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Winter 2011
Effect of Tunneling Barrier as a Spacer on Exchange Coupling of CoFeB/AlOx/Co Trilayer Structures

The influence of leadership and human capital management on global competitiveness

An Empirical Study on the Correlation between Customer Knowledge and Knowledge Chain on Service Quality

On the added virtual mass incremental (AVMI) factor for the transversely isotropic magneto-electro-elastic plates in contact with fluid

The Effect of Optimal Relational Distance on Relational Quality and Relational Performance
New Role Model of Innovation Incubation Center
Help and Support students in starting their own business

The Innovation Incubation center help and support those graduated students start their own business, however, in compared to other innovation Incubation centers from other universities, the innovation incubation and industrial cooperation center at I-Shou University, start ahead in helping students to start their own business. Industrial Management student Cheng Kuang Jin established an limited company called “heart of the fulfillment and knowledge integration” , the innovation incubation center will assist the selling and circulating of products that had already caused unrest internet discussions.

The director of the innovation incubation and industrial cooperation center at I-Shou University, Professor Yu-Ming Chiang, who is also the associate professor of industrial management department indicated that Cheng Kuang Jin is a very entrepreneurial-minded student. He started an financial planning team and earned his first pot of gold at age 19. He continuing his financial management skills and entrepreneurial talent after he entering I-Shou university, and formed a club. He further initiate his business ideas and established an limited company. The company’s main business is to promote financial education and business planning and the first set of products was aim is giving financial education meaning and created a simulation game called “ rich battle”.However this game need to find a way of circulating in the market that a company called Mia help circulation pathway development and caused unrest discussions on the internet regarding to the game.

Cheng Kuang Jin said this time through the cooperation with the innovation incubation center at the I-Shou University, that the richness of school resources and assistant and supports of the professional business and integration skills from the professor helped to solve business problems when starting an business. He was very grateful to the assistance of the school and support of professor that enable students to exert their expertise, the school will have next Bill Gates or Mark Zuckerberg in Taiwan.
Global International Invention Exhibition event (The Innovation of 2011 (3Cii)) At E-DA

Global International Invention Exhibition events! The “2011 “innovation (3Cii) will take place at the grand stadium at I-Shou University from 24th until the 27th of August. “The Innovation 2011 (3Cii) “activities included “The 2nd World Cup of Computer Implemented Inventions”, first International Festival of cultural innovation, and the Modern Innovations International Conference, with international guests on-site from twenty five countries, and more than 200 international guests from various domestic industry, government and academia to participate in the unprecedented grand scale.

The international activities were designed by the International Federation of Inventor’s Association whose head quarter are based in Budapest Hungary. Taiwan Invention and innovation Industry Association collaborative in planning, and with this year the I-Shou University as the host university, Taiwan is not only a strong base for computer hardware and software industry, many universities also cultivate high-quality human resources in IT industry and various areas of international competitions.

This not only can enhance the strength of the invention and application, but also by organizing this international competition, can increase Taiwan’s international visibility. Thereby promoting the related fields of private international exchange, and therefore has great significance to promote the benefits.
Excellent Management of Information Security of I-Shou University Received International Certification ISO27001 four years in a row

In order to strengthen the management of information security, after the school’s efforts, I-Shou University on August 2nd this year passed the ISO27001 international certification, and won certificate that received consent from the Taiwan’s technology limited company (SGS).

The re-certification not only a symbolized both the campus hardware and software and management of information security reached the international standards, but also demonstrates that school execution and performance of information security is very good.

As issues of information security issues are related to upgrading of industrial safety and international competitiveness, therefore, the whole faculty and staff of I-Shou University valued the importance of information security. Therefore, the information Security Promotion Committee was formed as early as from 1997 to actively promote information security and because the actively cooperation from the relevant administrative units that the processes and efficiency were improved and obtain ISO27001 international certification in August.

Three-year of improvement and reevaluation in passing the re-certification, making the performance and management of information security of I-Shou University excellent. The director of computer center from I-Shou University professor Bair Miin-Shyan indicated that the passing of re-certification owe to the actively cooperation from the relevant administrative units that the processes and efficiency were improved to the international standard. This also symbolized the hardware and software on campus and the management of information security was with international standards. This also prove that the school’s outstanding administrative performance, with the development efforts toward international direction.
Congratulations!
Honorary President of I-Shou University, Fu-Sheng Li Proudly Reaching and Received Four Fellowship on 20th of September 2011.

The four fellowships included Materials Research Society Taiwan, International Microelectronics And Packaging Society, Institute of Electronics and Electrical Engineers, Institute of Technology Management Taiwan.

The Honorary President of I-Shou University Dr. Fu-Sheng Li glorious received four fellowships from Electronic and Materials fields. He published more than hundred academic papers and received numerous awards from the industry, government and academia sectors and worth giving congratulations to.

