 70 × 70 and 80 × 80. The Factor C is assumed with 2 levels (treatments), which are viz. Alg_1 and Alg_2. For each experimental combination, 5 replications are assumed.

In this experiment, the covering coefficient matrix of each benchmark problem is a square matrix. This means that each customer location is treated as a potential site for locating facility.

The corresponding ANOVA model [20] is shown below.

$$Y_{ijkl} = \mu + A_i + B_j + AB_{ij} + C_k + AC_{ik} + BC_{jk} + ABC_{ijk} + e_{ijkl}$$

where,

Y_{ijkl} is the response (number of sites assigned with facilities) of the l^{th} replication for the i^{th} treatment of the

Factor A, j^{th} treatment of the Factor B and k^{th} treatment of the Factor C.

μ is the overall mean of the response.

A_i is the effect on the response due to the i^{th} treatment of the Factor A

B_j is the effect on the response due to the j^{th} treatment of the Factor B

AB_{ij} is the effect on the response due to the i^{th} treatment of the Factor A and the j^{th} treatment of the Factor B

C_k is the effect on the response due to the k^{th} treatment of the Factor C

AC_{ik} is the effect on the response due to the i^{th} treatment of the Factor A and the k^{th} treatment of the Factor C

BC_{jk} is the effect on the response due to the j^{th} treatment of the Factor B and the k^{th} treatment of the Factor C

ABC_{ijk} is the effect on the response due to the i^{th} treatment of the Factor A, j^{th} treatment of the Factor B and k^{th} treatment of the Factor C

e_{ijkl} is the random error associated with the l^{th} replication under the i^{th} treatment of the Factor A, j^{th} treatment of the Factor B and k^{th} treatment of the Factor C

The different hypotheses relating to this model are as listed below.

Factor A (Percentage Sparsity of Covering Coefficient matrix)

H_0: There is no significant difference in terms of solution between different pairs of treatments of the Factor A (Percentage sparsity of covering coefficient matrix)

H_1: There is significant difference in terms of solution between different pairs of treatments of the Factor A (Percentage sparsity of covering coefficient matrix)

Factor B (Problem Size)

H_0: There is no significant difference in terms of solution between different pairs of treatments of the Factor B (Problem Size).

H_1: There is significant difference in terms of solution between different pairs of treatments of the Factor B (Problem Size).

Factor C (Algorithm)

H_0: There is no significant difference in terms of solution between the two treatments of Factor C (Algorithm).

H_1: There is significant difference in terms of solution between the two treatments of the Factor C (Algorithm).

Interaction Components:

Factor A × Factor B: (AB_{ij})

H_0: There is no significant difference in terms of solution between the different pairs of interaction between Factor A and Factor B.

H_1: There is significant difference in terms of solution between different pairs of interaction between Factor A and Factor B.

Factor A × Factor C: (AC_{ik})

H_0: There is no significant difference in terms of solution between the different pairs of interaction between Factor A and Factor C.

H_1: There is significant difference in terms of solution between different pairs of interaction between Factor A and Factor C.

Factor B × Factor C: (BC_{jk})

H_0: There is no significant difference in terms of solution between the different pairs of interaction between Factor B and Factor C.

H_1: There is significant difference in terms of solution between different pairs of interaction between Factor B and Factor C.

Factor A × Factor B × Factor C: (ABC_{ijk})

H_0: There is no significant difference in terms of solution between the different pairs of interaction between Factor A, Factor B and Factor C.

H_1: There is significant difference in terms of solution between different pairs of interaction between Factor A, Factor B and Factor C.

A factorial experiment as per the above design was carried out to find the minimum number of potential sites which are to be assigned facilities under each experimental combination and such results (minimum number of potential sites assigned with facilities to cover all the customers) are summarized in **Table 5**. The results of ANOVA for the given factorial experiment are summarized in **Table 6**. From the **Table 6**, it is clear that all the calculated *F* ratios are greater than the respective table *F* values at a significance level of 5%, except the interaction components AB_{ij} and ABC_{ijk}. Our prime concern is to check the significance of the effect of the Factor *C* (algorithm) on the response variable. The calculated *F* value for the Factor *C* is 2991.611 as against the table *F* value of 3.84. Hence, the corresponding null hypothesis is to be rejected and its alternate hypothesis is to be accepted. This means that there is significant difference between the algorithms (Alg_1 and Alg_2) in terms of providing the minimum number of potential sites, which are assigned with facilities to cover all the customers. If we closely look at the values of the responses in **Table 5**, for each experimental combination, the solution provided by the Algorithm Alg_1 is less than the solution provided by the Algorithm Alg_2. The mean response of the Algorithm Alg_1 is 6.81 and that of the Algorithm Alg_2 is 15.79. By combining the above two facts, it is evident that the Algorithm Alg_1 performs better than the Algorithm Alg_2 in terms of providing solution, that is the minimum number of potential sites assigned with facilities to cover all the customers. This means that the GA based heuristic performs better than the GRASP based heuristic.

6.2 Comparison of GA Based Heuristic with Model

Since, the GA based heuristic performs better than GRASP based heuristic, next it is mandatory to check the performance of the GA based heuristic with that of the

Table 5. Responses (minimum number of sites assigned with facilities) of factorial experiment for comparison of GA based heuristic and GRASP based heuristic

Sparsity (%) (Factor A)	Replication	Problem size (Factor B)											
		30 × 30		40 × 40		50 × 50		60 × 60		70 × 70		80 × 80	
		Algorithm (Factor C)											
		Alg_1	Alg_2	Alg_1	Alg_2	Alg_1	Alg_2	Alg_1	Alg_2	Alg_1	Alg_2	Alg_1	Alg_2
16%	1	7	13	5	14	9	16	9	15	5	20	10	19
	2	7	11	8	14	8	14	7	17	8	19	9	20
	3	6	9	7	14	7	14	9	18	9	19	9	19
	4	6	16	7	13	7	12	8	19	9	18	9	18
	5	7	10	8	16	8	17	7	19	8	18	9	18
18%	1	8	12	7	14	7	13	7	15	7	16	9	15
	2	7	10	7	12	8	16	6	19	8	18	9	19
	3	6	10	8	17	6	18	7	19	9	20	7	18
	4	6	9	7	16	6	14	6	18	6	18	8	20
	5	8	12	6	14	7	13	7	17	7	20	9	18
20%	1	6	13	7	13	7	15	7	17	7	20	9	15
	2	5	10	6	13	6	16	8	20	9	19	7	18
	3	6	15	6	17	7	15	7	18	8	18	7	18
	4	4	10	6	13	7	13	7	15	7	17	8	18
	5	5	10	6	12	6	13	7	18	6	18	7	18
22%	1	5	13	6	13	7	16	6	18	8	18	7	16
	2	5	10	5	12	7	16	6	18	7	19	7	17
	3	5	10	6	12	7	17	6	19	7	22	7	19
	4	6	9	7	13	8	16	6	20	6	19	8	21
	5	6	11	5	14	7	16	7	19	8	19	8	18
24%	1	5	10	3	11	6	18	7	16	7	21	7	18
	2	5	9	6	11	6	18	7	23	6	18	6	19
	3	5	10	3	7	7	18	4	22	6	21	7	16
	4	6	11	6	13	6	15	6	15	6	19	7	19
	5	4	8	6	16	6	15	6	15	7	22	7	20

Table 6. ANOVA results for comparison of GA based heuristic with GRASP based heuristic

Source of Variation	Degrees of Freedom	Sum of squares	Mean Sum of Squares	Calculated F Ratio	Table F value at $\alpha = 0.05$	Inference
A_i	4	34.7500	8.6875	4.2972	2.37	Significant
B_j	5	933.4571	186.6914	92.3345	2.21	Significant
AB_{ij}	20	61.2929	3.06465	1.5159	1.57	Not Significant
C_k	1	6048.0320	6048.0320	2991.6110	3.84	Significant
AC_{ik}	4	29.9805	7.4952	3.7074	2.37	Significant
BC_{jk}	5	421.1914	84.2383	41.6678	2.21	Significant
ABC_{ijk}	20	40.6953	2.0348	1.0065	1.57	Not Significant
e_{ijk}	240	485.1992	2.0217			
Total	299	8054.5980				

mathematical model as presented in Section 3, which gives the optimal solution. It is well known that solving any mathematical model will be limited by its number of variables and the number of constraints, because of the software which will be used to solve the problem of interest. So, in this section, problems of limited sizes, viz., 32 × 32, 34 × 34, 36 × 36, 38 × 38 and 40 × 40, each with five replications are considered for comparing the performance of the GA based heuristic (Method 1) and that of the model (Method 2). The Problem Sizes are assumed to be the levels of "Factor A" and the Methods are assumed to be the levels of "Factor B".

The corresponding ANOVA model is shown below.

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$$

where,

Y_{ijk} is the response (number of sites assigned with facilities) of the k^{th} replication for the i^{th} treatment of the Factor A and the j^{th} treatment of the Factor B.

μ is the overall mean of the response.

A_i is the effect on the response due to the i^{th} treatment of the Factor A

B_j is the effect on the response due to the j^{th} treatment of the Factor B

AB_{ij} is the effect on the response due to the i^{th} treatment of the Factor A and the j^{th} treatment of the Factor B

e_{ijk} is the random error associated with the k^{th} replication under the i^{th} treatment of the Factor A and j^{th} treatment of the Factor B.

The different hypotheses relating to this model are as listed below.

Factor A (Problem Size)

H_0: There is no significant difference in terms of solution between different pairs of treatments of the Factor A (Problem Size).

H_1: There is significant difference in terms of solution between different pairs of treatments of the Factor A (Problem Size).

Factor B (Method)

H_0: There is no significant difference in terms of solution between different pairs of treatments of the Factor B (Method).

H_1: There is significant difference in terms of solution between different pairs of treatments of the Factor B (Method).

Factor A × Factor B: (AB_{ij})

H_0: There is no significant difference in terms of solution between the different pairs of interaction between Factor A and Factor B.

H_1: There is significant difference in terms of solution between different pairs of interaction between Factor A and Factor B.

A factorial experiment as per the above design was carried out to find the minimum number of potential sites which are to be assigned facilities under each experimental combination and such results (minimum number of potential sites assigned with facilities to cover all the customers) are summarized in **Table 7**. The results of ANOVA for the given factorial experiment are summarized in **Table 8**. From the **Table 8**, it is clear that all the calculated *F* ratios are less than the respective table *F* values at a significance level of 5%. Our prime concern is to check the significance of the effect of the Factor B (Method) on the response variable. The calculated *F* value for the Factor B is 1.5283 as against the table *F* value of 4.09. Hence, the corresponding null hypothesis is to be accepted and its alternate hypothesis is to be rejected. This means that there is no significant difference between the methods (Method 1 and Method 2) in terms of providing the minimum number of potential sites, which are assigned with facilities to cover all the customers. So, the performance of the GA based heuristic is equivalent to that of the model for the assumed problems of limited sizes.

Table 7. Results of GA based heuristic and model

Factor A (Problem Size)	Replication	Factor B (Method)	
		GA Based Heuristic (Method 1)	Model (Method 2)
32 × 32	1	4	4
	2	5	5
	3	4	4
	4	5	5
	5	5	5
34 × 34	1	5	4
	2	6	5
	3	4	4
	4	5	3
	5	5	5
36 × 36	1	5	4
	2	3	3
	3	4	4
	4	5	4
	5	5	5
38 × 38	1	5	5
	2	5	5
	3	4	3
	4	7	6
	5	6	6
40 × 40	1	6	6
	2	5	5
	3	3	2
	4	6	6
	5	6	6

Table 8. ANOVA results of comparison of GA based heuristic and model

Source of Variation	Sum of squares	Degrees of Freedom	Mean Sum of Squares	Calculated F Ratio	Table F value at α = .05	Inference
A_i	6.72	4	1.68	1.5849	2.61	Not Significant
B_j	1.62	1	1.62	1.5283	4.09	Not Significant
AB_{ij}	0.88	4	0.22	0.2076	2.61	Not Significant
e_{ijkl}	42.40	40	1.06			
Total	51.62	49				

7. Conclusions

The total covering problem under facility location problem is an important problem to determine the minimum number of sites to locate the facilities to cover all the customers. Since, this problem comes under combinatorial category, in this paper, an attempt has been made to develop heuristics and compare them in terms of their performance. In the first phase, the design of GA based heuristic is given and it is followed by the design of GRASP based heuristic. Later, a complete factorial experiment has been conducted to compare the performance of the two heuristics by assuming three factors, Factor A (Percentage Sparsity), Factor B (Problem Size) and Factor C (Algorithms). The Factor *A* is assumed with 5 levels, which are viz. 16%, 18%, 20%, 22% and 24%. The Factor *B* is assumed with 6 levels, which are, viz. 30 × 30, 40 × 40, 50 × 50, 60 × 60, 70 × 70 and 80 × 80. The Factor *C* is assumed with 2 levels, which are viz. Alg_1 and Alg_2. For each experimental combination, 5 replications are carried out. Through ANOVA, it is found that the GA based heuristic performs better than the GRASP based heuristic in terms of providing the solution for the total covering problem.

After having concluded that the GA based heuristic performs better than the other heuristic, in the next phase, a comparison is done between the solution of the GA based heuristic and that of the mathematical model presented in Section 3 for the total covering problem through a two factor complete factorial experiment. In this experiment five different problem sizes (32 × 32, 34 × 34, 36 × 36, 38 × 38 and 40 × 40) are considered. For each problem size, five replications are considered. By taking the problem size as one factor and the methods of solving the total covering problem (*GA based heuristic* and *Model*) as another factor, a factorial experiment was conducted and found that the there is no difference between the methods, viz., *GA based heuristic* and *model* in terms of providing solution for the total covering problem. Hence, it is concluded that the performance of the GA based heuristic can be equated to that of the model which gives optimal solution for small and moderate size problems. The reason of limiting the problem size to a maximum of 40 × 40 in this comparison is due the limitations of the number of variables and the number of constraints of a model that can be handled by software. Finally, it is concluded that the GA based heuristic performs better than the GRASP based heuristic to solve the total covering problem. Further, there is no significant difference between the GA based heuristic and the mathematical model, in terms of providing solution for the total covering problem for moderate size problems.

REFERENCES

[1] R. Panneerselvam, "Production and Operations Management," 2nd Edition, Prentice-Hall India (P) Ltd., New Delhi, 2005.

[2] C. Toregas, R. Swain, C. Revelle and L. Bergman, "The Location of Emergency Service Facilities," *Operations Research*, Vol. 19, No. 6, 1971, pp. 1363-1373.

[3] N. R. Patel, "Location of Rural Social Service Centers in India," *Management Science*, Vol. 25, No. 1, 1979, pp. 22-30.

[4] T. D. Klastorin, "On the Maximal Covering Location Problem and the Generalized Assignment Problem," *Management Science*, Vol. 25, No.1, 1979, pp. 107-111.

[5] O. Saatcioglu, "Mathematical Programming Model for Airport Site Selection," *Transportation Research-B*, Vol. 16B, No. 6, 1982, pp. 435-447.

[6] A. W. Neebe, "A Procedure for Locating Emergency-Service Facilities for All Possible Response Distances," *Journal of Operational Research Society*, Vol. 39, No. 8, 1988, pp. 743-748.

[7] R. Panneerselvam, "A Heuristic Algorithm for Total Covering Problem," *Industrial Engineering Journal*, Vol. 19, No. 2, 1990, pp. 1-10.

[8] G. Rajkumar and R. Panneerselvam, "An Improved Heuristic for Total Covering Problem," *Industrial Engineering Journal*, Vol. 20, No. 8, 1991, pp. 4-7.

[9] R. Panneerselvam, "Efficient Heuristic for Total Covering Problem," *Productivity*, Vol. 36, No. 4, 1996, pp. 649-657.

[10] M. E. O'Kelly, "The Location of Interacting Hub Facilities," *Transportation Science*, Vol.20, No.2, 1986, pp. 92-106.

[11] T. B. Boffey, "Location Problems Arising in Computer Networks," *Journal of Operational Research Society*, Vol. 40, No. 4, 1989, pp. 347-354.

[12] T. J. Chen and C. A. Yano, "A Multiplier Adjustment Approach for Set Partitioning Problem," *Operations Research*, Vol. 40, No. 1, 1992, pp. 40-47.

[13] W. A. Chaovalitwongse, T. Y. Berger-Wolf, B. Dasgupta and M. V. Ashley, "Set Covering Approach for Reconstruction of Sibling Relationships," *Optimization methods and software*, Vol. 22, No. 1, 2007, pp. 11-24.

[14] B. Pelegrin, J. L. Redondo, P. Fernandez, I. Garcia and P. M. Ortigosa, "GASUB: Finding Global Optima to Discrete Location Problems Genetic—Like Algorithm," *Journal of Global Optimization*, Vol. 38, No. 2, 2007, pp. 249-264.

[15] Sibel A. Alumur, Bahar Y. Kara and Oya E. Karasan, "The Design of Single Allocation in Complete Hub Networks," *Transportation Research B*: *Methodological*, Vol. 43, No. 10, 2009, pp. 936-951.

[16] V. Marianov, M. Mizumori and C. Re Velle, "The Heuristic Concentration—Integer and its Application to a Class of Location Problems," *Computers and Operations Research*, Vol. 36, No. 5, 2009, pp. 1406-1422.

[17] De A. C. Francisco, N. L. L. Antonio and M. R. Glaydston, "A Decomposition Approach for the Probabilistic Maximal Covering Location—Allocation Problem", *Computers and Operations Research*, Vol. 36, No. 10, 2009, pp. 2729-2739.

[18] V. Batanovic, D. Petrovic and R. Petrovic, "Fuzzy Logic Based Algorithms for Maximum Covering Location Problems," *Information Sciences*, Vol. 179, No. 1-2, 2009, pp. 120-129.

[19] T. A. Feo and M. G. C. Resende, "Greedy Randomized Adaptive Search Procedures," *Journal of Global Optimization*, Vol. 6, 1995, pp. 109-133.

[20] R. Panneerselvam, "Research Methodology," Prentice-Hall India (P) Ltd., New Delhi, 2004.

iBusiness, 2010, 2, 168-177
doi:10.4236/ib.2010.22020 Published Online June 2010 (http://www.SciRP.org/journal/ib)

How to Learn Knowledge from Foreign Partner: A Case Study of Japanese Joint Venture in Indonesia

Tirta N. Mursitama

Department of International Relations, Faculty of Social and Political Sciences, Universitas Indonesia, Depok, Indonesia.
Email: tirta.nugraha@ui.ac.id

Received January 26th, 2010; revised March 12th, 2010; accepted April 15th, 2010.

ABSTRACT

This research focuses on how local partner learn knowledge from foreign partner in Japanese joint venture in emerging economies context. Contribution of this research is as follows. First, by distinguishing the type and characteristics of each process, this typology enhances our understanding about JV as useful organizational learning mechanism, particularly in Japanese joint venture in emerging economies and about the source of firm's heterogeneity underlying learning process. Second, this extensive in-depth case study provides the clear evidences of the importance of internal learning capability process to improve technological capability, absorptive capacity, and relational rents generated from resource sharing mechanism. Third, this study, to best knowledge, is a pioneer research in Indonesia since technological issues have been paid little attention from scholars.

***Keywords*:** *Absorptive Capacity, Knowledge Acquisition and Sharing, Japanese Joint Venture, Indonesian Firm*

1. Introduction

This research focuses on how local partner learn knowledge from foreign partner in Japanese joint venture in emerging economies. It is an in-depth case study explaining internal learning capability transfer from foreign firms; resource sharing within business groups especially in developing human capital; and knowledge acquisition, assimilation, and exploitation process which is so-called absorptive capacity [1,2] in a leading electronic joint venture (JV) firm in Indonesia.

Focus of this study is to understand learning process in Panasonics Manufacturing Indonesia (PMI), a joint venture between Matsushita Electrical Industries and Gobel International. I find the different pattern of learning process and characteristics between blue collar workers (operators) and white collar workers (especially engineers). I also discuss the important roles of Japanese experts, example of technological capability, and underlying key success of learning in PMI.

1.1 Internal Learning Capability Transfer and Absorptive Capacity

International joint venture (IJV) has become popular mode of entry in emerging economies and particularly in Indonesia since 1970s. Recently, IJV has been studied by scholars from resource-based view and knowledge-based view that has focused on how resource acquisition, capability development as source of success in IJV [3,4].

Kogut and Zander [5] argue MNC as an organizational vehicle which has its superior efficiency by transferring knowledge across borders. Host partner, such as in the form of IJV, can learn from foreign partner through internal learning capability transfer. For instance, they can learn routines, production process, and production development up to marketing strategies. These lead to up grading capability of the firm. In addition, up grading capability and then contribute to IJV performance also depends on host partner's absorptive capacity [6-8]. This research lies in this stream with focus on how host IJV partner learns knowledge starting from understanding manufacturing system, improve it and finding and solving problems. These are what I argue as increasing absorptive capacity of host IJV partner.

2. Method

This research follows the replication logic, rather than sampling logic: whether case companies chosen could provide rich information in the aspects of research constructs [9]. PMI as one of the leading JV firm in Indonesia fits with these criteria. Matsushita, a parent company of PMI, also recognized as high performance business group in terms of technological and managerial capabilities. In addition, PMI has shown their eagerness to be studied by providing access to informants. The author also has long acquaintance with one of directors in other

member of Matsushita group in Indonesia who gave recommendation to PMI. It is useful to develop a relationship of mutual trust with respondents. Therefore, PMI also fits for practical reasons.

Letter of inquiry with a research's proposal explaining the objective, design, protocols and advantage of the research is sent in early 2006. The approval is given shortly and follows by pilot study on April to May 2006. First fieldwork is conducted in June to July 2006 whereas the second is on August to September 2006. The following steps are taken to ensure the good quality of this in-depth case study. First, I met with vice chairman and three senior managers to explain the research protocols and get initial comments and set up the more detailed schedules for field studies.

Second, the main informants are senior manager HR and senior manager R & D. I conduct nine interviews during April to September 2006: twice interviews both with vice chairman and senior manager R & D, and five times interviews with senior manager HR. Each interview is carried out lasting between thirty minutes and two hours. Following the standard procedures in doing case study, I used open-ended and semi-structured questionnaire [10]. Creswell suggests that good case study should meet the standard of quality verification, therefore I conduct triangulation of information — searching for the convergence information — relates directly to data situation in developing case study from data sources, theory, methods, and my self as investigator. In addition, member checking is done by sending the rough draft of writing to the informants after the entire interviews finished. All the interviews are recorded and field notes are also created.

Third, the rationale of this study that makes this study as a single-case study is to confirm, challenge, or extend the theory [10,11]. I use within-case study analysis in this study because several themes identified earlier are being confirmed, challenged, or extended within a single case.

2.1 Indonesia and Brief History of PMI

Indonesia is the largest country in Southeast Asia comprises more than 230 billion people in 2009. Within Association of Southeast Asian Nations (ASEAN), Indonesia has considered as country taking most liberal and neutral investment regime. The government has liberalized foreign direct investment up to 95% for foreign ownership in 1994. It has sharply increased since the government started to attract foreign investment in late 1960s and promoted pro-market policies. As a result, Indonesia has been transforming from agriculture-based country to more manufacturing-based country. Recently the contribution of service sector has increased in addition to manufacturing sector.

The abundant of natural resources, low wages, and liberal government policies attracted foreign investment, particularly Japanese investors since 1960s. Japanese investment has been the biggest and significant especially in light manufacturing industries such as electronics, machinery as well as more capital intensive industries such as automotive. Kosuke Imashimizu, president director of Japan External Trade Organization (JETRO) in year 2006 mentioned how important Indonesia for Japan. He said that historically, Japan is the largest investor in Indonesia.

PMI was built on July 1970 as joint venture between Matsushita Electrical Industrial Co. Ltd (MEI) with 60% and Gobel International (GI) with hold 40% of shares. However, its history starts from 1950s when the owner of Gobel, Mr. Moh. Gobel established Transistor Radio Manufacturing limited company which pioneered in radio transistor manufacturing. After he went to Japan as foreign student and met Mr. Konosuke Matsushita, the founder of MEI. In 1960, MEI and Transistor Radio Manufacturing limited company agreed to sign of technical cooperation. Based on the technical cooperation, this company was able to produce first black and white television in Indonesia in 1962. As the cooperation worked well, both parties agreed to establish joint venture, National Gobel in 1970—currently changed its name to PMI.

In 1974, Gobel established Met Gobel limited company as support the trading activities and importing products of Matsushita to Indonesia which not produced by PMI. This company also imported both consumer electronic product and professional electronics products such as broadcasting devices and capital equipment for the factory.

During 1980s and 1990s, Matsushita Gobel as a group strengthened her presence in Indonesia by establishing other sister companies such as Panasonic Gobel Battery Industry (manganese, lithium coin, torchlight), Panasonic Gobel Indonesia (sole agent of PMI), Panasonic Shikoku Electronics Indonesia (VCR, CD-ROM, and Combo TV for export), Panasonic Battery Batam (battery NICAD) and Panasonic Electronic Device Indonesia (ceramic components, speaker, inductive products and other related products). Incorporation with Matsushita Electric Works, they established Panasonic Electric Works Gobel Manufacturing Indonesia (PEWGMI) which produce lighting fixture, components, wiring devices; Panasonic Electric Works Gobel Sales Indonesia (sole agent and distributors of PEWGMI); Panasonic Electronic Device Batam, Panasonic Semiconductor Indonesia (semiconductors, microchips) and Panasonic Shikoku Electronics Batam (peripheral products).

PMI has 9 products line such as audio, fan, television, air conditioner, refrigerator, washing machine, electric iron, water pump and pants press. The oldest is audio business unit that established in 1970 with 2,000,000 production capacity per year. Manufacturing of fan and television started a year later in 1971 with 1,500,000 and

600,000 production capacities per year, respectively. Two year later, PMI established air condition business unit in 1973 with 250,000 production capacity per year. Production of refrigerator began in 1975 with 420,000 capacities per year. Washing machine, electric iron and water pump production established in 1979, 1985, and 1988, respectively. PMI produces 140,000 washing machines, 380,000 electric iron and 1,500,000 water pump per year. The latest product is pant press which started in 1995 with 25,000 production capacity per year.

PMI capital is US $ 23 million with Rp 1.595 trillion in sales (2005).

2.2 Learn How to Manufacture the Product

The objective of this type of learning is to understand one single task to perform manufacturing process. Focus of this learning is for new recruits both blue collars and white collars employees. **Table 1** provides summary of type and characteristics of internal learning mechanism at PMI.

2.2.1 Development of New Recruits of Blue Collars Employees

As electrical and households appliances manufacturer, PMI is part of labor-intensive industries, therefore the development of operators (blue collars) with emphasis on physical ability is important. New recruits are mainly high school graduates whose age around 20-22 years old. The objective is to perform one single task within one-line manufacturing activities through general training within three months probation period. They were asked to present what they understand about the process. There are "examinations" conducted in the end of week and particularly in the end of month to evaluate the progress of each operator. When they passed the "exam" then they granted permanent employee status. After that, the new recruits are assigned on OJT in more advance manner to understand and perform manufacturing tasks. He or she should be able to understand the relations between theoretical and practical matters. They are pushed to find problems and then find solutions. If they can not find any single problem and solution, they are considered as "can not learn properly". For new recruits, they are mainly working in single task in one-line manufacturing process. Each performs one single job. During 3 to 4 years commonly the new recruits can accumulate knowledge about manufacturing process and related jobs.

2.2.2 Development of New Recruits of White Collars Employees

Along with the higher educational background (mainly graduates from technical college or engineering department/bachelor), the objective here is to develop engineers who understand and capable to perform the whole or entire production process started from input (raw material checks, material warehouse management etc), production, assembly, and final products. They also should understand supporting activities such as product planning, purchasing, product engineering, production engineering and quality control. This type of workers should be able to perform inspection tasks for whole process.

Says Senior HRD manager: "*In the probation period, new recruits white collars employees are doing on the job-training (OJT). They assist their senior employees in wherever the senior performs their job. For instance, in the audio factory, new recruits should carefully examine the process from the beginning until the end of product. Those with electronics background (vis-à-vis mechanical) should examine the process from electronics point of view as well as those with mechanical background should understand the process from the mechanical engineering. Therefore, they can understand the actual process in the factory with their educational background. Thereby they can give assessment based on their expertise. If they can find the weakness of the process and or ideas for improvements, they can be considered "have learned". If it happens smoothly during probation period, new recruits will have higher chance to be recruited as permanent employees.*" (Interview, May 5, 2006).

There are similarity with new recruits of blue collars workers in terms of general training and process of recruitment such as three months probation, presentation, and exam. However, I found the emphasis of developing ability to find problems and then produce solutions of the workers. The role of factory manager is crucial in performing the evaluation of workers. He checked daily reporting of the workers based on their field (either electronics or mechanics), conducted test or quizzes related with the tasks, conducted end of week's test and end of month's assessment which usually took longer time. These mechanisms intended to ensure the progress of capability development of workers.

2.3 Learn How to Improve Manufacturing System

Objective of this type of learning is to improve better manufacturing system. Focus is for relatively mature blue collars employees and well-experienced white collars employees.

2.3.1 Development of Older Blue Collars Employees

As time goes by older blue collars workers are able to work better because of learning by doing. Since this is labor-intensive industry, physical ability of blue collar is important. The older the worker, at the point of time, their ability to produce results decrease. The challenge here is to create additional capability of blue collars workers in order to stay productive. Therefore the trigger to exploit new competency of older blue collars workers is when their productivity is decreasing along with their age, at around 40 years old. The productivity of blue collars employees can be compared among those whose age is 20 to 30 years and those whose age is 40 years. For in-

Table 1. Internal learning mechanisms: type and characteristics

Type of learning	To manufacture product		To improve manufacturing system		To find and solve problems	
	Blue collars (operators)	**White collars (engineers)**	**Blue collars (operators)**	**White collars (engineers)**	**Blue collars (operators)**	**White collars (engineers)**
What to be learned	One-line manufacturing system	Process, routines of entire production system	Cell-manufacturing system	Advanced manufacturing system, production, product development	One-line and cell-manufacturing system	Process, routines of entire production system and product development
Objective; emphasize	Able to perform one single task ; physical ability	Able to understand and capable to perform and supervise entire production process; thinking ability	Able to perform multitasks from start to final product; increase productivity or maintain worker productivity	Able to find more efficient and effective production routines	Ability to understand simple task in manufacturing system	Ability to understand, to think, to create better improvement (i.e. increasing productivity, better quality, reducing production cost etc)
Who	New recruits, high school graduate, 20-22 years old	New recruits, technical college or engineering bachelor graduates	Well-experienced operators	Middle and well-experienced engineers	New recruits, permanent employees both operators and engineers	
When/ period	First time enter company; probation (3 months)		When the physical strength decreases, approximately at 40 years age	3-4 years after permanent status is given and upward	From first time enter company (probation) until permanent status is granted	
How/ channel	General training (during probation), OJT based on education background		Groups of 4-5 workers	Project-based development, internal/external training, OJT domestic and foreign	General training (during probation), OJT	Project-based development, internal/external training, OJT domestic and foreign
Evaluation system	During probation (presentation →exam; checking mechanism)		Checking mechanism	Within each channel	During probation; checking mechanism	Within each channel
Trigger	Start labor-intensive manufacturing process (mainly, low-cost manufacturing)		Decreasing physical ability and productivity (specifically for operators) ; pressure from global competition; technology advancement			

Source: author, based on interviews

stance, in audio factory 20 to 30 years' old employees can do mounting (putting particular component in to circuit board) 10,000 sets everyday. But 40 years old employees, can only produce 9,000 sets per day. On the other hand, labor cost is increasing because each year there is a salary increment. To cope with this problems, the company develop new competency of blue collars workers from "ability to perform single task within one-line manufacturing" to "ability to perform multitasks within cell-system manufacturing".

In the single task manufacturing process, one can only produce or perform one single task assigned to her/him in the long assembly line which usually needs 30 employees to finish. On the other hand, within cell-production system 4-5 workers are assigned as a group in order to produce a particular product from the beginning until the finished product. Each employee can perform more than one task; it can be 5 or 10 tasks. Those 4-5 workers with well experience, multiple competencies can work together in "shadow-line" that is especially created for these people. The combination of 4-5 well-experienced blue collars workers can increase their productivity or at least to maintain as previous productivity level.

In this system, the level of productivity for each employee can still be measured. For instance, one employee produces 800 sets while other produces 1000 sets, competition happens among them. By competing each other, knowledge exploitation process materializes because they will put more efforts to produce. The more they produce, the more the payment they get. To do so, employee should be trained in additional ability move from general expertise to more specific ability. For instance, training in one-package specific ability of soldering, mounting, inspection and screwing.

In this process, I found that the role of factory manager to motivate the person is a key success of this process. It combines with better reward system for more productive workers. More competent workers who are more productive will be granted more rewards in terms of financial rewards.

2.3.2 Development of Well Experienced-White Collar Employees

The development of well experienced white collars employees are mainly through such mechanism: project-based development, internal training and domestic seminars/ lectures, external training and overseas seminar/lectures, and OJT in overseas.

Project-based development

After completing probation period, engineers start working as permanent employees. Based on the evaluation from the factory manager during the probation period, they were assigned to the job/task which is most related to his/her capability. For example, engineer who seems to be fit in assembly process during probation period, then he/she will be assigned to that job for the first time. However, after some time they will be assigned to other jobs in order to acquire all knowledge and manufacturing capabilities. Usually after 3-4 years of learning, engineers can accumulate good manufacturing capabilities.

Project-based development means to create capable engineers by assigning them into particular product development project that create a product from zero. A project is led by senior engineer and comprises of some engineers who work together closely even they were divided into sub-sub team according to their expertise. In this project team, they should think and create model based on some specifics information including features, shape, price, component availability, user-friendliness, and easy to be repaired if broken etc. This information is supplemented by result of market research conducted by the company and secondary data such as industry trend. The information captures customer's preference, necessity towards the products and their segments. Therefore, the engineers should be able to interpret customer's preference including taste and transform it into the final product. The ability of understanding customer's preference or needs is very important as stated by the informant: "*Product engineers should be able to act as if they are part of the segment in order to have better understanding customer's preference. However, sometimes engineers are reluctant to do it because they think that the product should be sophisticated and with newest technology regardless of the different segments. They think product for villagers (people living in country side) should have same features and function that is for urban people. In fact, it's totally different. To make them understand, to fight their ego, is very difficult.*" (Interview, July 18, 2006).

This is an example of project-based development in order to develop engineering capabilities. For instance, radio cassette project. Engineers should think comprehensively from technical matters, designs, considering production capability owned by the factory for producing the product, deadline of product launching and also should consider the price that can be afforded by customer. By keeping deadline of product launching in mind, therefore he or she should think and work harder to meet the schedule and deadline. Two or three engineers are assigned in the sub teams. The number of engineers in each team is based on the needs of each projects as well as based on the expertise owned by each engineers. The number of sub teams is also based on the needs of the projects considering the complexity and sophisticated the product that will be produced. All the process is supervised and controlled by manager.

This kind of project usually starts from market survey to understand the customer needs, segment, and behavior. The survey also provides the information about competitors including product's price. The team also buy the competitors products to understand what is their strength and weakness of the product, not to imitate their product because Matsushita has own brand name and standard.

By understanding the weakness and strength of the competitor's products, engineers understand the weakness and strength of PMI's products. If they think their product is worse than competitor's product, they challenged themselves to catch up and even create much better product with all means. As one informant mention that is so-called "engineer' spirit".

Valuable information not only derived from survey, but also from books, journals, as well as from the networks they have. These sources of information and knowledge are useful when they need some ideas of improvements or when they find difficulties about technical problems. Engineers are very common to have contact with previous college acquaintance, their teacher at school and mentors in university.