The honorary President of I-Shou University and the visiting chair professor Fu-sheng Li received fellowship certificate at the Annual Conference from the Material Research Society at the World Trade Centre in Nangang Taipei. Dr. Fu-Shang Li has outstanding research performances in the fields of electronic materials, manufacturing, and packaging. He first was given fellowship from international Microelectronics and packaging society (IMPS) in 2003, another fellow received from the” international Institute of Electronics and Electrical Engineering (IEEE) in 2009. In 2010 year fellow from the “Institute of Technology Management,” and another fellow from the “Materials Research Society Taiwan this year.” Dr. Fu-Sheng Li can be officially called the “4F “(4 FELLOW)now.

Dr. Fu-Sheng Li had been the professor and administrative manager at National Cheng Kung
University, and the president of I-Shou University. Dr. Fu-Sheng Li not only continued focus on the academic research in electronic technology, but also continued in R & D cooperation with the electronics industry. He has established two society such as the “International Microelectronics Packaging Society Taiwan branch” (IMAPS-Taiwan) and the “Taiwan Surface Mounting technology Association” (SMTA-Taiwan). In addition, in late August this year co-hosted the “3CII international invention and cultural innovation in computer applications and World Cup competition” with the International Federation of Inventors Alliance (IFIA). The Conference was completed with great success; Dr. Fu-Sheng Li also received the praised from the representatives of the twenty participating countries and was given FIA Knight class medal.

In August this year, Dr. Fu-Sheng Li has moved up in and was appointed in becoming the honorary president and visiting chair professor after twenty-one years as the president of I-Shou University, appointed as Honorary President and Chair Professor positions, continue to assist the new era of excellence-Shou University
Enhance international perspectives and promote exchange between Schools.

I-Shou University and Tokushima Bunri University from Japan formed sister schools

The signing ceremony for becoming sister schools between I-Shou University and Tokushima Bunri University from Japan were by the president of I-Shou University Dr. Wan-Long Hong and the chairman of Tokushima Bunri University Mr. Kawasaki Masato. The signing ceremony was simple with solemnity and through this was to wish to have further enhance the international perspective and academic exchange between two schools.

President Dr. Wan-Long Hong indicated that he welcomes the chairman Kawasaki Masato from the Tokushima Bunri University to visit I-Shou University. Although I-Shou University has only over 21 year of history and still a very young university, but has put efforts in academic performances that in 2011 the world university ranking, I-Shou University reached 480 places among other universities. I-Shou university continued to upgrading its ranking every year and received public recognition.
I-Shou University is the only university in Taiwan has closed integration with the other enterprises in the industry that provide students with adequate training and employment opportunities.

Chairman Masato Kawasaki indicated that this time to I-Shou University and I-Da Hospital for visit has left him a very deep and good impression. He praised the good teaching and medical equipments I-Shou University has. Tokushima Bunri University was honored become sister schools with I-Shou University, that the future further exchange and development between two schools was very looking forward to. Chairman Kawasaki Masato further pointed out and highlighted the importance of education, he believes that children are the future of the nation, that school must provide students with good learning devices. Although this might be more spending in buget, but education should start with today, to foster more talented students in the future. The international academic cooperation and academic exchanges I-Shou University has was rich and abundant. There are over one hundred seventy-five universities that have academic cooperation and exchange with I-Shou University. The signing sister schools with Tokushima Bunri University hope to continuing to show the international visibility of I-Shou University.
Wedding Pastry show and give happiness
The Hospitality Management department of I-Shou University Received Excellent Award for its Creativity Performance

The Economic Development Bureau of Kaohsiung City Government held “Happiness in Kaohsiung” wedding cakes and creative marketing design contest, all participated teams caused stirring at the new wedding. The department of Hospitality Management of I-Shou university received dazzling success, top three in ranking for creative works such as “happiness Graffiti Art Festival,” “met, macarons” and “Venus”, that shown new ingenuity in marketing.

Hospitality Management, sophomore student Hon Chi Lun received first prize for her “Happiness Graffiti Art Festival” indicated that she learned the art of graffiti during classes and thought the wedding photos in the past all mainly in the romantic theme. This time she combined the graffiti art with the romantic theme, let the graffiti arts become the scenes for wedding photography. This will bring more creative ideas for the wedding. Student of the same team Chen Lin indicated that participate in the competition is the accumulation of experiences. She hopes to accumulate more
experiences during the race for better understanding the abilities of other participants from other universities and enhance her abilities.

Second place winner, “Met, macarons,” senior year student Lin Yuxuan of hospitality management of the I-Shou University, indicated that the bright colors of macarons represent love with young and lively images, and the stuffing represent the feelings of sweet emotion. Therefore, a sweet loving images of Macaron was designed. Wu Hzi-Huan of the same team, said that during the competition process, they had encountered difficulty such as design in professional financial planning and other areas. But the teachers from the department encouraged and helped that received such good results should give grateful thanks to the teachers and the department.

Works that received third place, “Venus,” was from the senior year student Yingru Liu of hospitality management of I-Shou University. She indicated that nowadays young people are not interested in the traditional Chinese Style big red wedding cake packaging anymore, therefore in order to promote the Chinese cakes from the bakery industry, a new lovely gift packaging was designed to attract the attention of the young couples. Student Wu Zhi-Xuan from the same team mentioned that the name “Venus” with the slogan “Let love find you” was because Venus represented the goodness of Love that slogan “Let cupid find you gives a sweet romantic wedding images.