Engineers are talented person with full of ideas and in high spirit to implement many kind of technology including most sophisticated technology they know. Sometimes they have personal conflict between their eagerness to implement their ideas which usually includes most sophisticated technology and customer's needs which sometimes does not need such sophisticated technology, specifically for customers in country side.

For instance, the debate between the usage of transistor instead of integrated circuit (IC) for the radio cassette for the customers in country side. Engineers propose IC for the radio cassette they will produce because the technology is higher and follows the international technological trends, but it will cost much for customer in the country side. For transistor, to turn on the power of the radio only needs 1.2 volt that can be supplied by 2 batteries of 1.5 volt. These batteries are available in many stores with cheap price, therefore affordable for the customers. Using the IC will need higher voltage to turn on the power which is 1.8 volt (higher voltage than 1.2 volt). Therefore, if radio cassette use transistor, the battery will last longer than use IC. With longer batteries, the customers are happier because it cost money less. In addition, the radio cassette with transistor is much easier to be repaired because they only need to change the transistor. The private electronics service counters throughout the country are usually able to repair with new transistor which is widely available in the electronics stores, including in country side. However, from the point of view production cost is much higher for radio cassette with transistor because needs longer process, the customer's needs and satisfaction is much more important for PMI.

From this point, the concept of R & D in this factory, particularly for radio cassette (audio) factory emphasize on development side which considers more on applicability. Rather, research side that is more basic science. My informant also underlines that "*we are proud of our product, a radio cassette with transistors because customers perceive our radio higher quality as long-life product compare to others. It makes our product famous…From the technological point of view we can learn that sometimes we do not need high or sophisticated technology in our products but more appropriate technology that fits with customer's need. Even though this technology is almost sunset but we still can produce much profit from those products, including for export market."* (Interview, July 18, 2006).

In addition to think the appropriate technical specification and design of the product, engineers should also consider that product can be manufactured in their factory. In other words, the product should be easily produced in accordance with production capability in the factory. Moreover, the product also should also be repaired easily not only as part of after sales service counters, but also in many private radio cassette service counters throughout the country.

My informant underlines that "*usually each engineer joins one project each year, but if they can collaborate in two projects each year, it can be considered as a great learning process. These kinds of engineering knowledge and capabilities can not be found at school. The engineers accumulate the knowledge and capabilities in the factory, what I called it 'factory as school', vis-à-vis a formal school like college or university."* (Interview, July 24, 2006).

Internal and external training and domestic/overseas seminars/courses

The company also held internal training for engineers. They have "Matsushita Global Institute", a group's training development center, but act as independent entity provides general training such as application of manufacturing techniques in the factory and also customized training for engineers based on company's requirements. Says senior manager, "*We ask the Institute to create special program for us…for example, how to create same perception between sales person and production employees…sometimes there is a conflict or misunderstanding between them…sales person claims that they want to sell product but the stocks are unavailable…or on the other hand, production employee said that they already produced products but sales person does not sell it…then we ask the Institute to train them in more practical and applicable manner…and these kinds of program increase their performance positively…"* (Interview, May 5, 2006).

The company also sends engineers to external training within the country (domestic) with regards to their technical expertise. In addition to acquire more technical knowledge, they also get more experience, broaden their horizon and build networks from reputable universities and make friends who help the engineers in doing their work when it is needed.

Overseas seminars or lectures also can be a channel for engineers' capability development. In this seminar, they

do not only learn about technical expertise but also how to build the networks among people.

OJT in overseas

Main mechanism to develop relatively well-experience white collars workers is through OJT in other company within their groups domestically and abroad. As part of Matsushita group, well experienced-engineers have been sent to R & D facility in Singapore and working together in other company such as in Malaysia and Thailand. Furthermore, local engineer from PMI who sent to Singapore for 3 years has been assigned as chief engineer in their last 2 years. He leads a special team including Singaporean engineers to develop audio product. Says senior manager, *"The quality of our engineers is good…they are not behind foreign engineers in terms of quality…we can compete…yet we send engineers to become chief engineer in Matsushita group's company in Singapore…but we lack in facilities…therefore as a whole (combination between engineers and facilities, added) we are behind them…that's our weakness…"* (Interview, May 5, 2006).

Regular training in Japan was also assigned either short term or long term ranging from weeks, months until 2 or 3 years. Through OJT, they learned and applied some techniques or skills directly into the particular task. For example, they sometimes brought "jobs" from JV company in Indonesia to parent firm in Japan. They can not complete it in Indonesia because of lack of testing facilities such as electro magnetic compatibility (EMC). In line with the timing for product deployment to the market, they tried to finish the jobs with help, support and supervision from Japanese experts in parent company. As one of informant says: "W*ith help from experts, we can acquire more knowledge and broaden our horizon within different learning circumstances*" (Interview, July 24, 2006).

2.4 Learn How to Find Problems and Solutions

Despite learn how to manufacture the product and to improve manufacturing system, I found the unique way of learning how to find problems and solutions. This type of learning occurs for new recruits of white collars employees.

I underlined the important of "checking mechanism" to ensure learning process of engineers. The tight control and evaluation from factory manager especially in the end of month's assessment is indispensable in deciding whether new recruits" have learned something" or "have not learned yet". In the end of month's meeting, he performed three ways as checking mechanisms:

1) To check "book of training" of the workers. If the new recruits wrote many notes, the manager praised them as "doing proper learning". According to the manager, if the workers wrote many notes, it means that he or she was eager to think of "something" about the production process. Actually, they could write anything about the process that mainly as tacit knowledge. By taking a note, he or she then can read it again in the afternoon. It can be considered as part of assimilation process of new knowledge. If they can not understand than they can consult with senior engineers or directly to factory manager about what they found.

2) To evaluate workers' ability in finding problems and then finding solutions of the problems according to his field specialty (e.g. electronics or mechanics). If they can find problems, then try to find solutions meaning that new recruits "are thinking", generate own ideas, or try to synthesize between theoretical background they have and practical matter in the factory. The typical problem that may rise is how to increase productivity, to shorten lead time, to reduce costs by shortening lead time, or point improvement. The management hopes either new recruit can think how to create better quality from the engineering point of view or reducing production cost. New recruits can propose anything such as better lay out of production etc. If new recruits can not find any single problems, factory manager assess them with lower capability of learning. If it happens until the end of third month, they are termed as persons who do not want to think. Therefore, they might not eligible to be granted the permanent employee status because in this type of worker the main emphasis is on "ability to think", to create better improvement, not physical matter. This is the main different with blue collars workers. Here I termed this mechanism as *"learning by finding problems and solutions"*.

3) To motivate new recruits to learn more and more by creating "embarrassing environment" during the meeting. Factory manager strongly challenged and criticized new recruits by telling them their lack of ability to learn, to pump up their spirit to learn more, to work harder and to be tougher, and sometimes he made them crying. The ultimate goal of this mechanism is to produce engineers who able to create better improvement overtime and able to compete with others.

3. Role of Japanese Experts in JV Company

As JV, Japanese experts always remain in JV company as representative of parent company regardless new products, techniques, or system will be launched or not. They stay usually for 5 years. Japanese experts sent to JV company has different expertise ranging from electronics, mechanical and production. The decision to send Japanese experts is depended upon the strategy that JV will pursue to strengthen the company. For example, if in the first phase, they decide to strengthen engineering so parent company will send senior engineers who have expertise in engineering. Then, if they decide to strengthen production capacity and efficiency, therefore parent company will send senior production engineers.

The role of the Japanese experts in JV company are as follows:

1) *As advisor*, they give advice to the company regarding particular matters such as engineering and production. Their main job is firstly to guarantee quality, reliability, and safety of the products or production processes meet the parent company standard. Therefore, they can use brand name of parent company. As the senior engineer, his involvement is in a way of advising, supervising and solving the problems when the local engineers can not solve it. Transfer of know how occurs during these processes.

During their assignment time in JV company, there is usually only one person senior engineer in the particular field of expertise. Therefore, sometimes it is necessary to send local engineers to acquire additional expertise to parent company or other factory within group's company abroad. In case of developing 2-doors refrigerator, many expertises are needed such as mechanical design, electronics, cooling system *etc*. However, Japanese expert usually only hold one expertise, so to fulfill this lack two local engineers were sent to parent company in Japan to learn how to develop this refrigerator. Therefore, in the same time both engineers in JV company side and those who sent to parent company side develop 2-doors refrigerator together. They exchange the information.

2) *As window*, they teach JV company management as well as engineers regarding new rules, system, or special requirement as part of parent company standard. In this case, they act as "bridge" between parent company and JV company vice versa. For example, since 2004 JV company is obliged to follow ROHS (restriction used of hazardous materials) program. Because it is new program and no body in JV company knows, therefore they explain the substance of the program and how should it be proceed. As on of informant says: "*in this manner, Japanese expert act as window in each factory. They do reporting, target setting, distributing the documents. As this is new program from parent company, therefore, the meeting has been held for all JV company under the same group and they conduct real case study for each factory*".

3) *As motivator and mentor*, they give motivation to local engineers to pursue better capability in the future. He tells one of informant about his experience as Japanese senior engineer including efforts to balance life as employee in Japanese company and his personal life. Despite working together in the factory, he taught my informant technical matters during off-work. They also went to social gathering together such as dinner, sport activities and singing songs. He wanted to see my informant to be one of future capable engineer within JV company. He kept his eye on my informant's learning process. My informant says: "*I am a young engineer in this company before I met him (Japanese expert) many years ago, then I had long discussion with him. He told me both good and bad side working as engineer in Japanese company, about balancing life in the company and family. He convinced me that success at work that is for the advancement of family life. The better he works, the better life is for family too. He wanted me to learn from his experiences and wanted to see me as key person for this company in the future. Since than, I worked harder from early in the morning until* 9 *or* 10 *pm to learn more to understand work as engineer with high spirit and discipline. That is what I learned from Japanese experts, responsibility and hardworking*".

4. Discussion and Conclusions

This research has examined how to learn from foreign partner in the context of Japanese joint venture in Indonesian electronic industry. Specifically, this research provides three type and mechanism in learning for both blue and white collars workers.

Technological Capability. After 36 years JV and plus 10 years technical assistance, PMI has been able to develop their technological capability. For example in audio (radio/tape/cassette) as the oldest production that started from 1970. Now, PMI can produce and design from 0 (zero). In the beginning of production only minor changes and modifications were made. Since 1986, audio department has started to make major changes and create own design. For example, engineer worked hard to find the special taste of Indonesia people such as sound with high treble and bass audio. They read some electronics journals, consults with their mentor including former supervisor in college, discuss with friends in their networks, and discuss with Japanese expert and convince parent company about this product. Finally, PMI can fully design and produce audio which meet with local tastes not only the sound but also the physical performance of the product since 2000.

Key Success. Based on discussion above, I can summarize some underlying key success in learning process at PMI as follows:

1) Good training system particularly with strong determination of managers (factory manager and HRD manager) to train blue and white collars workers. They conduct unique way of learning using checking mechanism, learning by finding problems and solutions, creating embarrassing environment for workers. This create strong fundamental of absorptive capacity ranging from acquiring, assimilating, transforming and exploitation into such technological capability.

2) Managers have been successful to motivate workers in human resources development by applying some principles as follows: a) Long life learning process to acquire knowledge, not only from formal school but company as school for the workers; b) Try to always be in the good health by regular sports exercises; c) Discipline; d) Responsibility; and e) Hardworking.

3) The existence of Japanese experts has created mutual benefits and two-way rounds of learning both from

parent company side and JV company. PMI earned more advanced techniques, skills and knowledge from parent company while Japanese experts learned about local knowledge such as culture, languages, and market. Local partner also perform daily operations and deal with wor- kers' problems as well as with the government. Both parent and local partners work together in their own roles.

4) Successful technology or knowledge transfer is based on principle "willingness to give from parent, and willingness to learn from local partner". Matsushita gave opportunity to PMI to develop product based on their needs and local taste (such as audio products). On the other hand, PMI has put all their efforts to utilize this opportunity. This contributes to the concept of absorptive capacity that both foreign and local partner are needed to ensure successful absorptive capacity.

5) Being part of group membership, especially as JV, PMI has benefited from world wide production networks that provide human networking, accumulating experience and knowledge and sharing testing facilities including R & D facilities.

The contribution of this research is as follows. First, by distinguishing the type and characteristics of each process, this typology enhances our understanding about JV as useful organizational learning mechanism, particularly in Japanese joint venture in emerging economies [12] and about the source of firm's heterogeneity underlying learning process [13,14]. Second, this extensive in-depth case study provides the clear evidences of the importance of internal learning capability process to improve technological capability; and absorptive capacity [15-17]; and relational rents generated from resource sharing mechanism [18,19]. Third, this study, to best knowledge, is a pioneer research in Indonesia since technological issues have been paid little attention from scholars.

For the managers, this research recommends ways to acquire, assimilate, and utilize the knowledge especially from foreign partner in JV. The typology of learning in this study can be used as benchmark in examining technological as well as managerial capabilities in other firms. Therefore, the managers can create appropriate strategies for their firm considering who are the foreign partner and resource and or capabilities they have as local partner.

The limitation of this study is that insights from parent's company can not be examined, yet it will enrich the understanding of two-ways learning between parent and local partner, particularly from their motivation and parent's global strategies. As Matsushita is recognized as one of world class companies, future studies examining the effect of being member of high performance business group is also worth. A comparison with other type of IJV ownership will also enrich our understanding.

REFERENCES

[1] W. Cohen and D. Levinthal, "Absorptive capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, Vol. 35, No. 1, 1990, pp. 128-152.

[2] S. A. Zahra and G. George, "Absorptive Capacity: A Review, Reconceptualization, and Extension," *Academy of Management Review*, Vol. 27, No. 2, 2002, pp. 185-2003.

[3] M. A. Lyles and J. E. Salk, "Knowledge Acquisition from Foreign Parents in International Joint Ventures," *Journal of International Business Studies*, Vol. 27, No. 5, 1996, pp. 877-904.

[4] A. Inkpen and P. Beamish, "Knowledge, Bargaining Power, and The Instability of International Joint Ventures," *Academy of Management Review*, Vol. 22, No. 1, 1997, 1960, pp. 177-202.

[5] A. Kogut and U. Zander, "Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation," *Journal of International Business Studies*, Vol. 4, No. 24, 1993, pp. 625-645.

[6] M. A. Lyles and J. E. Salk, "Knowledge Acquisition from Foreign Parents in International Joint Ventures," *Journal of International Business Studies*, Vol. 27, No. 5, 1996, pp. 877-904.

[7] W. Cohen and D. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, Vol. 35, No. 1, 1990, pp. 128-152.

[8] P. J. Lane, J. E. Salk, and M. A. Lyles, "Absorptive capacity, learning, and performance in international joint ventures," *Strategic Management Journal*, Vol. 22, No. 1, 2001, pp. 1139-1161.

[9] J. R. Lee and J. S. Chen, "Internationalization, Local Adaptation, and Subsidiary'S Entrepreneurship: An Explanatory Study on Taiwanese Manufacturing Firms N Indonesia and Malaysia," *Asia Pacific Journal of Management*, Vol. 20, No. 1, 2003, pp. 50-72.

[10] J. W. Creswell, "Qualitative inquiry and research design: Choosing among five traditions," Sage Publications, London, 1998.

[11] R. K. Yin, "Case Study Research: Design and Methods", Second Edition, Sage, 1994.

[12] J. F. L. Hong, H. Easterby-Smith and R. S. Snell, "Transferring Organizational Learning Systems to Japanese Subsidiaries in China," *Journal of Management Studies*, Vol. 43, No.5, 2006, pp. 1027-1058.

[13] S. Lall, "Technological Capabilities and Industrialization," *World Development*, Vol. 20, No. 2, 1992, pp. 165-186.

[14] W. Xie and G. Wu, "Differences between Learning Process In Small Tigers and Large Dragons: Learning Processes of Two Color TV (CTV) Firms within China," *Research Policy*, Vol. 32, No. 8, 2003, pp. 1463-1479.

[15] W. Cohen and D. Levinthal, "Innovation and Learning: Two Faces on R & D," *Economic Journal*, Vol. 99, No. 3, 1989, pp. 569-596.

[16] W. Cohen and D. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, Vol. 35, No. 1, 1990, pp. 128-152.

[17] S. A. Zahra and G. George, "Absorptive Capacity: A Re-

view, Reconceptualization, and Extension," *Academy of Management Review*, Vol. 27, No. 2, 2002, pp. 185-2003.

[18] J. H. Dyer and H. Singh, "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage," *Academy of Management Review*, Vol. 23, No. 4, 1998, pp. 660-679.

[19] T. N. Mursitama, "Creating Relational Rents: The Effects of Business Groups on Affiliated Firms' Performance in Indonesia," *Asia Pacific Journal of Management*, Vol. 23, No. 4, 2006, pp. 537-557.

iBusiness, 2010, 2, 178-182
doi:10.4236/ib.2010.22021 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Analysis and Evaluation for Core Competence of Insurance Company Based on SEM

Hengqing Tong[1], Yang Ye[1], Yichao Pan[1], Shudan Lu[1], Jie Zhang[2]

[1]Department of Mathematics, Wuhan University of Technology, Wuhan, China; [2]Department of Accounting, Chongqing Technology and Business University, Chongqing, China.
Email: tonghengqing@126.com, yeyang19851016@163.com

Received March 28th, 2010; revised April 27th, 2010; accepted May 21st, 2010.

ABSTRACT

Evaluation the core competence reasonably plays an important role in the insurance company, it is related to whether the insurance can maintain a stable long-term competitive advantage or not, and whether obtain a stable long-term excess profits or not. In this paper, we select 6 *first-degree indexes* (*including the core competence*) *and* 28 *second-degree indexes to evaluate the core competence of insurance company by Structural Equation Model* (*SEM*), *and analysis the relationships among the first-degree indexes. Besides, we use a new algorithm proposed by us to improve the calculation of SEM.*

Keywords: *Core Competence, Insurance, SEM, Algorithm*

1. Introduction

The essential of competition among enterprises is scramble for the required resources of their survival and development of enterprises, the competitiveness of enterprises is the ability of enterprises to compete for resources [1]. Traditional competitive theory still can not make a satisfactory answer of the long-term ups and downs of Enterprise. However, the theory of the core competitiveness study the ability of optimal allocation of resources of enterprises from the short-term extends to long-term. And point out that in order to make sure the survival and development of corporate sustainability, we must have more ability of optimal allocation of resources. In other words, companies must have strong core competitiveness.