The vice chairman of Hospitality Management department professor Hsu Kuan Liu indicated that students involved in competitions are the best way to earn experiences in practice and life. This should also let students understand their current capabilities and their differences between other students from other universities. Competitions can stimulate students’ inner creative potential and learn the spirit of team work from it.
**Effect of Tunneling Barrier as a Spacer on Exchange Coupling of CoFeB/AlOx/Co Trilayer Structures**

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**Abstract**

Magnetic tunneling junctions (MTJs) have a sandwiched structure, comprising a top ferromagnetic (FM1) layer, an insulating tunneling layer (spacer), and a bottom ferromagnetic (FM2) layer. The exchange coupling in MTJs has been widely studied because the effect of spacer thickness has on the ferromagnetic spin-coupling can be applied to read-head sensors, spin-valve structures, and magnetoresistance random access memories (MRAMs). In this study, the MTJs were deposited in the following sequence: glass/CoFeB(50Å)/AlOₓ(d)/Co(100Å), where d = 12, 17, 22, 26, and 30 Å is the thickness of the AlOₓ layer. From the saturation magnetization (Mₛ) results, we found that the exchange coupling strength and coercivity (H_c) can be varied significantly by the tunneling barrier AlOₓ spacer. The X-ray diffraction patterns (XRD) show a main peak of hexagonal close-packed (HCP) Co with a highly (002) textured structure is obtained at 20 = 44.7°, while AlOₓ and CoFeB are amorphous states. The full width half maximum (FWHM) of the Co (002) peak decreases with increasing AlOₓ thickness, indicating that the Co layer is more crystalline. The magnetic results indicate that the magnetic characteristics are related to the Co
1. Introduction

In recent years, increased attention has been given to ferromagnetic exchange coupling in magnetic fields, and there has been a rapid increase in exchange coupling issues due to the discovery of spintronics. The magnetic tunneling junction (MTJ) has a trilayer structure composed of a top ferromagnetic (FM1) layer, an insulating tunneling layer (spacer), and a bottom ferromagnetic (FM2) layer, which can be used in high-density read/write heads, magnetoresistance random access memories (MRAM), and gauge sensor fields because spin-dependent tunneling induces a very large magneto-resistance (MR). The MR depend on factors such as the indirect spin exchange-coupling of ferromagnetic layers, and the insulating tunneling layer quality, which both significantly affect the magnetic performance. However, fabrication of high-quality junctions requires a ferromagnetic layer with high polarization, perfect microstructure, and proper indirect spin exchange-coupling phenomenon between FM1 and FM2 layers. Chen et al. investigated the Si/Ta/CoFeB/AlO\textsubscript{x}/Co/IrMn/Ta and glass/Co/AlO\textsubscript{x}/CoFeB systems. The results showed the higher 63% of tunneling magnetoresistance (TMR) ratio was obtained in Si/Ta/CoFeB/AlO\textsubscript{x}/Co/IrMn/Ta system, and 12% of TMR was obtained in glass/Co/AlO\textsubscript{x}/CoFeB system. However, in this glass/CoFeB/AlO\textsubscript{x}/Co MTJ, we found a much lower TMR ratio. In short, the higher TMR ratio of MTJ is related to deposited film sequence and different substrate effect. However, few studies on the properties of CoFeB/AlO\textsubscript{x}/Co MTJs have been reported. In this work, we focus on the correlation between the ferromagnetic crystallinity and the magnetic properties. The results indicate that the stronger Co (002) texture can enhance the higher saturation magnetization (M\textsubscript{s}) and reduce the coercivity (H\textsubscript{c}) values.

2. Experimental details

A multilayered MTJ was deposited onto a glass substrate by dc magnetron sputtering. The typical base chamber pressure was lower than 1.5 \times 10^{-7} Torr, and the Ar working chamber pressure was 5 \times 10^{-3} Torr. Our MTJ had the following features: glass/CoFeB(50Å)/AlO\textsubscript{x}(d)/Co(100Å), where d = 12, 17, 22, 26, and 30 Å. The target composition of the CoFeB alloy is 40 wt.% Co, 40 wt.% Fe, and 20 wt.% B. To form an AlO\textsubscript{x} barrier, we first deposited Al on the bottom FM electrode (the CoFeB layer), and the AlO\textsubscript{x} layer was then formed by reactive sputtering in an oxidizing atmosphere composed of a mixture of Ar/O\textsubscript{2} in the ratio of 9:16. The plasma oxidation time varied from 30 to 70 sec, while the initial thickness of the Al layer was increased from 12 Å.
to 30 Å. To study the microstructure, the degree of Co (002) layer texturing was characterized by X-ray diffraction (XRD) using Cu K_{α1} radiation. The magnetic properties of MTJ were detected by a superconducting quantum interference device (SQUID).