The core competence was first proposed by C. K. Prahalad and Gary Hamel [2]. This theory is a kind of business strategy concept and paradigm which has great vitality; it opened the real password of the modern business success in a sense. Enhance the core competitiveness have great strategic significance for the development of the insurance business. Insurance companies operate with the characteristics of debt, once the insurance companies have poor core competitiveness, poor operating performance and unable to bear the compensation or payments, they will harm the vital interests of the insured, and even affect the stability of the whole society. So it is very significant to study the core competence of insurance company.

The core competence of insurance company is different from the general company. Professor J. P. Jan believes that the following 3 reasons account for this phenomenon. First, the insurance company cannot establishment the core competence rely on market segmentation or monopoly. Second, insurance products cannot apply for a patent. Third, regulatory authorities require the insurance company provide the transparent and open information of the insurance products for financial supervision [3]. Based on this features, many scholars establish the model to evaluate the core competence of insurance company. Such as DEA data envelopment analysis model, BSC (Balanced Score Card model) [4] and so on. Among the most important and most widely recognized model is FCEM (Fuzzy Comprehensive Evaluation Model) [5]. However, all of the above models are very subjective in a sense. In this paper, we introduce a model in which the coefficients and weights are calculated by samples, so it is more objective and convincing, and could offer more deep analysis for the index systems.

2. SEM for the Core Competence of Insurance Company

SEM is a rapid-developing embranchment of Application Statistics, which has a wide application in the area of Psychology, Economics and Sociology [6,7], especially in Customer Satisfaction Index (CSI) [8] model which is required by a series of ISO9000 criterions. This model

not only studies the interior relationship among various factors, but also the relative and causal relations among latent variables. As we know, we cannot observe the value of the core competence directly. So it is a latent variable, and we can use the SEM to research.

Different companies have different competitive advantages; it may be different with the company's industrial environment and strength. For example, Intel's core competence is the chip manufacturing technology; Coca-Cola Company's core competence is a trademark and formula, while Galanz's core competence is the large-scale and low-cost production capacity. The difference of the external environment and internal resources among the different industry is very large, so the constituent elements and cultivation methods of the core competence would be different with each other. Therefore, with the basic principles of selected index [9], we consider the specificity of the insurance enterprise; identified 5 first-degree indexes which have relate to the enterprise's core competence, all of them are latent variables. In order to study the core competence, we have to seek the observed variables for each latent variable. The variables are listed in **Table 1** as follows:

There exists 13 relationships among the 6 structural variables (latent variables), which are expressed in **Figure 1** (The relationships among variables are $\gamma_1 \sim \gamma_5$, expressed with dashed arrowheads; the relationships among independent variables are β_{ij}, expressed with real-line arrowheads). The structural relationship among the latent variables (structural model) can be put as follows:

As shown in the **Figure 1**, we can see the path relationships or causalities among these variables. Next we can express these causalities among the structural variables as equations as below:

$$\begin{pmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{pmatrix}=\begin{pmatrix}0 & 0 & 0 & 0 & 0\\ \beta_{21} & 0 & 0 & 0 & 0\\ \beta_{31} & \beta_{32} & 0 & 0 & 0\\ \beta_{41} & \beta_{42} & \beta_{43} & 0 & 0\\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 0\end{pmatrix}\begin{pmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{pmatrix}+\begin{pmatrix}\gamma_{11}\\ \gamma_{12}\\ \gamma_{13}\\ \gamma_{14}\\ \gamma_{15}\end{pmatrix}\xi_1+\begin{pmatrix}\varepsilon_{\eta_1}\\ \varepsilon_{\eta_2}\\ \varepsilon_{\eta_3}\\ \varepsilon_{\eta_4}\\ \varepsilon_{\eta_5}\end{pmatrix} \tag{1}$$

In general, suppose that $\eta_1 \sim \eta_m$ are m dependent variables, arranging them as a vector η by column as (1), that is $\eta' = (\eta_1', \eta_2', \cdots, \eta_{m-1}', \eta_m')$, we called it as endogenous latent variables; and $\xi_1 \sim \xi_k$ are k independent variables, arranging them as a vector ξ by column also, $\xi' = (\xi_1', \xi_2', \cdots, \xi_{k-1}', \xi_k')$, we call it as exogenous latent variables. Then $m \times m$ square matrix B is the coefficient matrix of η, and $m \times k$ matrix Γ is the coefficient matrix of ξ, let ε_η is the residual vector, then Equation (1) may be extended as:

$$\eta = B\eta + \Gamma\xi + \varepsilon_\eta \tag{2}$$

where $m = 5$ and $k = 1$.

Table 1. Index of variables

Structural variables	**Observed variables**				
Organizational capacity ξ_1	Employ satisfaction x_{11}	Employee turnover x_{12}	Enterprise cohesion x_{13}	Staff training input rate x_{14}	
Quality of service η_1	Customer Satisfaction y_{11}	Corporate reputation y_{12}	Customer loyalty y_{13}	Corporate social image y_{14}	Emergency Management capacity y_{15}
Innovation capacity η_2	New insurance development rate y_{21}	New insurance development cycle y_{22}	R & D investment rate y_{23}	New insurance premium income rate y_{24}	Patents possess rate y_{25}
Market capacity η_3	Market possess rate y_{31}	Insurance depth y_{32}	Insurance density y_{33}	Market reaction speed y_{34}	Explore new market capacity y_{35}
Risk management η_4	Solvency y_{41}	Capital adequacy rate y_{42}	Investment Income rate y_{43}	Insurance funds efficiency y_{44}	
Core competence η_5	ROE y_{51}	Sales profit rate y_{52}	Profit growth rate y_{53}	Per capita profit y_{54}	Financial stability factor y_{55}

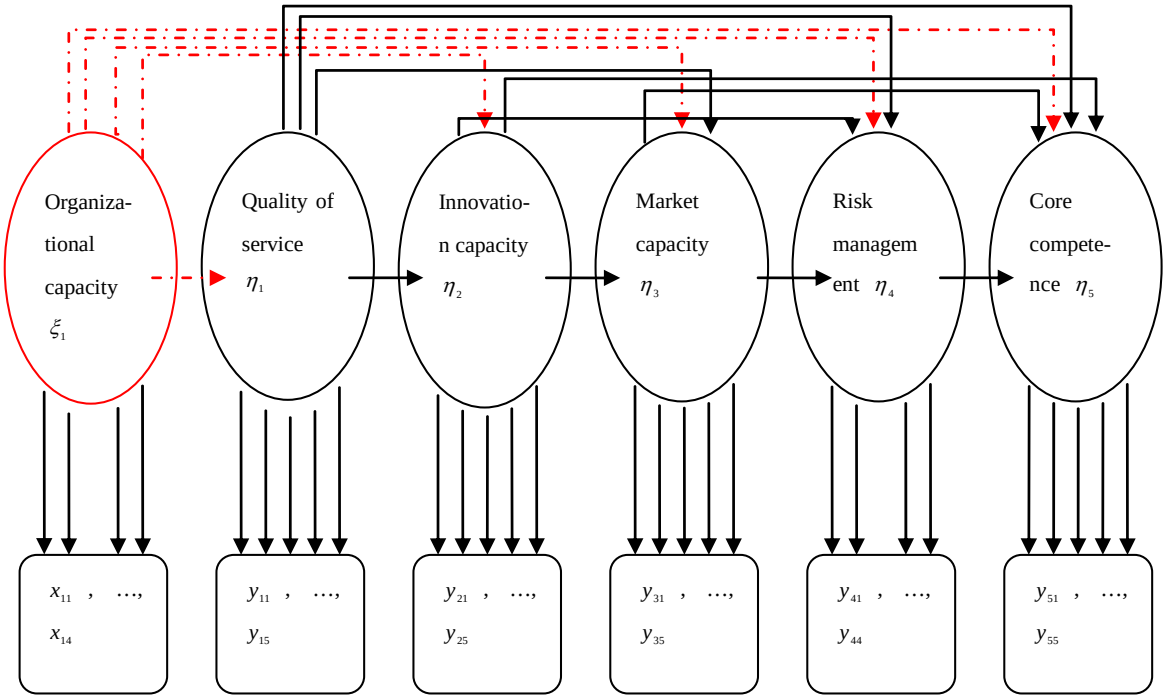

Figure 1. Path relationships among variables

There are always two systems of equations in a SEM. One is a structure system of equations among structural variables, and the other one is a measurement system of equations between structural variables and observed variables. From the above narrative, we can know the Equation (2) is the structure system of equations. And the structural variables are always implicit and cannot be observed directly. So there must have many observed variables to reflect the structural variables. And the relationships between the latent variables and the observed variables are the other equations of SEM, which are measurement system equations.

From the above, we know there are k exogenous latent variables and m endogenous latent variables. Generally the observed variables corresponding to ξ_i are denoted as x_{ij}, $i=1,\cdots,k$; $j=1,\cdots,h(i)$, here $h(i)$ is the number of observed variables corresponding to ξ_i. Similarly, the observed variables corresponding to η_t are denoted as y_{ts}, $t=1,\cdots,m$, $s=1,\cdots,g(t)$, here $g(t)$ is the number of observed variables corresponding to η_t. Then the observation equations in the **Figure 1** can be expressed as the relationship from the observation variables to the structural variables:

$$\xi_i = \sum_{j=1}^{h(i)} \psi_{ij}\, x_{ij} + \varepsilon_{xi},\ \ i=1,\cdots,k \tag{3}$$

$$\eta_t = \sum_{s=1}^{g(t)} \omega_{ts}\, y_{ts} + \varepsilon_{yt},\ \ t=1,\cdots,m \tag{4}$$

Where ψ_{ij}, ω_{ts} are the summarizing coefficients, and ε with subscripts are random error items. Let $X_i' = \left(x_{i1}',\cdots,x_{ih(i)}'\right)$, $Y_t' = \left(y_{t1}',\cdots,y_{tg(t)}'\right)$, $\psi_i' = (\psi_{i1},\cdots,\psi_{ih(i)})$, $\omega_t' = (\omega_{t1},\cdots,\omega_{tg(t)})$. Then combining the Equations (2), (3) and (4) as:

$$SEM^{+} = \begin{cases} \eta = B\eta + \Gamma\xi + \varepsilon_\eta \\ \xi_i = \psi_i' X_i + \delta_{xi},\ \ i=1,\cdots,k \\ \eta_t = \omega_t' Y_t + \delta_{yt},\ \ t=1,\cdots,m \end{cases} \tag{5}$$

here SEM^{+} is the structural equations model with positive observation.

On the other hand, the measurement equations can be also expressed as follows:

$$\begin{pmatrix} x_{i1} \\ x_{i2} \\ \vdots \\ x_{ij} \end{pmatrix} = \begin{pmatrix} \upsilon_{i1} \\ \upsilon_{i2} \\ \vdots \\ \upsilon_{ij} \end{pmatrix} \xi_i + \begin{pmatrix} \varepsilon_{x_{i1}} \\ \varepsilon_{x_{i2}} \\ \vdots \\ \varepsilon_{x_{ij}} \end{pmatrix} \tag{6}$$
$$i=1,\cdots,k;\ j=1,\cdots,h(i)$$

$$\begin{pmatrix} y_{t1} \\ \vdots \\ y_{ts} \end{pmatrix} = \begin{pmatrix} \lambda_{t1} \\ \vdots \\ \lambda_{ts} \end{pmatrix} \eta_t + \begin{pmatrix} \varepsilon_{y_{t1}} \\ \vdots \\ \varepsilon_{y_{ts}} \end{pmatrix} \tag{7}$$
$$t=1,\cdots,m;\ s=1,\cdots,g(t)$$

here, υ_{ij} and λ_{ts} are the loading coefficients, and ε with subscripts are random error items yet.

Let $\upsilon_i' = \left(\upsilon_{i1}, \cdots, \upsilon_{ih(i)}\right)$ and the same time let $\Lambda_t' = \left(\lambda_{t1}, \cdots, \lambda_{tg(t)}\right)$. Then (5) and (6) can be expressed as:

$$X_i = \upsilon_i \xi_i + \varepsilon_{xi}, \ i = 1, \cdots, k \tag{8}$$

$$Y_t = \Lambda_t \eta_t + \varepsilon_{yt}, \ t = 1, \cdots, m \tag{9}$$

Combine the Equations (2), (8) and (9), then we can get:

$$SEM^- = \begin{cases} \eta = B\eta + \Gamma\xi + \varepsilon_\eta \\ X_i = \upsilon_i \xi_i + \delta_{xi}, \ i = 1, \cdots, k \\ Y_t = \Lambda_t \eta_t + \delta_{yt}, \ t = 1, \cdots, m \end{cases} \tag{10}$$

here SEM^- the structural equations model with converse observation.

3. Modular Constraint Least Squares Solution (MCLS)

We can skillfully use the least squares method in regression between each structural variable and its corresponding observation variables, and obtain the least squares solution of structural variable by the modular constraint of structure vector if we analyzing the observation equations of SEM carefully [10,11]. The algorithm for MCLS can be expressed as follows:

Algorithm 1. The MCLS of structural vector in SEM.

Step 1 In SEM^-, suppose ξ_i, η_t all are unit vectors, we can calculate the least square estimates of the coefficients between each structural variable and its corresponding observation variables:

$$\begin{gathered} \upsilon_{ij}^2 = x_{ij} x_{ij}' - \hat{\varphi}_{ij}^2 \\ j = 1, \cdots, h(i); i = 1, \cdots, k \end{gathered} \tag{11}$$

where

$$\begin{gathered} \hat{\varphi}_{ij}^2 = \hat{\phi}_{ij}^{-1}, \hat{\Sigma}_{ix} = x_i x' \\ diag(\phi_{i1}^2, \phi_{i2}^2, \cdots, \phi_{ih(i)}^2) = \hat{\Sigma}_{ix}^{-1} \end{gathered} \tag{12}$$

Similarly we have

$$\begin{gathered} \hat{\lambda}_{ts}^2 = y_{ts} y_{ts}' - \hat{\vartheta}_{ts}^2 \\ s = 1, \cdots, g(t); t = 1, \cdots, m \end{gathered} \tag{13}$$

where

$$\begin{gathered} \hat{\vartheta}_{ts}^2 = \hat{\theta}_{ts}^{-1}, \hat{\Sigma}_{ty} = y_t y' \\ diag(\hat{\theta}_{t1}^2, \hat{\theta}_{t2}^2, \cdots, \hat{\theta}_{tg(t)}^2) = \hat{\Sigma}_{ty}^{-1} \end{gathered} \tag{14}$$

Step 2 In SEM^-, calculate the least square estimates of structural variables by using of $\hat{\upsilon}_{ij}, \hat{\lambda}_{ts}$:

$$\begin{gathered} \hat{\xi}_{il} = \frac{\hat{\upsilon}_i' X_{il}}{\hat{\upsilon}_i \hat{\upsilon}_i'}, \hat{\eta}_{tl} = \frac{\hat{\lambda}' Y_{tl}}{\hat{\lambda}_t \hat{\lambda}_t'} \\ i = 1, \cdots, k; t = 1, \cdots, m; l = 1, \cdots, N \end{gathered} \tag{15}$$

Step 3 In SEM^+, make use of $\hat{\xi}_i, \hat{\eta}_t$ obtained in Step 2 to calculate the estimates of regression coefficients ψ_{ij}, ω_{ts} according to common linear regression method.

Step 4 In SEM^+, make use of $\hat{\xi}_i, \hat{\eta}_t$ obtained in Step 2 to calculate the estimates of coefficient matrix B, Γ.

Notice that (2) is a common linear regression equations, we can use the two-stage least squares method to calculate it.

4. Definite Linear Algorithm with Prescription Constraint

According to the above algorithm, we can get the modular constraint least squares solution based on the constraints of the unit structural vector. But the solutions are not unique, and irrelevant to the modular length of the latent variables. As we know, it is not reasonable to stipulate that modular length of each structural variable is 1. If each modular length of the structural variable is not equal in possibly existing optimal solution set, then MCLS is not good.

An exploring way to improve the algorithm is to find a more reasonable constraint to replace modular constraint. After getting MCLS, we can change the modular length of structural variable in measurement system of equations to make the path coefficient between each structural variable and its corresponding observation variables satisfying prescription condition. That is:

$$\sum_{j=1}^{h(i)} \psi_{ij} = 1, \ \psi_{ij} \geq 0, \ i = 1, \cdots, k \tag{16}$$

$$\sum_{s=1}^{g(t)} \omega_{ts} = 1, \ \omega_{ts} \geq 0 \ t = 1, \cdots, m \tag{17}$$

Next, we compute the prescription condition from two cases.

If the corresponding path coefficients of MCLS are all non-negative at the beginning, we just need to divide a constant at the two sides of the Equation (3) and (4). This constant should be the sum of corresponding path coefficients in MCLS.

If the corresponding path coefficients of MCLS have negative at the beginning, we can not completely use the method of prescription regression [12]. However, we can change prescription condition and let $\psi_{ij} \geq \delta$, $\omega_{ts} \geq \delta$, here $\delta > 0$ but not $\delta = 0$, and δ may be decided by

user according to the actual problem. That is:

$$\sum_{j=1}^{h(i)} \psi_{ij} = 1, \quad \psi_{ij} \geq \delta, \quad i = 1, \cdots, k \tag{18}$$

$$\sum_{s=1}^{g(t)} \omega_{ts} = 1, \quad \omega_{ts} \geq \delta, \quad t = 1, \cdots, m \tag{19}$$

If some initial regression coefficients are less than δ, they are all changed as δ, and the corresponding independent variables multiplied by coefficient δ should be removed to the left of the equation in regression process.

Under on these conditions we can continue to improve the algorithm of MCLS.

Algorithm 2. Improvement on Step 3 of the Algorithm 1

Step 3* After getting the estimated values as $\hat{\xi}_i, \hat{\eta}_t$ of the structural variables ξ_i, η_t in Step 2 of Algorithm 1, we calculate the summarizing coefficients ψ_{ij}, ω_{ts} by prescription regression, and next calculate the estimated values of ξ_i, η_t again.

Step 3*.1 Define $\hat{\xi}_i, \hat{\eta}_t$ in Step 2, and calculate $\hat{\psi}_{ij}, \hat{\omega}_{ts}$ in SEM^+ by common regression.

Step 3*.2 For any i, if $\hat{\psi}_{tj} \geq \delta$ ($\delta \geq 0$) and $\sum_{j=1}^{h(t)} \psi_{ij} = c_i$ for all j. Then the both sides of Equation (3) are divided by c_i. In the same way, the both sides of Equation (4) are divided by c_t on the conditions.

After checking all i, t, go to Step 4 in Algorithm 1.

Step 3*.3 For any i, t, if there is j or s to make $\hat{\psi}_{ij} < \delta$ or $\hat{\omega}_{ts} < \delta$ ($\delta \geq 0$), then let corresponding item be fixed, that is $\hat{\psi}_{ij} = \delta$ or $\hat{\omega}_{ts} = \delta$. The corresponding observation variables x_{ij} or y_{ts} with its coefficient δ should be removed to the left of the equation, and combined with the latent variable $\hat{\xi}_t$ or $\hat{\eta}_i$ to regress, that is go to Step 3*.1 and Step 3*.2. After regression, the corresponding observation variable x_{ij} or y_{ts} with its coefficient δ should be removed to the right of the equation.

5. Final Remarks

In this paper, we propose SEM to analysis and evaluate the core competence of insurance company, and improve the algorithm of the SEM. It is more objective and scientific to use SEM in the evaluation of the core competence of insurance company compared with traditional methods, such as AHP, FCEM and so on, because the coefficients of this evaluation system are calculated by samples rather than designed arbitrarily. Therefore, we can have a better understanding the relationships among the indexes, which will do a great favor to decision-making analysis and evaluate for the core competence of insurance company.

REFERENCES

[1] Z. Q. Wang, "Study on Insurance Company Core Competence," Southwestern University of Finance and Economics, Chengdu, 2007.

[2] C. K. Prahalad and H. Gary, "The Core Competence of the Corporation," *Harvard Business Review*, Vol. 68, No. 3, 1990, pp. 79-91.

[3] J. P. Jan, "The Model Analysis of the Core Competence of Insurance Company," *Zhejiang Statistical*, Vol. 2, 2004, pp. 20-22.

[4] J. Sun, "Study the Evaluation System of the Core Competence of Property Insurance Company," *Journal of insurance professional college*, Vol. 23, No.1, 2009, pp. 37-42.

[5] M. J. Yu, "Evaluation Index System of the Core Competence of Insurance Company," *Tongling College Journal*, Vol. 3, 2004, pp. 14-16.

[6] S. Y. Lee and X. Y. Song, "Model Comparison of Nonlinear Structural Equation Models with Fixed Covariates," *Psychometrika*, Vol. 68, No. 1, 2003, pp. 27-47.

[7] S. Y. Lee and N. S. Tang, "Bayesian Analysis of Structural Equation Models with Mixed Exponential Family and Ordered Categorical Data," *British Journal of Mathematical and Statistical Psychology*, Vol. 59, 2006, pp. 151-172.

[8] C. Fornell, D. M. Johnson and W. E. Anderson, "The American Customer Satisfaction Index: Nature, Purpose, and Findings," *Journal of Marketing*, Vol. 60, No. 4, 1996, pp. 7-18.

[9] A. R. Xu, "Establish Evaluation Index System of the Core Competence of Insurance Company," *Statistics and Decision*, Vol. 2, 2004, pp.12-13.

[10] Z. Q. Yang, "The Applications of Generalized the Least Squares Model," *Chinese Science Bulletin*, Vol. 7, 1982, pp. 389-392.

[11] H. Q. Tong, L. Xiong and H. Peng, "Self-Organized Path Constraint Neural Network Structure and Algorithm," *Neural Information Processing*, Part I, 2006, pp. 457-466.

[12] K. T. Fang, D. Q. Wang and G. F. Wu, "A Class of Constraint Regression-Fill a Prescription Regression," *Mathematica Numerica Sinica*, Vol. 4, No. 1, 1982, pp. 57-69.

iBusiness, 2010, 2, 183-187
doi:10.4236/ib.2010.22022 Published Online June 2010 (http://www.SciRP.org/journal/ib)

An Empirical Study on the Contribution of Foreign Trade to the Economic Growth of Jiangxi Province, China

Yuhong Li[1,2], Zhongwen Chen[2], Xiaoyin Wang[3]

[1]College of Economics and Management, Huazhong Agricultural University, Wuhan, China; [2]Business School, Jinggangshan University, Ji'an, China; [3]College of Science, Huazhong Agricultural University, Wuhan, China.
Email: wxywxq@126.com

Received March 19th, 2010; revised April 20th, 2010; accepted May 22nd, 2010.

ABSTRACT

In open economy, development of foreign trade greatly impacts on GDP growth. Adapting simple regression for researching the relationship between foreign trade including total export and total import and GDP growth of Jiangxi province, with the collected 30*-year statistical data from* 1978 *to* 2007*. The result indicates that foreign trade has contributed a lot to the GDP growth of foreign trade and still has great potential to be tapped. There is a positive correlation between the foreign trade and GDP. And import has influenced Jiangxi province's economic growth more and more. Finally, the paper points out that in order to maintain the economic growth, Jiangxi must unswervingly implement the opening-up policy and be aware of trade protectionism.*

Keywords: *Foreign Trade, Contribution, Simpler Regression*

1. Introduction

Since the reform and opening up, China's foreign trade, which is playing a significant role in the world, has become more and more important [1]. But the proportion of China's total import volume in the GDP can not match the average level of the developed countries. Obviously, the foreign trade is closely related to economic growth in China. The importance of foreign trade for a country is increasingly prominent, though there are many researches related to contribution that foreign trade to GDP growth, researches particularly focus on one province or region is not common. Since the reform and opening up, foreign trade in Jiangxi province has experienced rapid development. From 1978 to 2007, exports and imports in Jiangxi province increased from 705.7 million dollars to 9.479 billion dollars [2].The increase of foreign trade is faster than the increase of GDP, and the proportion of foreign trade in GDP is increasing too. Therefore, this paper attempts to study on the contribution that foreign trade to GDP growth in Jiangxi province since the reform and opening up.

Many domestic scholars analyze foreign trade's contribution to GDP growth by studying the stimulating effect of net export. In four-sector economy,

$$\Delta GNP = \Delta C + \Delta I + \Delta G + (\Delta X - \Delta M)$$

That's to say the GNP increment (ΔGNP) equals the sum of consumption increment (ΔC) and investment increment (ΔI) and the government expenditure increment (ΔG) and the gross export increment ($\Delta X - \Delta M$). Therefore, the percentage of increase of GDP growth caused by foreign trade equals the product of GDP growth and the contribution degree of foreign trade to GDP growth. And the contribution degree of foreign trade to GDP growth equals the quotient of the net export increment divided by the GDP growth increment.

There is certain shortcoming in this method, which partially takes Keynes's view and simply regards import as an out leakage of GDP to attain the result that import has negative effect on GDP growth [3]. However, trade theory and practice proves that both import and export promote the national economy welfare and economic growth. For example, the import of cheap commodities can decrease production cost and increase consumers' welfare, and the import of capital goods and technology can promote the technological progress and improve labor productivity [4]. Therefore, we cannot simply consider only foreign trade export or net exports to the national economy and the influence of foreign trade should

be from the aspects of national economic role in promoting the comprehensive analysis and evaluation. Therefore, the following will get down on each total foreign trade volume index, namely, the gross foreign trade (import and export), the gross import, the gross export and the net foreign trade (the balance of export and import)on analysis of several aspects of GDP. As a result, both import and export should be considered in research to evaluate their influence on national economy separately. This paper analyzes contribution of foreign trade to GDP growth from the perspective of foreign trade volume, import volume, export volume and the net export volume respectively.

The general idea of this paper is to use multivariate linear regression analysis method in econometrics, taking indices related to foreign trade as repressors and GDP as explained variable in this model. Then use SPSS 11.5 and Excel 2007 for statistical analysis in order to test foreign trade's contribution to GDP growth of Jiangxi province.

2. The Construction of Model

2.1 Hypothesis

Different indices related to foreign trade contribute to GDP growth in different degree.

2.2 The Construction of Simple Regression Function

$$Y = A_0 + A_1X + \varepsilon$$

where Y refers to the explained variable related to GDP growth. X is the variable related to foreign trade. A_0 is the constant; A_1 is coefficient which stands for the degree of variable's increase caused by each unit's increase of explaining variables. As different indices are discussed in this paper separately, simple regression analysis is enough in the research.

Taking statistic data from 1978 to 2007 of Jiangxi province as sample, this paper analyzes foreign trade's contribution to GDP growth in Jiangxi province from four aspects including foreign trade volume, import volume, export volume and net export.

3. Construction and Test of Econometric Model

3.1 Foreign Trade Volume's Contribution

In order to **r**eveal the total foreign trade's contribution to GDP, this paper analyzes the ratio of dependence on foreign trade and relation coefficient between foreign trade and GDP.

3.1.1 The Ratio of Dependence on Foreign Trade

The ratio of dependence on foreign trade is the ratio of total foreign trade in GDP, which reveals the dependency of a country's economy and the open level of the country's market. Therefore,

Ratio of dependence on foreign trade = total foreign trade/GDP

The result figured out according to the statistic data of foreign trade from 1978 to 2007 in Jiangxi province shows that the ratio of dependence on foreign trade in Jiangxi province, which has an overall increasing trend (see **Figure 1**), increased from 1.22% in 1978 to 12.67% in 2007. That's to say, the economic growth of Jiangxi province relies on the growth of foreign trade volume to a certain degree.

3.1.2 Correlated Coefficient and Regression

Based on above analysis and data, it can be found that there is linear correlation between foreign trade volume and GDP.

The following part analyzes foreign trade volume's contribution to GDP from the aspect of general correlation coefficient. The equation is

$$\rho_{xy} = \frac{(x,y)}{\sigma_x \sigma_y}, \quad \sigma_x = \frac{\sum (X_i - U_x)^2}{n};$$

$$\sigma_y = \frac{\sum (Y_i - U_y)^2}{n}; \quad \mathrm{Cov}(x,y) = \frac{\sum (X_i - U_x)(Y_i - U_y)}{n}$$

Based on the statistical data, the author analyzes the foreign trade volume of Jiangxi province from 1978 to **2007**, and attains the general correlation coefficient ρ = 0.971906, so there is strict correlation between foreign trade volume and GDP.

However, how much has foreign trade volume stimulated GDP? Using general least square technique estimation to do further regression analysis, before which T test and F test are carried on.

Suppose Y stands for the total GDP, and XM stands for the total foreign trade volume. The result of the regression analysis is shown as the following:

The regression formula is,

$$Y = 658575.03 + 8.276XM$$

$$R^2 = 0.927 \quad F = 358.82 > F_{0.05} = 4.2$$

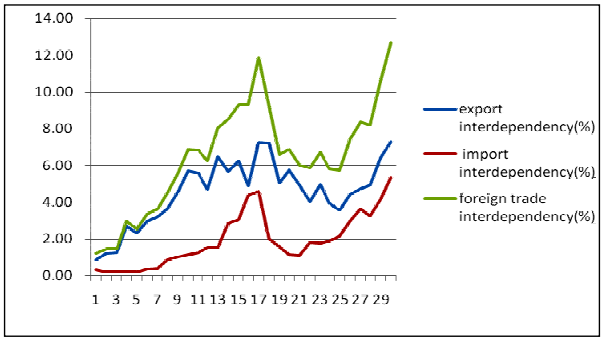

Figure 1. The trend of dependency of Jiangxi's GDP on foreign trade

The regression results show that: (1) there is strong positive correlation between Jiangxi province's foreign trade volume and GDP, and the fitting degree shown as **Figure 2**, in which the purple line represents the regression line and X represents total foreign trade, is very good, which means that the expansion of foreign trade can promote economic growth; (2) the regression coefficient of total GDP and foreign trade is 8.276, which means that every US $ 1 increase in foreign trade can increase US $ 8.276 in GDP, and the marginal outputs of foreign trade is quite high. It further verifies the importance of developing foreign trade.

3.2 Correlation between Export Volume and GDP

3.2.1 Ratio of Dependence on Export

The ratio of dependence on export refers to the degree that a country's national economy relies on export. That is the proportion of export in GDP, which can be attained in the formula:

Ratio of dependence on export = export/total GDP

Based on the statistical data, we have figured out the ratio of dependence on export increasing from 0.88% in 1978 to 7.30% in 2007 in Jiangxi province. It reached the peak in 2007 particularly. That' s to say, the degree that economic growth of Jiangxi province relies on the growth of foreign trade volume is overall increasing, especially during 1978 to 1994.

3.2.2 Correlated Coefficient and Regression Analysis

Suppose Y stands for the total GDP, and X stands for export. Using general least square technique estimation to do further regression analysis on the bases of the certain data, and the result is shown as the following:

The regression formula is,

$$Y = 495610.794 + 14.420X$$

$$R^2 = 0.930\ F = 374.495 > F_{0.05} = 4.2$$

The regression results show that: (1) there is strong positive correlation between Jiangxi province's export and GDP, and the fitting degree shown as **Figure 3**, in which the purple line represents the regression line and X represents export, is very good, which means that the expansion of export can promote economic growth; (2) the regression coefficient of total GDP and export is 14.42, which means that every US $ 1 increase in export can increase US $ 14.42 in GDP, and the marginal outputs of export is quite high. It proves the rationality of export-led economy.

3.3 Correlation between Import Volume and GDP

3.3.1 Ratio of Dependence on Import

Similar to the ratio of dependence on exports, the ratio of dependence on import refers to the degree that a country's national economy relies on import. That is the proportion of import in GDP, which can be attained in the formula:

Ratio of dependence on import = import/total GDP

Based on the statistical data, we have figured out the ratio of dependence on export in Jiangxi province increasing from 0.34% in 1978 to 5.37% in 2007. It reaches the peak in 2007 particularly. That' s to say, the degree that economic growth of Jiangxi province relies on the growth of foreign trade volume is still overall increasing , but import falls in some years due to certain reasons.

3.3.2 Correlated Coefficient and Regression Analysis

Suppose Y stands for the total GDP, and M stands for import. Using general least square technique estimation to do further regression analysis on the bases of the certain data, and the result is shown as the following:

The regression formula is,

$$Y = 899939.8024 + 18.98M$$

$$R^2 = 0.904F = 263.69 > F_{0.05} = 4.2$$

The regression results show that: (1) there is strong positive correlation between Jiangxi province's import and GDP, and the fitting degree shown as **Figure 4**, in which the purple line represents the regression line and X represents import, is very good; (2) The regression coefficient of total GDP and import is 18.89, which means

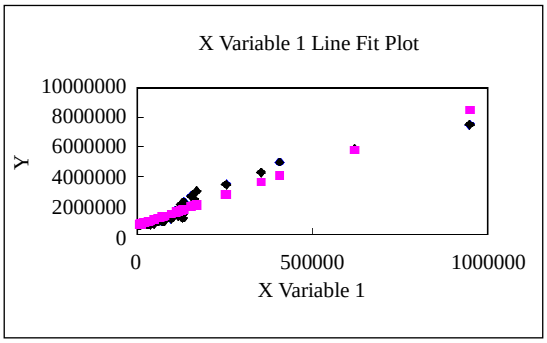

Figure 2. The fitting effect of GDP and foreign trade volume

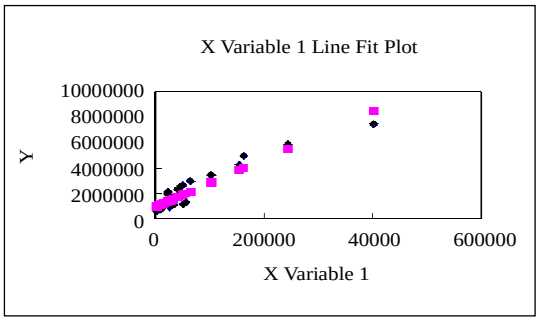

Figure 3. The fitting effect of GDP and export

that every US $ 1 increase in import can increase US $ 18.89 in GDP, and the marginal outputs of export is quite high. It shows that Jiangxi province is performing well in import and in order to achieve the objective of opening up, the import should be further encouraged.

3.4 Correlation between Net Export Volume and GDP

In order to study the final factor of foreign trade contributed to economy, the paper analyzes the net export too. According to Y = F (K, L, X – M), the net export obviously promote economy. The net export is represented by (X – M), Using general least square technique estimation to do further regression analysis, and the result is shown as the following:

The regression formula is,

$$Y = 53732.69 + 41.386\ (X - M)$$

$$R^2 = 0.7F = 65.039 > F_{0.05} = 4.2$$

The regression results show that: (1) there is strong positive correlation between Jiangxi province's net export volume and GDP, and the fitting degree shown as **Figure 5**, in which the purple line represents the regression line and X represents net export, is very good, which means that the expansion of net export can promote economic growth; (2) the regression coefficient of total GDP and net export is 41.386, which means that every US $ 1 increase in foreign trade can increase US $ 41.386 in GDP, and the marginal outputs of foreign trade is remarkable high. That's to say, Jiangxi could pursue trade surplus aimlessly. It can help to accumulate the capital and foreign exchange deposit so that to enhance higher speed of economic growth.