3. Results and discussion

Figure 1 shows the XRD patterns of the laminated CoFeB(50Å)/AlO_{x}(d)/Co(100Å) MTJ junctions. This result indicates that the junctions exhibit a hexagonal close-packed (HCP) Co with a highly (002) texture at 2θ = 44.7°. In addition, the microstructures of CoFeB and AlO\textsubscript{x} are in an amorphous state. In order to confirm the HCP Co (002) structure, the Bragg’s law can be estimated for d-spacing. The Bragg’s formula can be written as:

\[ \lambda = 2d_{hkl}\sin\Theta \]

where \( \lambda \) denotes the wavelength of the CuK\textsubscript{α1} line; \( d_{hkl} \) means the inter-spacing distance of each diffraction plane; and \( \Theta \) is the half angle of the diffraction peak. According to formula (1) calculation, the \( d_{hkl} \) of Co is 2.0257 Å. Comparing to previous investigation [17,18], the \( d_{hkl} \) of FCC Co (111) is 2.0467 Å, and the \( d_{hkl} \) of hexagonal close-packed (HCP) Co (002) is 2.023 Å. It indicates the HCP Co (002) exists in this study. We can confirm the Co structure is hexagonal close-packed (HCP). The corresponding full width half maximum (FWHM, B) of the Co (002) peak is shown in Fig. 2.

![Fig. 1. X-ray diffraction plots of the CoFeB(50Å)/AlO\textsubscript{x}(d)/Co(100Å) MTJ.](image)

![Fig. 2. The FWHM (B) result as a function of the thickness (d) of the AlO\textsubscript{x} layer.](image)

Figure 2 plots the B (FWHM) of the CoFeB(50Å)/AlO\textsubscript{x}(d)/Co(100Å) MTJs as a function of d. Scherrer’s formula can be written as,

\[ d = \frac{0.9\lambda}{B\cos\Theta} \]

where d is the grain size, \( \lambda \) is the wavelength of the CuK\textsubscript{α1} line, B is the full width half maximum (FWHM) of the (002) peak, and \( \Theta \) is the half
angle of the diffraction peak. This formula can be used to calculate the grain size and determine the crystallinity. As shown in Fig. 2, B is reduced by increasing the AlO\textsubscript{x} tunnel barrier thickness the FWHM of the Co layer decreases. This phenomenon explains why the grain size of Co is enlarged and the Co (002) texture is enhanced.

The magnetic properties of CoFeB/AlO\textsubscript{x}/Co MTJ are shown in Figs. 3 and 4. First, the saturation magnetization (M\textsubscript{s}) versus the AlO\textsubscript{x} thickness is shown in Fig. 3. The M\textsubscript{s} of Fig. 3 presents the total spin exchange-coupling contribution of CoFeB/AlO\textsubscript{x}/Co. Evidently, no spacer tunneling barrier AlO\textsubscript{x} layer, the direct spin exchange-coupling effect of the CoFeB/Co bilayer structure is stronger than the indirect spin exchange-coupling effect of the CoFeB/AlO\textsubscript{x}/Co MTJ. This suggests that the tunneling barrier AlO\textsubscript{x} inserted into the CoFeB interface results in indirect spin exchange-coupling oscillation. The M\textsubscript{s} of CoFeB/AlO\textsubscript{x}/Co MTJ is enhanced to 850 emu/cm\textsuperscript{3} as the AlO\textsubscript{x} thickness is increased. It can be reasonably concluded that Co texturing can induce an indirect ferromagnetic spin exchange-coupling interaction between the CoFeB and Co layers. The Co texture of MTJ can be possible concluded that the magneto crystalline anisotropy demonstrates the CoFeB/AlO\textsubscript{x}/Co exchange-coupling effect, results in higher M\textsubscript{s}. Based on this reason, the stronger Co (002) texture can enhance higher indirect ferromagnetic spin exchange-coupling, revealing the results in Fig. 3.

In Fig. 4, the dependence of coercivity (H\textsubscript{c}) on the AlO\textsubscript{x} thickness (d) is plotted. From the hysteresis loop result, it exhibits the two-step characteristic, we can infer the anti-parallel alignment between the CoFeB and Co layers. When the external field (H) switches the CoFeB/
AlO$_x$/Co, it initially rotates the coercivity of CoFeB, then as a larger field $H$, the coercivity of Co is rotated to saturation. $H_c$ declines as the AlO$_x$ thickness is increased. A possible reason is spin coupling and the degree of decoupling of CoFeB/AlO$_x$/Co in this situation. The Co (002) texture can enhance the spin exchange-couple arrangement. From Fig. 2, the thinner AlOx has a higher FWHM, and the Co (002) texture is weaker. When the external field (H) tries to switch the MTJ junction, it must rotate the CoFeB and Co layers, respectively, resulting in a higher $H_c$ value. In contrast, the Co (002) texture can increase the stronger spin exchange-coupling interaction between the CoFeB and Co layers for thicker AlO$_x$. The rotated field (H) only switches the CoFeB/AlO$_x$/Co exchange-coupling field, resulting in a lower $H_c$ value. From the magneto crystalline anisotropy, the stronger Co (002) texture induces the higher indirect CoFeB/AlO$_x$/Co exchange-coupling interaction. The weaken Co (002) texture reduces the lower CoFeB/AlO$_x$/Co exchange-coupling interaction. When the external field (H) rotates the weaken Co (002) texture of CoFeB/AlO$_x$/Co MTJ, it must rotate the coercivity of CoFeB and Co layers individually, results in higher $H_c$ value. Another reasonable cause could be the polarization and depolarization of spin tunneling in the oxidation plasma process. Briefly, if d is thin (for example, d = 12 Å), the CoFeB bottom electrode may become over oxidized, resulting in oxidation at the CoFeB/AlO$_x$ interface. The surface pinning effect of CoFeB/AlO$_x$ interface possibly results in some defects, including oxidation, roughness, and inclusions. The defects can make displacements of the domain walls motion difficult and cause $H_c$ values to increase.