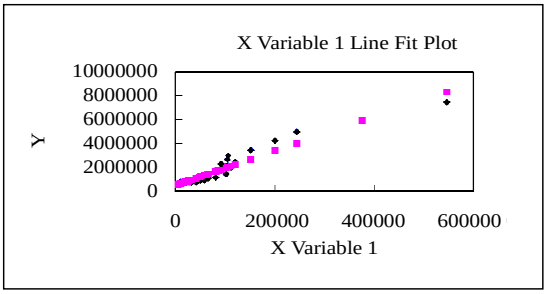

Figure 4. The Fitting Effect of GDP and Import

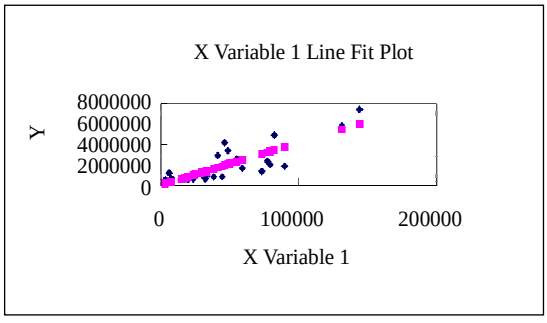

Figure 5. The fitting effect of GDP and net export

4. Conclusion and Discussion

1) The empirical study suggests that the total foreign trade volume, the import volume, the export volume and the net export volume all have strict correlation ship with Chinese Jiangxi Province's GDP. One should be paid more attention to is that the correlation between import and GDP is bigger than that between export and GDP. That is to say, import plays better than export in stimulating GDP growth. This result tells us that Jiangxi could not ignore the impact of import on stimulating economy while enhancing export, and the contribution of import to GDP growth at any time, or restrict the import to pursue foreign exchange deposit, and could not follow America to buy "CHINA" either.

2) With deepening the reform and opening-up, the rate of foreign trade dependence is becoming bigger increasingly; the correlation between GDP and export as well as import is enhanced year by year. Although the improvement of foreign trade in Jiangxi to GDP growth is less than that in some of eastern provinces, Jiangxi, as an inner province, without geography location advantage, its export-led economy still has a wonderful future as long as it can make the most of each kind of resources.

3) Keynes, a famous economist, ever said: "export is for better import". That is to say, export is to provide with better situation to support importing what we don't have or more efficient products. As an inner province, though Jiangxi can make the most of its resources and improve its employment rate, it could not restrict import while expanding export. Otherwise, it will slow down the speed of improving the living level of the people in Jiangxi. Simultaneously, it will be harm for the effective use of global resources and for the integration as well.

While, future research should be proceeded. As being known that linear regression is based on the hypothesis that the linear relationship between foreign trade and economic growth is true, but in fact, it may be not perfect to research the above issue. So we should adapt more advanced methods for researching the casualties between foreign trade and economic growth. Whether there exists long time or short term stable causalities could be further researched in the future.

5. Acknowledegments

This paper is assisted by the projects: Jiangxi provincial Co-operated Social Science Projects, A Study on the Development of Service Industry and Trade in Service in Jiangxi Province (Project ID: **09YJ249**) and A Research on the Evolution of the Spatial Economy in Jiangxi and Agglomeration of Industry (Project ID: **09YJ245**); A

Study on the Development of Logistics in Ji'an City Based on the Theory of Industry Cluster (Project ID: **JR0816**).

REFERENCES

[1] J. Li, "A Study on the Foreign Trade during Chinese Economy Growth," Ph. D. Dissertation, College of Economics, Jilin University, June 2006.

[2] China Statistic Bureau, "China Statistics Year Book," China Statistics Press, Beijing, 2008.

[3] X. P. Liu, "An Empirical Study on Chinese Import and Export and Economic Growth-Research the Improvement of Foreign Trade to Economic Growth from the Growth Rate," *Journal of Modern Economic Science*, Vol. 3, 2001, pp. 55-60.

[4] X. M. Wang, "The All-Side Analysis of New International Trade," People's University of China Press, Beijing, January 2000.

iBusiness, 2010, 2, 188-192
doi:10.4236/ib.2010.22023 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

Evaluation of Social Risk Using Structural Equation Model

Wei Shan[1], Hengwen Liu[2], Yichao Pan[2], Hengqing Tong[2]

[1]College of Science, Jinan University, Jinan, China; [2]Department of Mathematics, Wuhan University of Technology, Wuhan, China.
Email: tonghengqing@126.com

Received February 28th, 2010; revised April 3rd, 2010; accepted May 5th, 2010.

ABSTRACT

A quantitative method to evaluate social risk using structural equation model (*SEM*) *is developed. Evaluation of social risk is the essential step in early warning of social risk. On the basic of the society stability, a scientific and applicable index system of social risk is put forward, which includes* 6 *first-level indexes and* 40 *second-level indexes. Based on these indexes and relationships among them, a structural equation model is introduced, and an improved partial least square* (*PLS*) *algorithm by finding the best iterative initial value is proposed.*

Keywords: *Social Risk Evaluation, Structural Equation Models, Unit Vector Constraint*

1. Introduction

Nowadays, social conflict of different interest has become more and more intense, which consequently result in potential social risks. In 1986, Ulrich Beck the German prominent sociologist put forward the theory of risk society in his best works, Risk Society. Social risk refers to the uncertainty that endangers the social stabilities, equilibrium and development. Generally speaking, our social risk management gets along with economic mechanism very well, but because of the relationship and sequence between the reformation and social risk management, it's inevitable that social risk management policy often lags behind the reform. This kind of lagging makes social risk management unable to resolve the rough social problems in time. Therefore, it's necessary to appraise and supervise the social risk, to the effect that we can detect the incompatibility between the policies and the development of the society, and make necessary adjustment in time. Therefore, an evaluation system for social risk should be established in order to accurately predict and rapidly react in very early stage, with the purpose of minimizing social and economic losing.

Social risk evaluation is a broader concept for the ideas of the so-called social indicators movement which goes back to a classical work of Raymond A. Bauer, Social Indicators, from 1966 [1]. The Club of Rome raised considerable public attention in 1972 with its report The Limits to Growth, a brilliant publication which is influential still today. It predicted that economic growth could not continue indefinitely because of the limited availability of natural resources [2]. Prof. Linfei Song has begun the research on social risk early warning using the methods of social indicators since 1990s. And in 1995 he put forward the social risk synthesized index system (SRSS), which including 50 indexes. But the summarizing coefficients in this index system are designed aforehand. In 2004, Prof. Yaojun Yan built up the social stability early warning system, which includes 55 indexes containing the domain of political, economic, social natrural and international environment. There were greatly improved and development between the latter index system and the former in both the scientificalness and rationality [3,4].

At present, main systematic evaluation methods of social risk, which are in common use, includes Analytic Hierarchy Process (AHP), Systematic Grading Method and Fuzzy Systematic Grading Method and so on. There are always index systems in these evaluation methods, and these indexes need to be summarized. Traditionally the summarizing coefficients are designed aforehand, usually in the form of expert grading or questionnaire investigating. However, in this paper, we introduce a method in which the summarizing coefficients are calculated by samples, so it is more objective and convincing, and could offer more deep analysis for the index systems.

2. Measure the Social Stability by SEM

SEM is a rapid-developing embranchment of Application Statistics, which has a wide application in the area of Psychology and Sociology, especially in Customer Satisfaction Index (CSI) model which is required by a series

of ISO9000 criterions. This model not only studies the interior relationship among various factors, but also the relative and causal relations among latent variables.

There are always two systems of equations in a SEM. One is a structure system of equations among structural variables, and the other one is a measurement system of equations between structural variables and observed variables. It has been thought and said that establishing a scientific and rational evaluation index system can not only provide a credible gist for decision-making analysis of social risk, but also maintain our social stability and harmony. Therefore, it's important and urgent to quantitative analysis and build effective social risk index immediately. Now we build a SEM for evaluation of social risk. The model includes 6 structural variables and 40 observed variables. The variables are listed in **Table 1** as follows: Notice that the numbers of observed variables corresponding each structure variable are 6, 6, 8, 8, 5, 7.

Table 1. Index of variables

Structural variables	*Observed variables*		
Situation of external environment ξ_1	The influence degree by the world economic recession x_{11}	The influence degree by economic sanctions and economic frictions x_{12}	The effect degree by armed interventions and terrorist attacks x_{13}
	The quantity of people died in disasters x_{14}	the proportion of damage area caused by disasters x_{15}	Proportion of economic loss caused by disasters x_{16}
Economic power index η_1	Per capita GDP growth rate y_{11}	Per capita state revenue growth rate y_{12}	Growth rate of agriculture added value y_{13}
	Contributions rate of scientific and technological to the economic growth y_{14}	Urban residents per capita disposable income growth rate y_{15}	The consumer price index(CPI) y_{16}
Social security level η_2	Household annual savings ratio y_{21}	Society-wide general retail price index y_{22}	Engel's coefficient y_{23}
	Medical insurance coverage rate y_{24}	Urban unemployment rate y_{25}	Endowment insurance coverage rate y_{26}
	Unemployed insurance coverage rate y_{27}	Population proportion below security line for minimum subsistence y_{28}	
Capability of Social controlling η_3	the number of police officers for every 10,000 people y_{31}	Incidence rate of crime by taking advantage of duty of national public servants y_{32}	The incidence rate of major criminal cases y_{33}
	Activity level of Religious activities y_{34}	The incidence rate of major accidents y_{35}	The quantity of letters and visits from the people y_{36}
	Divorce rate y_{37}	The incidence rate of major economic cases y_{38}	
Distribution of social wealth η_4	per capita income ratio of the highest-income industries and the lowest-incomes industries y_{41}	the income ratio of the 10% of the highest-income earners with 10% of the lowest-income earners y_{42}	the gini coefficient ratio of rural residents and urban residents y_{43}
	gini coefficient y_{44}	Residents' disposable income ratio of urban and rural y_{45}	
Social psychology η_5	the confidence level of the social development prospect y_{51}	Satisfaction rate with the relations between cadres and the masses y_{52}	Satisfaction rate with the economic income y_{53}
	Gross National tolerance on the corruptions y_{54}	Tolerance on the inequity of the administration of justice y_{55}	National Tolerance on the income differentials y_{56}
	Gross National Happiness index (life satisfaction and subjective well-being index) y_{57}		

There exists 13 relationships among the 6 structural variables (latent variables), which are expressed in **Figure 1** below (The relationships among variables are $\gamma_1 \sim \gamma_5$, expressed with dashed arrowheads; The relationships among independent variables are β_{ij}, expressed with real-line arrowheads). The structural relationship among the latent variables (structural model) can be put as follows:

Among the structural variables there are some path relationships or causalities. These causalities among the structural variables can be expressed as equations as below.

$$\begin{pmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{pmatrix}=\begin{pmatrix}0 & 0 & 0 & 0 & 0\\ \beta_{21} & 0 & 0 & 0 & 0\\ 0 & \beta_{32} & 0 & 0 & 0\\ \beta_{41} & 0 & \beta_{43} & 0 & 0\\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 0\end{pmatrix}\begin{pmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{pmatrix}+\begin{pmatrix}\gamma_{11}\\ \gamma_{12}\\ \gamma_{13}\\ \gamma_{14}\\ \gamma_{15}\end{pmatrix}\xi_1+\begin{pmatrix}\varepsilon_{\eta 1}\\ \varepsilon_{\eta 2}\\ \varepsilon_{\eta 3}\\ \varepsilon_{\eta 4}\\ \varepsilon_{\eta 5}\end{pmatrix} \quad (1)$$

In general, suppose that $\eta_1 \sim \eta_m$ are m dependent variables, arranging them as a vector η by column as (1); and $\xi_1 \sim \xi_k$ are k independent variables, arranging them as a vector ξ by column also. Then B square matrix B is the coefficient matrix of η, then $m \times k$ matrix Γ is the coefficient matrix of ξ, ε_η is the residual vector, then SEM (1) may be extended as:

$$\eta = B\eta + \Gamma\xi + \varepsilon_\eta \quad (2)$$

The structural variables are implicit and cannot be observed directly. Each structural variable is corresponding with many observed variables.

Suppose that there are M observed variables and each one has N observed values, then we will get a $N \times M$ matrix. The relationships between the structural variables and the observed variables can also be expressed as follows:

$$\begin{pmatrix}x_{11}\\ x_{12}\\ \vdots\\ x_{111}\end{pmatrix}=\begin{pmatrix}\upsilon_{11}\\ \upsilon_{12}\\ \vdots\\ \upsilon_{111}\end{pmatrix}\xi_1+\begin{pmatrix}\varepsilon_{x11}\\ \varepsilon_{x12}\\ \vdots\\ \varepsilon_{x111}\end{pmatrix} \quad (3)$$

$$\begin{pmatrix}y_{i1}\\ \vdots\\ y_{iL(i)}\end{pmatrix}=\begin{pmatrix}\lambda_{i1}\\ \vdots\\ \lambda_{iL(i)}\end{pmatrix}\eta_i+\begin{pmatrix}\varepsilon_{yi1}\\ \vdots\\ \varepsilon_{yiL(i)}\end{pmatrix} \quad i=1,\ldots,4 \quad (4)$$

where x_{tj}, $j=1,\ldots,5$ (There are 5 observed variables in **Table 1**) are the observed variables corresponding to ξ_t, $t=1,\ldots,L(i)$ ($L(i)$ are respectively 6, 6, 8, 8, 5, 7, in **Table 1**) are the observed variables corresponding to η_i, $i=1,\ldots m$, υ_{1j}, λ_{ij} are load items. We call (2) (3) (4) a SEM for evaluating the social risk.

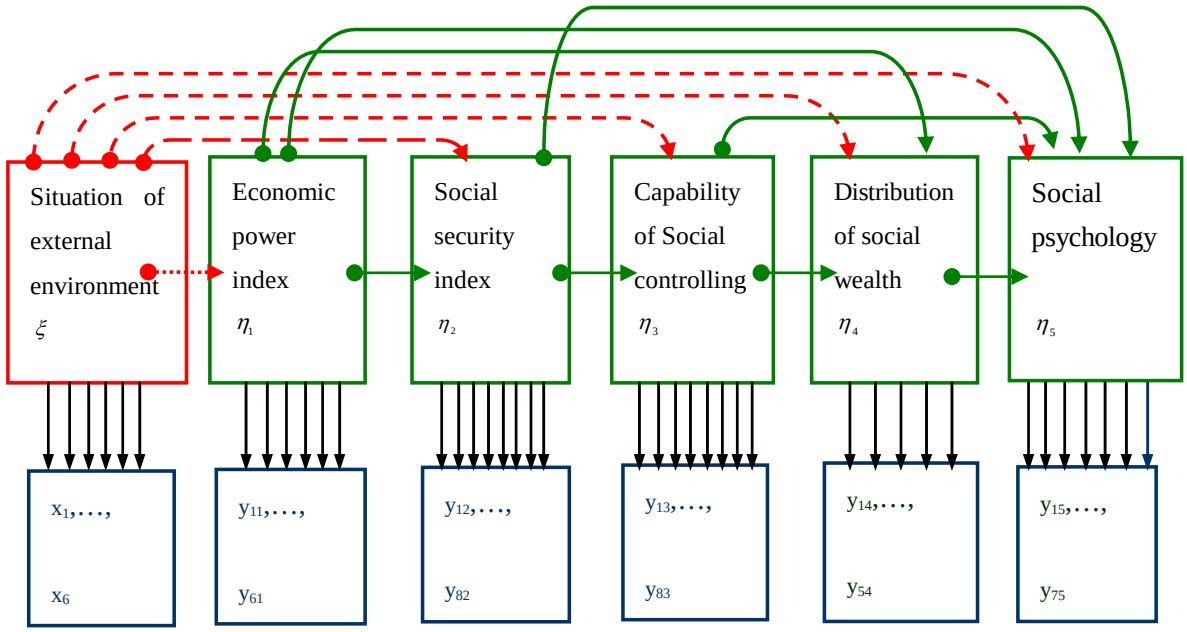

Figure 1. Social risk index model

3. The Best Initial Value in PLS Algorithm of SEM

At present, there exist two algorithms to solve SEM, one is Linear Structure Relationship (LISREL) which has a abundant theory system but lacks of practicability, the other one is PLS which is widely applied in many areas but its convergence can not be assured or its convergence rate is too slow, since its iterative initial value is given arbitrarily. However, we find that arbitrary initial value is not necessary and PLS can be calculated by a suitable iterative initial value based on the least square estimation in the observation equations.

Equation (4) can be written as:

$$Y_i = \eta_i \Lambda_i + \delta \tag{5}$$

And $Y_i{}'Y_i \approx \Lambda_i{}'\eta_i{}'\eta_i\Lambda_i = \eta_i{}'\eta\Lambda_i{}'\Lambda_i$, it we set structural variables as unit vectors, namely $\eta_i{}'\eta_i = 1$, then:

$$Y_i{}'Y_i \approx \Lambda_i'\Lambda_i \tag{6}$$

Which is an approximate equality between two $L(i)\times L(i)$ matrixes under the meaning of least square and its detail form is:

$$\begin{pmatrix} y_{i1}y_{i1}' & y_{i1}y_{i2}' & \cdots & y_{i1}y_{iL(i)}' \\ y_{i2}y_{i1}' & y_{i2}y_{i2}' & \cdots & y_{i2}y_{iL(i)}' \\ \cdots & \cdots & \cdots & \cdots \\ y_{iL(i)}y_{i1}' & y_{iL(i)}y_{i2}' & \cdots & y_{iL(i)}y_{iL(i)}' \end{pmatrix} \approx \begin{pmatrix} \lambda_{i1}^2 & \lambda_{i1}\lambda_{i2} & \cdots & \lambda_{i1}\lambda_{iL(i)} \\ \lambda_{i2}\lambda_{i1} & \lambda_{i2}^2 & \cdots & \lambda_{i2}\lambda_{iL(i)} \\ \cdots & \cdots & \cdots & \cdots \\ \lambda_{iL(i)}\lambda_{i1} & \lambda_{iL(i)}\lambda_{i2} & \cdots & \lambda_{iL(i)}^2 \end{pmatrix} \tag{7}$$

Be attention each element in the left is the product of two vectors, while element in the right is the product of two numbers. Next set diagonal elements in the two sides equal, then:

$$\lambda_{ki}^2 = y_{ki}'y_{ki}, \quad k = 1,\cdots, j \tag{8}$$

We can do it for variable ξ with the same method. In this way we get the initial value of coefficients between observed variables and structural variables under the meaning of least square, namely the estimation value $\hat{\lambda}_i = (\hat{\lambda}_{i1},\cdots,\hat{\lambda}_{iL(i)})'$ of matrix Λ_i.