4. Conclusion

The CoFeB(50Å)/AlO$_x$(dÅ)/Co(100Å) MTJs were fabricated to study the microstructure and magnetic properties, such as $M_s$ and $H_c$, as functions of the AlO$_x$ barrier thickness $d$ (which was varied from 12 to 30 Å). In addition, the microstructure of the MTJs shows that the Co (002) texture is enhanced, as the AlO$_x$ is increased. The FWHM of Co (002) texture reduces, as the tunneling barrier AlO$_x$ thickness is increased. This phenomenon explains why the grain size of Co is enlarged and the Co (002) texture is enhanced. Moreover, the relationship between the Co (002) texture and the magnetic properties suggests that the enhanced Co (002) texture can increase the higher saturation magnetization ($M_s$) and reduce the coercivity ($H_c$). A larger $H_c$ is found at thinner AlO$_x$ thicknesses, because the spin decoupling effect occurs between the CoFeB and Co layers and the domain pinning effect exists over the oxidized CoFeB/AlO$_x$ interface.

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References

The influence of leadership and human capital management on global competitiveness

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Abstract

The major aim of this study is to explore the influence of top management teams’ leadership and human capital management on a firm’s global competitiveness. Given the exploratory nature of this research, we targeted companies headquartered in Taiwan but with foreign subsidiaries. A questionnaire survey was administered and altogether 114 companies took part in the study. The results indicated that leadership of top management teams not only had direct positive impact on a firm’s global competitiveness, but also had indirect positive impact on a firm’s global competitiveness through the meditating effects of international human capital management.

Keywords : leadership, human capital management, global competitiveness

Research background and hypotheses

The resource-based view of the firm theory advocates that in certain circumstances sustained competitive advantages can be achieved through leveraging a firm’s resources, such as human
capital (Coff, 1997). As significant growth has been experienced in developing economies, a challenge for multinational companies (MNCs) is how to effectively manage and enable human capital to compete successfully in the global market (Ready and Conger, 2007). A first aim of study thus is to investigate the influence of human capital management on a firm’s global competitiveness, and to focus on identifying critical human resources management (HRM) practices that contribute to a firm’s success in the global market. We introduce the construct of international human capital management (IHCM), which is referred to as HR practices that facilitate the development and exploitation of a firm’s international human capital, the human capital that enables a firm to compete in the global markets (Ling and Jaw, 2006). As most management practices can be copied sooner or later by competitors, it is critical for firms to assure that their IHCM practices lead to sustainable competitive advantages (Hatch and Dyer, 2004). In this study, we further introduce the construct of the leadership of top management teams (TMTs) which may be critical driving force to enhance the effectiveness of IHCM and facilitate globalization performance. Given that few scholars have empirically examined the possible mediating effect of human capital management, we also aim to examine the possible mediating effect of IHCM between leadership of TMTs and a firm’s global competitiveness. Specifically, this study intends to explore the following questions. First, does IHCM enhance a firm’s global competitiveness? Second, is there any mediating effect of IHCM between TMTs’ leadership and global competitiveness? The followings are the research hypotheses:

H1  Leadership of TMTs has positive impact on a firm’s IHCM.
H2  International human capital management has positive impact on a firm’s global competitiveness.
H3  Leadership of TMTs has positive impact on a firm’s global competitiveness.
H4  Leadership of TMTs has positive impact on a firm’s global competitiveness through the mediating effect of IHCM.

**Method**

Given the exploratory nature of this study, we adopted a purposive sampling process. We targeted companies headquartered in Taiwan but with foreign subsidiaries. Altogether, managers in 114 Taiwanese companies responded to the survey. A questionnaire measuring TMTs’ leadership, IHCM, and global competitiveness was administered to top managers or HR professionals. The questionnaire was adapted from Ling and Jaw’s (2011) study. Leadership of TMTs attempts to measure TMTs’ intellectual agility, visionary leadership, and the ability to integrate organizational culture and cope with pressure or hardship (Adler and Bartholome, 1992; Ali and Camp, 1996; Wu et al., 2002; Rastogi, 2003; Ling and Jaw, 2006). International human capital management seeks to measure
a firm’s human resource management (HRM) practices that facilitate the development and exploitation of a firm’s human capital in order to achieve global competitiveness (Ling and Jaw, 2006; 2011). Using Ling and Jaw’s (2011) study as a starting point, five constructs were identified to measure IHCM: (1) global selection (Ichniowski and Shaw 1999; Ling and Jaw, 2011), (2) human capital investment (Edvinsson and Malone, 1999; Dzinkowski, 2000; Grossman, 2000; Ling and Jaw, 2011), (3) global leadership development (Davenport, 1999; Beckman, 1999; Gloet and Terzirovski, 2004; Ling and Jaw, 2011), (4) integrating training with performance (Ichniowski and Shaw, 1999; Yahya and Goh, 2002; Ling and Jaw, 2011), and (5) socialization (Garavan et al., 2001; Ling and Jaw, 2011). IHCM is a ‘system’ in which all the practices are closely interrelated, and one aspect could not exist without all the others (Milgrom and Roberts, 1990; Itoh, 1994). In terms of global competitiveness, following Ling and Jaw’s (2011) study, both human capital return and global initiatives were used to measure the performance of IHCM. In the current study, the scale of global initiatives is considered a composite measure encompassing three constructs: (1) global innovation, (2) global learning, and (3) global marketing (Pucik et al., 1993; Birkinshaw, 1997; Hitt et al., 1998). In terms of instrument reliability, the Cronbach’s α values of each scale, TMTs’ leadership (α=0.835), international human capital management (α=0.957), and global competitiveness (α=0.949), are all greater than 0.8. It is confirmed that the instrument for this study possesses adequate reliability.

**Results**

**Structural Equation Modeling (SEM)**

An initial SEM model was built to explore the relationships among TMTs’ leadership, IHCM, and global competitiveness. After a series of modifications, we reached acceptable, substantive final SEM results (Figure 1). The goodness-of-fit statistics indicated a good fit for the final results ($p = 0.378; \chi^2/df = 1.030; \text{RMSEA} = 0.016; \text{NFI} = 0.999; \text{CFI} = 1.000; \text{RFI} = 0.992; \text{ILI} = 1.000; \text{TLI} = 1.000$).

**Direct Effect**

For the direct effect, it is confirmed that IHCM has positive impact on a firm’s global competitiveness. IHCM regresses positively toward human capital return ($\beta=0.320, p<0.01$), global learning ($\beta=0.309, p<0.01$), global marketing ($\beta=0.291, p<0.05$), and entrepreneurial innovation ($\beta=0.342, p<0.01$). Hypothesis 2 is thus verified that IHCM has positive impact on a firm’s global competitiveness. The results also reveal that TMTs’ leadership has positive impact on IHCM. TMTs’ leadership regresses positively toward IHCM ($\beta=0.542, p<0.01$). Hypothesis 1 is supported that leadership of TMTs has positive impact on IHCM. We further find that TMTs’ leadership has positive impact on global competitiveness. TMTs’ leadership regresses positively toward global learning ($\beta=0.504, p<0.01$), global marketing ($\beta=0.433, p<0.01$), and global innovation ($\beta=0.564, p<0.01$). TMTs’ leadership also
regresses positively toward human capital return ($\beta=0.430$, $p<0.01$). Therefore, Hypothesis 3 is supported that leadership of TMTs has positive impact on a firm’s global competitiveness.

**Indirect Effect**

The analysis results also indicate that TMTs’ leadership has indirect positive impact on human capital return ($\beta=0.238$, $p<0.01$), global learning ($\beta=0.274$, $p<0.01$), global marketing ($\beta=0.237$, $p<0.01$), and global innovation ($\beta=0.317$, $p<0.01$). This implies that in addition to the direct effect, TMTs’ leadership has indirect positive impact on a firm’s global competiveness through its direct positive impact on IHCM. Hypothesis 4 is thus confirmed that leadership of TMTs has positive impact on a firm’s global competiveness through the mediating effect of IHCM.

**FIGURE 1.** The Final Model (only direct effects are shown here)

**Discussions and conclusions**

The SEM model provided some interesting findings. Firstly, the results offered evidence to support hypothesis 2 that IHCM enhances a firm’s global competiveness. IHCM not only contributes to a firm’s global innovation, but also enhances its global marketing and global learning. Our results are consistent with previous studies in that MNC’s human resource management plays a crucial role in acquiring and enhancing organizational global competence for the firm (Pucik et al., 1993; Makadok and Walker, 2000; Minbaeva et al., 2003). The results also confirmed Luthans and Youssef’s (2004) assertion that selection, training and development can be used as effective human capital management tools. IHCM has demonstrated its significant role in the pursuit of MNC’s global competiveness for the organizations studied.

In this light, the focus of HR practices should be on leveraging and integrating human capital so that an international talent pool with social complexity and inimitability can be ultimately developed to support a firm’s global competiveness. For instance, MNCs may create their global innovation advantage by developing a pipeline of leaders with global experience who are selected for their skills and competency rather than their nationality (Ready and Conger, 2007). Furthermore, to enhance global innovation, MNCs may also consider offering employees opportunities to visit headquarter for better understanding of corporate culture, or offering socialization programs that lead organizational members to shared attitudes, values and assumptions. Socialization may speed up the rate at which global managers learn their duties, thereby improving their productivity (Hatch and
Dyer, 2004). Firms are also suggested to invest more on employee training to enhance their capability in global learning and global marketing. International assignments such as short-term overseas rotations or visits not only increase managers’ global networks, but also provide them with more degrees of freedom in managing the complexities of global multi-market competition (Adler and Bartholome, 1992; Carpenter et al., 2001). Moreover, cross-cultural training program may be used to enhance global managers’ culture awareness and culture sensitivity (Ready and Conger, 2007). As indicated by Grote (2000), building leadership development system is one of the most difficult-to-imitate competitive strategies within the domain of HRM.