Next we will estimate structural variable η_i. Suppose $\eta_i = (\eta_{i1},\eta_{i2},\cdots,\eta_{iN})'$, then the vector form of (13) is

$$\begin{pmatrix} y_{i1s} \\ \vdots \\ y_{iL(i)s} \end{pmatrix} \approx \begin{pmatrix} \lambda_{i1} \\ \vdots \\ \lambda_{iL(i)} \end{pmatrix} \eta_{is}, \quad s = 1,\cdots, N \tag{9}$$

where vector $Y_s = (y_{i1s},\cdots,y_{iL(i)s})'$ is the transversal vector of matrix y_i. Let vector $\hat{\lambda}_i$ multiple two sides of (9), we get the least square estimation of η_{is}

$$\begin{aligned} \lambda_i'\lambda_i\eta_{is} &= \sum_{k=1}^{L(i)} \lambda_{ik}^2\eta_{is} \\ &= (\lambda_{i1},\cdots,\lambda_{is}) \begin{pmatrix} y_{i1s} \\ \vdots \\ y_{iL(i)s} \end{pmatrix} = \lambda_i' Y_s \end{aligned} \tag{10}$$

$$\hat{\eta}_{is} = \frac{\hat{\lambda}_i' Y_s}{\hat{\lambda}_i\hat{\lambda}_i'}, \quad s = 1,\cdots, N \tag{11}$$

where $\hat{\lambda}_i$ has been estimated before. We can also get estimate υ_{tj} and ξ_t in the same way. Then we get all estimation values of structural variables, they satisfy

$$\| \eta_i - \sum_{j=1}^{L(i)} \omega_{ij} y_{ij} \| \to \min \tag{12}$$

Its geometrical meaning is to seek the distance between a unit sphere and a hyper-plane and its solution is unique under the condition that it is not linearly dependent among vectors y_{ij}.

After getting the least square solution $\hat{\xi}_t, \hat{\eta}_i$ of the structural system of equations, we can easily gain the solution of (2) with two-phase least square method. In other words, it dose not need to iterate since we get the least square solution $\hat{\xi}_t, \hat{\eta}_i$ of the observed equation system based on unit vector constraint and the solution satisfy the two systems of equations of SEM.

4. Final Remarks

In this paper, we propose structural equation model to measure social risk. It is more objective and scientific to use SEM in the evaluation of social risk compared with traditional methods, such as AHP, Fuzzy Systematic Grading Method and so on, because the summarizing coefficients of this evaluation system are calculated by samples rather than designed aforehand. Therefore, we can have a better understanding the relationships among the indexes, which will do a great favor to decision-making analysis of the social stability.

5. Acknowledgements

We thank the anonymous reviewers for their constructive remarks and comments. The project was supported by the National Natural Science Foundation of China (30570611, 60773210).

REFERENCES

[1] R. A. Bauer, Social Indicators, MIT. Press, October 1967.

[2] D. H. Meadows, D. L. Meadows, J. Randers and W. W. Behrens, "The Limits to Growth," Universe Books, New York, 1974.

[3] L. F. Song, "Social Risk Index System and Social Fluctuation," *Sociological Studies*, 1995.

[4] Y. J. Yan, "A Study on the Measurement of Social Stability and Construction of the Presentiment Management System," *Sociological Studies*, 2004.

[5] H. Q. Tong, Data Analysis and Statistical Computation (DASC), Electronic Publication, Science Press of China, Beijing, 2005.

[6] C. M. Wang and H. Q. Tong, "Best Iterative Initial Values for PLS in a CSI Model," *Mathematical and Computer Modeling*, Vol. 46, No. 3-4, 2007. pp. 439-444.

iBusiness, 2010, 2, 193-200
doi:10.4236/ib.2010.22024 Published Online June 2010 (http://www.SciRP.org/journal/ib)

Scientific Research

The Impact of Financial Crisis on B2C *e*-Commerce

Fateme Ghadami, Abdollah Aghaie, Morteza Mohammadkhan

IT Group-Faculty of Industrial Engineering, K. N. Toosi University of Technology, Tehran, Iran.
Email: Fateme.ghadami@gmail.com, aaghaie@kntu.ac.ir, m.m.khan@kntu.ac.ir

Received October 13th, 2009; revised February 1st, 2010; accepted March 6th, 2010.

ABSTRACT

Many experts believe that the global financial crisis in 2008 *is the worst of its kind since the Great Depression in* 1929. *The crisis was started from housing market in the US and spread quickly into financial markets. It has had a ripple effect around the world and many other industrialized economies were troubled by its consequences and almost every industry has been influenced by its outcomes. Online retail* (*or B2C e-Commerce*) *as a part of retail industry was not immune from the financial crisis and its sales has a dramatic decline. In this paper it is found that* 3 *factors are main players which have impacted on online retail sales including: less credit available; increasing saving rate and decreasing consumption expenditures and falling consumer confidence and sentiment. Also by representing several figures and tables, factors affecting this trend such as age class, income and gender are discussed.*

***Keywords*:** *Financial Crisis, Online Retail, B2C e-Commerce*

1. Introduction

The year of 2008 was not a good year for economy. In this year many countries were troubling by financial crisis. Many experts believe the crisis was started from housing market in the US and then was spread into financial markets. Through this way many banks and financial firms around the globe were affected by consequences of the crisis.

The housing bubble in the United States grew up alongside the stock bubble in the mid-90s. Increasing in stock prices made unexpected wealth for people and they started to spend this extra money. This led to the consumption boom of the late 90s, with saving rate out of disposable income falling from close to 5% in the middle of the decade to just over 2% by 2000 [1]. This extra money encourages people to buy better and bigger homes. So it results in exceeding demand than supply because in the short-run the supply of housing is relatively fixed. This increase in demand triggered housing bubble and it led to an increase in price. Therefore the house price grew from 1992 to 2005 and it peaked in 2006. After that by bursting the housing bubble, prices started to decline.

The signs of financial crisis appear by housing bubble burst and drastic decline in house prices which were started in 2007, and eventually with the failure, merger or conservatorship of several large United State-based financial firms it became prominently visible in September 2008. The crisis had a ripple effect around the world and many other industrialized economies were troubled by its consequences. It caused a deep recession and many believe the crisis is the worst of its kind since the Great Depression in 1929.

Outcomes of the crisis are not just limited to financial and housing markets. Its consequences have spread around the world and affected almost all aspects of people's lives. For example it has several significant socio-economic impacts such as:

Increasing unemployment rate: By incidence the financial crisis, companies tried to reduce their expenses so as a solution they cut the number of their employees. Therefore the crisis resulted in increasing in unemployment rate.

Inflation or deflation: The crisis has had both inflationary and deflationary effects in the world. It causes people have less credit to finance their purchases so by diminishing trades and decrease in demand, prices come down. This situation is named deflation. On the other hand to repel the crisis some governments injects money into society. Sometimes this decision has inflationary results as it caused increasing inflation rate in some countries [2].

Moreover, the financial crisis has influenced major industries such as auto manufacturers, health insurance, tourism and etc. Another major industry which is influenced by the financial crisis is retail industry. Retail in-

dustry composed of 2 main sections: offline or traditional retail and online retail (business to consumer or simply B2C). In another point of view online retail is a kind of e-Commerce which can be categorized under the IT industry. This paper is trying to investigate how the global financial crisis in 2008 has affected online retail.

2. Background

Since the global financial crisis is a recent event, there is no particular academic research about its probable effects on e-Commerce, specially B2C e-Commerce or online retail. There are just a few news websites or market research websites which have performed researches related to this topic. For example NYTIMES.com and Forrester Research Inc. are two main websites which had some information about the impact of financial crisis on e-Commerce. According to [3] it was predicted the financial crisis would not have any visible impact on technology sector. It was expected jus Internet advertisement companies that got much of their business from mortgage brokers and some software companies which sell their product to financial services companies would face trouble. But after a while on October 2008 Wall Street Journal notified that the technology industry which had seemed immune to the financial crisis, was squeezed because of slackening demand and cutting costs to prepare for a prolonged downturn [4]. Companies like Intel in hardware sector and SAP in software sector have faced such problems. Also, to reduce costs some other giant companies like Google, Yahoo and eBay have cut down the number of their employees. Altogether, it can be said the technology sector like other industries is affected by the consequences of the financial crisis. Actually the crisis has affected customer behavior in many ways. It has changed customers' buying priority.

3. Statistics and Analysis

Occurrence of financial crisis has a significant impact on the US economy. Increasing unemployment rate and lack of a strong financial resource for household have caused their buying power has diminished and people are forced to have a fundamental revision on their shopping way.

By comparing statistics from [5-10], it can be clearly seen that online retail is affected by the crisis (**Table 1**).

In the first quarter of 2008 and before appearing crisis signs, online retail sales was about $ 32.4 billion, a growth of 13.4% respect to the same period time last year. 16.9% decline in online retail sales in the first quarter of 2008 respect to prior quarter was because of increasing sales in the holiday season as there is in the 4th quarter of 2008 and 1st quarter of 2009. In the 2 next quarters it has 8.9% and 4.6% growth respect to same period in the last year, a decreasing growth. Totally can be seen in 2008 online retail has a decreasing growth and in 2009 it reached to an increasing negative growth. These statistics show how the financial crisis has affected online retail industry. It has caused a decline in overall growth rate for the industry. There could be supposed several reasons for the decline:

Online buyers have less available credit to finance their purchases [11]. A consequence of financial crisis is Credit Crisis. A credit crisis is a reduction in the general availability of loans or a sudden tightening of the conditions required to obtain a loan from the banks [12]. So consumers are no longer to take equity out of their homes to fund spending. Moreover less credit available causes fewer credit cards issues. One important feature which attract consumer to buy online is convenient use of credit cards. Credit crisis has an effect on online buyers spending through credit cards.

Economic conditions have forced people to save more than past [11]. According to [13] in the past 4 quarters consumption expenditures had negative growth, in third and fourth quarters of 2008 it had 4.7% and 5% decline respectively and in the first and second quarters of 2009 with smoother decline it had 1.5% and 1.3% negative growth respectively. Moreover saving rate has had a significant growth rate in the same period (**Table 2**). It reached from 2.2% in third quarter of 2008 to 5% in second quarter of 2009.

Reduced consumption expenditures means decline in spending by customer and increasing saving rate also implies further decline. In these economic conditions people try to do something which makes them feel more confident. With less job security and increasing unemployment rate they try to reserve a safe financial source for hard times. This situation can be translated into difficult times for retail industry. In a recession period online buyers look for retailers who discount their products and

Table 1. Retail and online retail sales 2008 – 2009 [5-10]

	Online Retail Sales	Percent Change From Prior Quarter	Online retail sales Percent Change From Same Quarter a Year Ago	retail sales Percent Change From Same Quarter a Year Ago	Online retail as a Percent of Total
1st Q 2008	$ 32.4 billion	–16.9%	13.4%	3.7%	3.4%
2nd Q 2008	$ 32.5 billion	0.5%	8.9%	2.3%	3.1%
3rd Q 2008	$ 31.6 billion	–2.8%	4.6%	0.9%	3.1%
4th Q 2008	$ 37.1 billion	17.3%	–5.5%	–8.6%	3.8%
1st Q 2009	$ 30.2 billion	–17.7%	–5.7%	–11.6%	3.6%
2nd Q 2009	$ 30.8 billion	2.1%	–4.5%	–10.6%	3.3%

Table 2. Consumption expenditures and saving rate 2008 – 2009 [13]

Quarter / Case	Percent Change From Prior Quarter					
	1st Q 2008	2nd Q 2008	3rd Q 2008	4th Q 2008	1st Q 2009	2nd Q 2009
Consumption Expenditures	3.7%	3.9%	−4.7%	−5.0%	−1.5%	−1.3%
Saving Rate	1.2%	3.4%	2.2%	3.8%	3.7%	5.0%

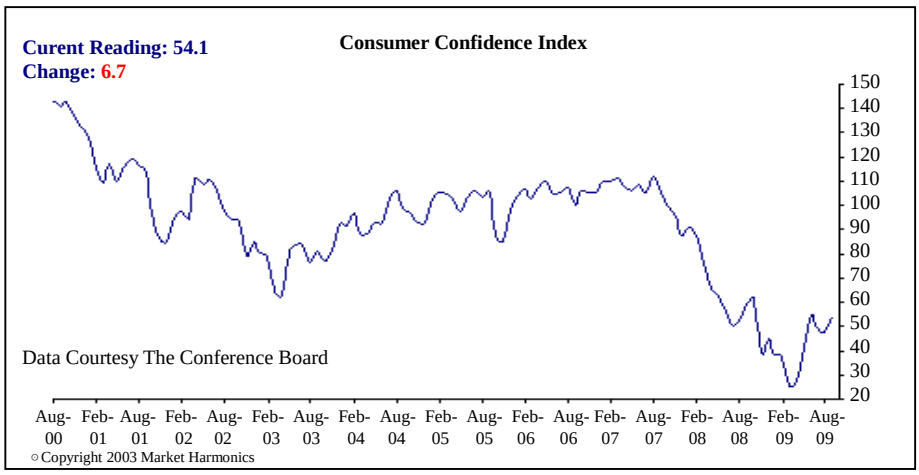

Figure 1. Consumer confidence index (CCI) 2000 – 2009

services. Those retailers who sell luxury brands and specialty products will damage more than others.

Other effecting factors are CCI and CSI indices. These factors measure consumers' attitude toward economy and their own financial conditions and are indicators designed to measure consumer confidence, which is defined as the degree of optimism on the state of the economy that consumers are expressing through their activities of saving and spending [12] Based on **Figure 1** CCI has sharply declined through August 2007 to February 2009. It means people became more pessimists about the economy. Also CSI which is represented by Reuters/University of Michigan Surveys of consumers has a similar trend. According to the August report Consumers increasingly expect the economy to improve in the months ahead even as they report the worst assessments of their personal finances since the surveys began in 1946. Although the economic recovery is likely to have already started, consumers' spending will remain in low gear for an extended period of time. Director of the survey has said the growth of total personal consumption expenditures at just 1.6% during 2010. The Index of Consumer Sentiment was 65.7 in the August 2009 survey, just below the 66.0 in July and the 67.5 in last year's August survey. The key August change was in the job situation. Consumers believed the unemployment rate was nearing its cyclical peak, although most thought it would still increase to just above 10% [14].

4. Traditional Retail vs. Online Retail

Aforementioned reasons have caused online retail sales to decline, though by referring to **Table 1** and comparing total retail and online retail, it can be inferred that traditional retail had a bigger reduction in sales than online retail. Several reasons could be supposed for this situation:

Online retail has attractive inherent features which are inherited from electronic commerce. Online consumers could easily buy everything they need ay any times in any where they have connection to Internet. So availability is an appealing characteristic of online retail (**Figure 2**).

Online shopping seems a less expensive way of buying. Searching products online make online buyers avoid impulse buying. Moreover they could use free shipping offers so it save money even more. Also usually there are many discount and bonus which are offered by retailer websites. Moreover pure online retailers don't have costs such as store maintenance, tax and etc so they could provide cheaper products or services. Also by shopping online, customers don't pay for fuel or transportation expenses.

Online buyers are typically wealthier and less affected by the economy. Online buyers with household incomes of $ 75,000 or more, represent the largest group of the online buying population [11]. So recession does not affect this group severely and they won't change their shopping habits intensely.

Disproportionate online spending by men will support online sales. The male/female spending split is almost equal online; this contrasts with offline, where women are commonly held to account for roughly 70% of purchases. The percentage of males who will shop less overall is 18 percentage points lower than the percentage of females who will adopt the same attitude as a result of the current state of the US economy [11].

Internet provides a comprehensive set of information related to a particular product or service. This facility attracts more people to shop online. They could conveniently use search engines to acquire information they need. Since online buying has no switching cost, online customer could freely use search engine to find what they want. Internet helps online buyers feel more confident that they are buying the right product to meet their needs.

Online shopping offers consumer and expert opinions [11]. Product reviews are one of the features that clearly distinguish the online experience from the offline one. This type of content offers an extra boost of confidence and will continue to attract consumers.

5. Studying New Trends among Online Buyers after Financial Crisis

Financial crisis of 2008 has changed online buyers' shopping habits. Actually they are trying to adapt themselves to new conditions. This adaptation has caused some new special trends among buyers and consequently online buyers.

New economic conditions have forced online buyers to cut back considerably on their online purchases. Many online consumers scaled down in holiday season of 2008. Holiday season usually is a good time for online retail industry but according to the results of surveys 70.8 percent of online consumers have said they are planning to spend less money holiday 2008 compared to past holiday seasons [15]. The online Holiday Spending Survey was conducted during the height of the worst economic crisis in decades which has had a significant impact on consumer confidence—a key driver in the consumer spending equation (**Figure 3**).