Likewise, the results on the important role of TMTs’ leadership in IHCM are also valuable to MNCs. The findings are in agreement with Ready and Conger’s (2007) on that the vitality of a company’s talent management process is a product of commitment and management of the senior executives. A vision emphasizing the importance of entrepreneurship as well as a commitment to develop human capital will facilitate individual managers’ effort to develop entrepreneurial capabilities such as agility, creativity, and skill to manage resources strategically (Alvarez and Barney, 2002). The indirect positive impact of TMTs’ leadership on human capital return, global marketing, global learning and global innovation found in this study also supports Ling and Jaw’s (2006) findings on the positive relationship between human capital and a firm’s global initiatives.

Finally, the results confirm our expectation that leadership of TMTs is positively associated with a firm’s global competiveness through the mediating effect of IHCM. The results indicate that TMTs’ leadership not only directly enhances a firm’s global competiveness, but also indirectly strengthens it through the mediating effect of IHCM. Entrepreneurial leaders are better at taking advantage of global opportunities and managing human capital for contributing to the firm’s overall goals in the global context. To the same degree, when the five types of IHCM practices, global selection, human capital investment, global leadership development, integrating training with performance, and socialization, are integrated and implemented together, IHCM then plays a mediating role in linking TMTs’ leadership to the development of global competiveness.

Reference


An Empirical Study on the Correlation between Customer Knowledge and Knowledge Chain on Service Quality

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Abstract
The marketing mode has shifted from being product-oriented to customer-oriented. Simultaneously, old boundaries among manufacturing products, ideas and services are crumbling, while the distinctions between manufacturing and service industries are fading away. Moreover, customers are increasingly putting more emphasis on the quality of the products and services that they consumed, rather than the price. As a result, when an enterprise is able to provide excellent service to its customers, its costs will not only be reduced, but its profits and market share will also increase. Thus, managers must know the most important customer knowledge and through the primary activities of knowledge chain to improve their service quality and customer’s overall satisfaction. However, literatures about the customer knowledge, knowledge chain and service quality is still insufficient. Thus, this study will explore how an enterprise can apply a knowledge chain to absorb customer knowledge in order to enhance corporate service quality and competitive advantage.

Keywords: Customer Knowledge, Knowledge Chain, Service Quality
**Introduction**

Service quality is significant due to the fact that it is closely related to financial performance, customer satisfaction, and customer retention (Saravanan and Rao, 2007). It can provide firms with a good opportunity to find answers to many unsolved questions related to consumer behavior (Sanchez-Perez, et al., 2007). Simultaneously, business managers realize that a high level of customer satisfaction can only be achieved by enhancing service quality. Nevertheless, merely possessing knowledge on the quality of goods is not sufficient to develop an in-depth understanding of service quality. Empirical studies on how an enterprise can actually transform customer knowledge to enhance its service quality are still rare. Campbell (2003) also stated that while most firms generally understand their customers’ behavior, they do not know how to utilize this knowledge. Moreover, customer knowledge cannot be generated automatically, as success in this project depends on the organization’s ability to manage this knowledge (Demarest, 1997). As a result, this study proposes a conceptual framework and uses questionnaire and statistical analytical techniques to explore the correlation between the customer knowledge and knowledge chain with regard to service quality. Moreover, through the following five primary activities—acquisition, selection, generation, internalization, and externalization—this study will illustrate how firms apply the knowledge chain to obtain customer knowledge and then utilize it to develop innovative services, thus eventually enhancing service quality.

**Literature Review**

**Customer Knowledge**

In order to enhance enterprises’ competitiveness, they should focus on its customers and collect customer knowledge so that they can understand the reason why customers purchase its products (Garcia-Murillo and Annabi, 2002; Davenport, Harris and Kohli, 2001). Wayland and Cole (1997) stated that enterprises can acquire customer knowledge by creating interactions and dialogues with customers, observing how customers use products or experience service, as well as analyzing corporate data and information in order to forecast customer behavior. Gibber et al. (2002) noted that enterprise should carefully observe, interact and make dialogues with their customers to acquire customer knowledge so that they can provide customized service and maintain long-term relationship. Yeung et al. (2008) further proposed a conceptual framework based on product quality, customer service, effective salesperson, effective communication, and social compliance as main attributes of customer knowledge to explore how customer knowledge improve operational performance of a firm. Liao et al. (2010) further indicated that enterprise can use the data warehouse and data-mining tools to integrate product and marketing knowledge and to extract customer knowledge, respectively. Then, this knowledge can provide distributors and retailers to develop new products and increase the relationship between corporate and customer.