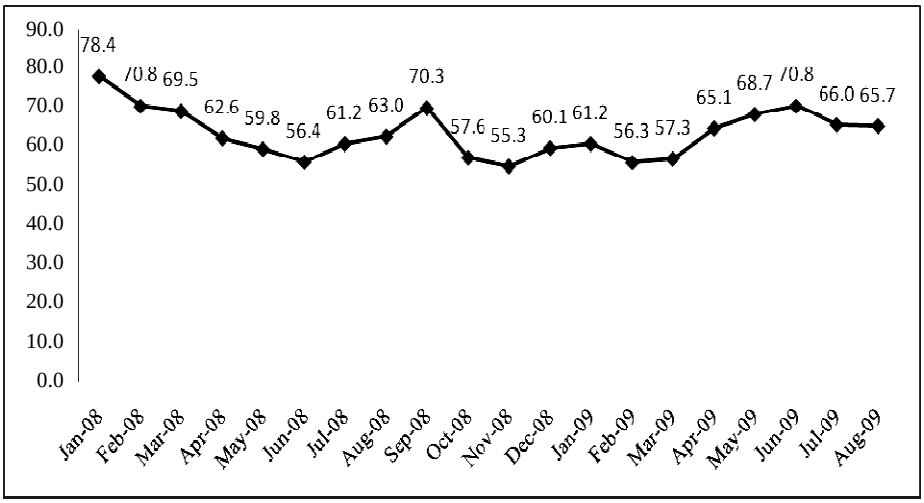

Figure 2. Consumer sentiment index (CSI) 2008 – 2009

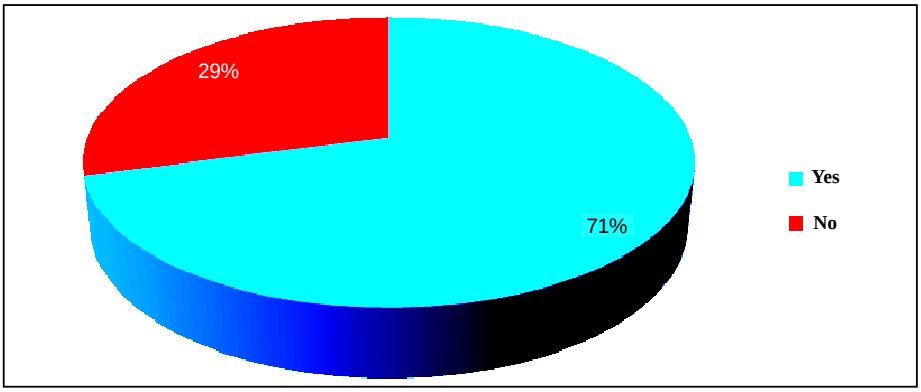

Figure 3. Are you planning to spend less money this holiday season than in past holiday seasons [15]?

The factors that directly affect 70.8 percent of online consumer's decisions to spend less 2008 holiday season are: increasing prices of necessities (39.5%), lack of confidence in the economy (30.6%), less money coming in overall (14.1%), and decreasing home values and other savings (**Figure 4**) [15].

Other significant contributing factors found in this survey (unemployment, lack of annual bonus, and credit line reduction) are closely tied to the effect the economy has on consumer's discretionary income.

When it comes to researching and purchasing 2008 holiday season, online shopping resources are gaining ground on the traditional offline approach. 96.5 percent of shoppers expected to do some purchasing online in 2008 holiday season. Survey results from the October 2007 Holiday Trends Survey compared to the recent Holiday Spending Survey highlights that online consumers expected to purchase more online than last year. This holiday season, 55 percent of survey respondents expected to purchase more than half of their holiday gifts online, while only 45 percent had expected to purchase online last holiday season—an increase of 10 percentage points over a one year period (**Figure 5**) [15].

Holiday season of 2008 it was all about researching the lowest price and finding the best value. Convenience is secondary for most consumers. Online shoppers find shopping and purchasing online appealing because it is easier to compare and find the lowest price (37.4%), it provides the convenience of shopping at anytime and from anywhere (24.1%), it offers free shipping and return policies (23.9%) and it provides online shopper to avoid stressful crowds and parking (14.6%) (**Table 3**) [15].

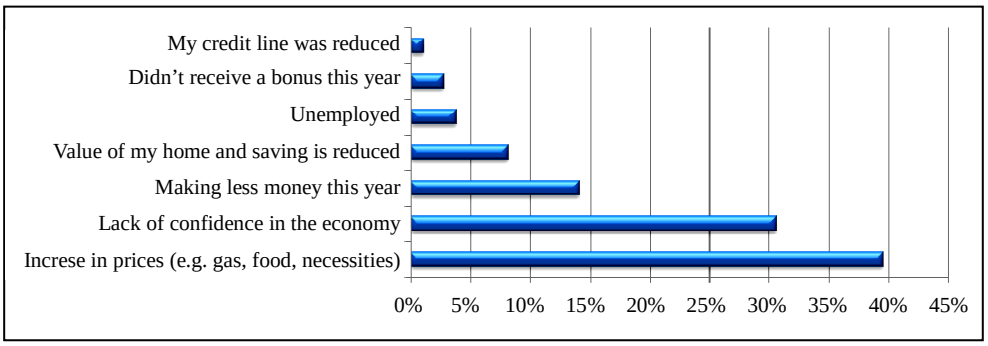

Figure 4. Why have you decided to spend less money holiday season of 2008? [15]

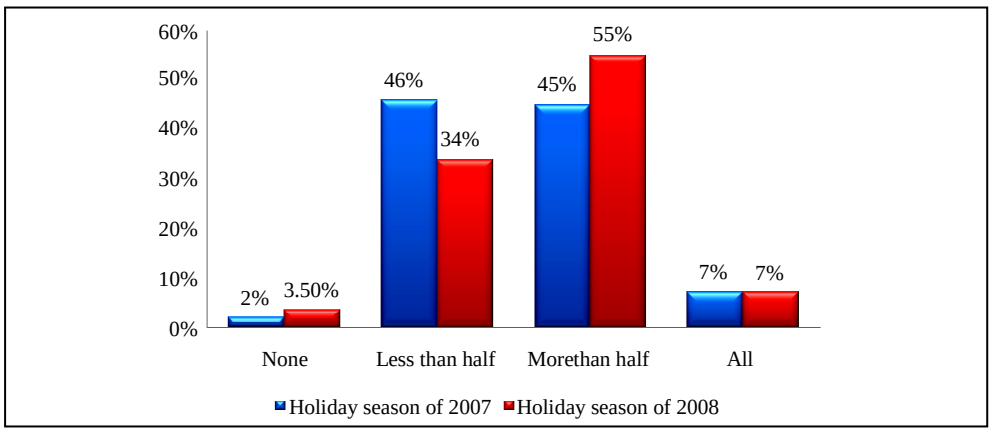

Figure 5. How much of your holiday purchasing do you expect to do ONLINE? [15]

Table 3. Which appeals to you most about shopping and purchasing ONLINE holiday season of 2008? [15]

Rank	Reason	Percent
1	Easier to compare and find the lowest price	37.4
2	Convenience of shopping anytime/anywhere	24.1
3	Free shipping offers and return policies	23.9
4	Avoid stressful crowds and parking	14.6

Savvy online consumers have used a variety of techniques to save money in 2008 holiday season. The primary technique which 53.1 percent of online shoppers used this holiday season to save money was sticking to a budget to control impulse buying. Survey findings show that consumers were taking the time to research and find deals by shopping at discount or outlet stores (43.1%), using shopping comparison Web sites (37.6%), and only purchasing sale items (34.6%) (**Table 4**) [15].

Online consumers struggling in a weak economy continue to use the Internet to shop. 91 percent of online shopper use Internet because researching products online makes them feels more confident about their purchases. Same percent of online buyers announce that comparing prices online reassures them that they are getting the best deal. Seventy-five percent of online consumers looked to purchase from merchants that do not charge sales tax or offer free-shipping.54 percent of online buyer said they search for coupons and discounts online even if they plan to shop offline. Another 37 percent of online consumers used the Internet to purchase products because it helped them avoid impulse purchases (**Figure 6**) [16].

Women 'spend less' consistently more than men 'spend less'. Interestingly, a higher percentage of women reported that they made an effort to spend less on dining out (74%), entertainment (72%), and purchasing online (55%) or purchasing in-store (69%) as compared to men. Overall, the majority of consumers have spent less on eating out at restaurants (69%), engaging in entertainment outside the home (67%), purchasing consumer goods and services online (47%) and in-store (63%) in response to the tough economic times (**Figure 7**) [17].

Table 4. Which money saving techniques will you use in the next few months to save money on holiday shopping? [15]

Method	Percent
Stick to a budget to control impulse buying	53.1
Shop at discount or outlet stores	43.1
Use shopping comparison web sites	37.6
Only purchase sale items	34.6
Use a low interest credit card and/or cash	15.5
Not giving gifts to people who received them last year (e.g. co-workers, service attendants)	10.1
Make items (*i.e.* crafts)	9.5

Figure 6. How much do you agree with the following statements about your spending behavior in this tough economy? [16]

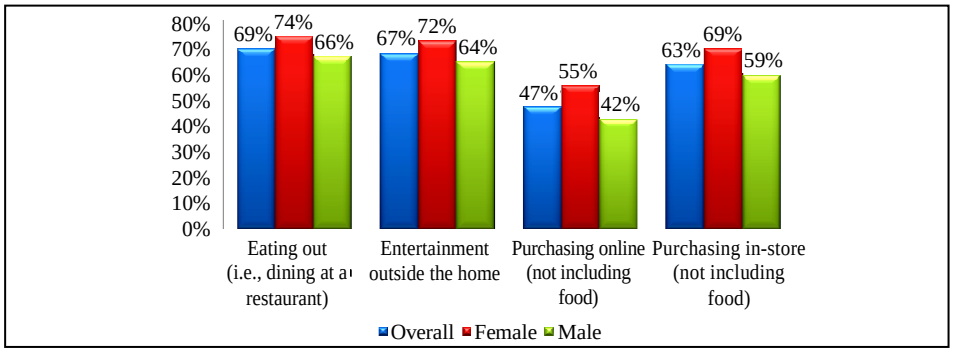

Figure 7. In the past 3 months, how has the current state of the U.S. economy impacted your money-spending on the folloing: "I spent less" [17]

Another factor which affects online buyers' behaviors is their age class. According to the surveys people between 29 and 42 are most likely to delay making nonessential retail purchases in Q4 to conserve finances. These people were also the most likely to agree that they had tried to control fixed monthly costs such as utilities and that they had trimmed back on vacation plans. On the other hand older buyers—people older than 42—were more optimist and they expected the economy to get better in 2009. And when asked about specific changes they had made in spending in the Q4, they indicated that they took a practical approach to watching their budget: They were more likely to cut back on fixed monthly costs and conserve gas but were less likely to postpone travel [18].

Consumer spending varies within different income segments. Online buyers are wealthier and less affected by the economy. Online buyers with household incomes of $ 75,000 or more represent the largest group of the online buying population. They make up more than 40% of all online buyers—almost twice the number of those with household incomes of $ 50,000 to $ 75,000. They are also less affected by the economy than the average consumer. This group makes an average of 10 purchases per year, which is two more than the average online buyer. Survey findings demonstrate that 37.7 percent of consumers making more than $ 100,000 say they do not plan to spend less this holiday season. Of these consumers, 38.9% indicated "I don't feel the effects of the economy." Whereas 22.4 percent of consumers making less than $ 50,000 say they do not plan to spend less this holiday season compared to past holiday seasons (**Figure 8**) [11].

5. Analysis

According to the statistics described above, it is obviously seen that online retail has encountered a big challenge during 2008 and still is straining to conquest it. Recession, increasing unemployment rate and reduced consumers confidence are factors that play roles in growing the challenge. Although e-commerce has attractive features but it was not immune from the crisis. As can be seen in **Table 1** like other industries, retail industry has been faced problem and its sales declined dramatically. In spite of these problems people still have preferred online retail and it has a greater portion of their shopping as compared with past year. There could suppose several reasons for this trend. Online shopping seems as a less expensive way to purchase things, it's more convenient, it makes people feel more confident about the product and its price and by using online shopping people avoid impulse buying. These factors altogether cause people can save more money in these difficult times.

One factor which affect saving trend is gender. According to the statistics women have had more serious reactions to financial crisis relative to men. They have decided to reduce their spending on different activities such as dining out, entertainment, online shopping and etc. On the other hand fewer men have made similar decisions. It can be inferred women are more cautious about events like economic turmoil.

Another factor affecting online consumer behavior and their saving trend is their age class. Each age class has its own preferential activities and try to cat back on other doings. Younger online shoppers try to delay making non essential retail purchases, control fixed monthly costs such as utilities and trimmed back on vacation plans. On the other hand older online shoppers try to cut down on the fuel consumption of their car and purchasing non essential retail items but they haven't decided to postpone their travels.

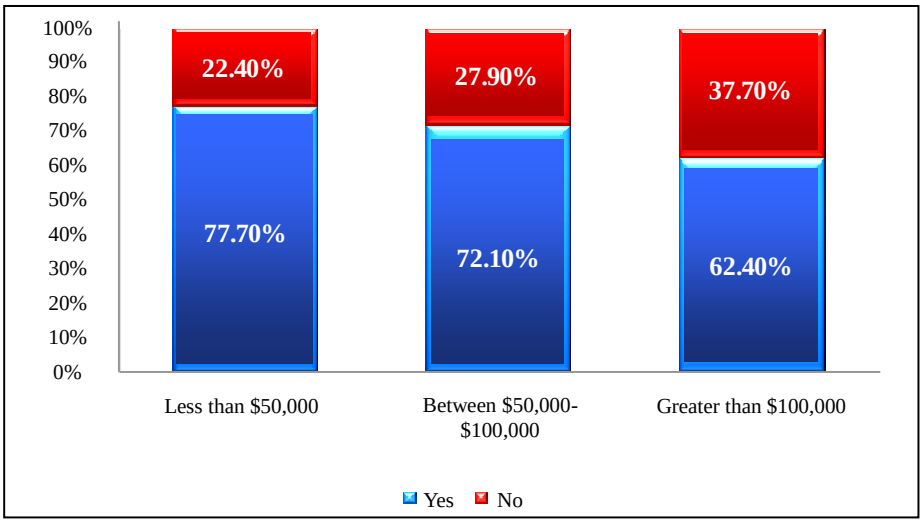

Figure 8. Are you planning to spend less money holiday season of 2008 than in past holiday season? [15]

Finally the last factor which influences online buyers' behavior is income. It is obvious that more income results in more spending so those people, who have had high income, have been affected less the others by the crisis. On the other hand most of online buyers are wealthier than other buyers and so it's reasonable for them not to spend less. As can be seen in **Figure 8** higher percentage of those people, who have less income, have decided to spend less.

6. Conclusions

According to the results of data analysis presented in the paper, financial crisis has impacted online retail industry in a negative way. Three factors play roles in this way: 1) lack of credit, 2) increasing saving rate, decreasing consumption rate and 3) decreasing CCI and CSI indices. It has caused online retail sales to decline but as have been seen its impact on the online retail sales is more moderate than offline retail sales. As described above e-commerce have inherent features which have resulted in attracting consumer to buy online in these difficult times. Moreover the crisis caused online buyers changed their buying habits. Several factors have affected this trend such as income, age class and gender. Online retailer should consider these affecting factors and use a proper marketing method for each group to make profit.

REFERENCES

[1] D. Baker, "The Housing Bubble and the Financial Crisis," *Journal of Real-World Economics Review*, 2008.

[2] CNBC.com, "Financial Crisis Has Inflationary and Deflationary Potential," Consumer News and Business Channel, 2008, www.cnbc.com

[3] C. Miller, "Silicon Valley Barely Touched by Financial Crisis—So Far," 2008, http//:www.nytimes.com

[4] P. Tam, B. Worthen and R. Guth, "Silicon Valley Finds it isn't Immune from Credit Crisis," *The Wall Street Journal*, 2008, http://online.wsj.com

[5] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 1st Quarter 2008," US Census Bureau News, May 2008.

[6] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 2nd Quarter 2008," US Census Bureau News, Aug 2008.

[7] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 3rd Quarter 2008," US Census Bureau News, Nov 2008.

[8] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 4th Quarter 2008," US Census Bureau News, Feb 2009.

[9] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 1st Quarter 2009," US Census Bureau News, May 2009.

[10] E-Commerce statistics, "Quarterly Retail e-Commerce Sales 2nd Quarter 2009," US Census Bureau News, Aug 2009.

[11] P. Evans, V. Sehgal, C. Bugnaru and B. McGowan, "US Online Retail Forecast, 2008 to 2013," Forrester Inc, March 2009.

[12] www.wikipedia.org

[13] BEA's Overview of the Economy. http//:www.bea.gov/ newsrelease/xls/glance.xls

[14] R. Curtin, "Economy Set to Improve, but Finances Expected to Remain Weak," University of Michigan & Reuters, Aug 2009.

[15] PriceGrabber Inc, "Holiday Online Shopping Forecast 2008," PriceGrabber Inc., Los Angeles, 2008.

[16] S. Rodriguez, "Economic Climate Shifts Consumers Online," PriceGrabber Inc., Los Angeles, March 2009.

[17] PriceGrabber Inc, "Economic Trends in Consumer Spending," PriceGrabber Inc., Los Angeles, June 2009.

[18] A. J. Rousseau, "Consumers' Recession Reactions Vary by Generation," Forrester Inc., Los Angeles, Dec 2008.

Call for Papers

iBusiness

ISSN 2150-4075 (Print) ISSN 2150-4083 (Online)
http://www.scirp.org/journal/ib

iBusiness(iB) is an international refereed journal dedicated to the latest advancement of internet and Business. The goal of this journal is to keep a record of the state-of-the-art research and promote the research work in these fast moving areas.

Subject Coverage

This journal invites original research and review papers that address the following issues in business and information. Topics of interest include, but are not limited to:

- Data Mining
- Decision Making Process
- E-Commerce
- E-Government
- Financial Analysis
- Geographic Information System
- Information Management
- Information Security
- Investment Analysis
- Knowledge Management
- Process Improvement
- Requirement Analysis
- Risk Management
- Supply Chain Management
- System Analysis
- Technology Innovation

We are also interested in short papers (letters) that clearly address a specific problem, and short survey or position papers that sketch the results or problems on a specific topic. Authors of selected short papers would be invited to write a regular paper on the same topic for future issues of the ***iB***.

Notes for Intending Authors

Submitted papers should not have been previously published nor be currently under consideration for publication elsewhere. Paper submission will be handled electronically through the website. All papers are refereed through a peer review process. For more details about the submissions, please access the website.

Website and E-Mail

http://www.scirp.org/journal/ib **E-mail: ib@scirp.org**

iBusiness, **2010, 2, 99-200**
Published Online June 2010 in SciRes (http://www.SciRP.org/journal/ib/).

TABLE OF CONTENTS

Volume 2 Number 2 **June 2010**