As a result, customer knowledge is an important organizational asset that is not merely a
response towards customers’ preferences, but they can also enhance the ability of the company to develop innovative products and ideas (Leonard, 1998; Hargadon and Sutton, 2000). Based on a review of relevant literature, this study found that the ability of acquiring customer knowledge should be performed through generating, structuring, and organizing customer information (Li and Calantone, 1998). Moreover, the breadth, depth, and uniqueness of customer knowledge possess tremendous influence towards product and service innovation (De Luca and Atuahene-Gima, 2007).

**Knowledge Chain**

Value chain model is a concept proposed by Porter (1985) in his book entitled “Competitive Advantage.” He assumed that value chain is the basic tool for identifying competitive advantage and improving corporate structure. Based on technique and strategy, corporate activities can be classified into primary and support activities. Primary activities include inbound logistics, operations, outbound logistics, marketing and sales, and service that directly contribute to the final products. While support activities include procurement, technology development, human resource management, and firm infrastructure that indirectly support the primary activities. Based on Porter’s value chain model, Lee and Yang (2000) proposed knowledge value chain model that divides knowledge management activities into knowledge management (KM) process and KM infrastructure. The KM process includes knowledge acquisition, innovation, protection, integration and dissemination. While KM infrastructure includes chief knowledge officer (CKO) and management, knowledge worker recruitment, knowledge storage capacity, and customer/supplier relationship. At the same time, they explained further that KM Process can be effective if supported by the KM infrastructure and thus eventually KM performance can be enhanced.

Based on Porter’s value chain model, Holsapple and Singh (2001) also developed the Knowledge Chain Model and classified the KM activities into primary and support activities. The primary activities include knowledge acquisition, selection, generation, internalization, and externalization; while the support activities include knowledge leadership, coordination, control and measurement. Furthermore, they also proposed that enterprise could apply knowledge chain to analyze and understand each activity and resource required to implement KM in order to plan an appropriate training plan and enhance competitive advantage.

**Service Quality**

Oliver (1981) assumed that service quality and satisfaction level are not the same. Service quality is customer’s extensive evaluation on positive and negative matters, while satisfaction level is customer’s temporary response towards positive and negative matters. Grönroos (1982; 1984) assumed that service quality is generated through comparison between perception and expectation regarding the service. Before experiencing the service, customer always has
an expectation. After experiencing the service, customer always has a certain perception. Hence, when the expectation exceeds the perception, it means that the service quality is extremely low. On the contrary, when the expectation is lower than the perception, then the service quality is extremely high. In 1984, Grönroos extended the service quality model by adding the following three aspects: functional quality, technical quality and image. Functional quality refers to how the service is delivered which will define customers’ perceptions regarding interactions that occur during service delivery. Technical quality shows what customers receive in the service encounter or the outcome of service act. Functional and technical qualities can influence customer’s image on the enterprise that will influence customer’s perception on the service quality.

Parasuraman et al. (1985) explained that the service quality should be measured during the process of providing service and usually takes place when the customer and the staff are dealing with the service. Hence, the satisfaction of service quality is measured based on the comparison between the perceptions and expectations on the service delivered. At the same time, they also classified ten interrelated factors that influence service quality as follows: reliability, responsiveness, competence, courtesy, access, communication, credibility, security, understanding and tangibles. In 1988, they further proposed SERVQUAL measurement that simplified the aforementioned ten factors into the following five main factors: tangibles, reliability, responsiveness, assurance, and empathy. Simultaneously, they found that there is a significant relationship among service quality, marketing variables and profitability. In other words, if enterprises are able to provide better service quality, it is possible to acquire higher market growth and market share (Parasuraman et al., 1996). Therefore it is known that customers’ previous service experience, unique demand and consumption condition might influence their subjective judgments on the service quality (Palmer, 2005).

**Conceptual Model and Hypotheses**

This research investigates the relationship among knowledge chain, customer knowledge and service quality to understand how enterprise acquires customer knowledge by means of knowledge chain model in order to enhance service quality and obtain competitive advantages. The conceptual model is shown in Fig. 1.

![Fig. 1 Conceptual model](image)

Butler (2000) assumed that enterprises should effectively utilize knowledge on customer demand to increase customer satisfaction so that customers will grow their repeat-purchase willingness and behavior. Furthermore, customers
sometimes could not express their demands. Therefore, enterprises should be equipped with excellent communication ability in order to effectively interact with customers and gain knowledge regarding customer demand. If enterprise possesses outstanding customer knowledge, it can help customers understand their demand and problems to provide appropriate service and problem solution that will eventually enhance service quality (Hedaa and Ritter, 2005). Hence, this research assumes that if enterprises can apply the five aspects proposed by Yeung et al. (2008)—product quality, customer service, marketing specialist, effective channel and social responsibility—to acquire effective customer knowledge, then it is possible to enhance service quality. This research proposes the following hypotheses:

**Hypothesis H₁. The higher of the degree of customer knowledge has a positive correlation with service quality.**

Zhang and Zhao (2006) assumes that knowledge management is a research on strategies, procedures, and techniques to acquire, select, combine, and share knowledge that allows enterprises to lever their information and expertise to enhance corporate productivity and decision quality. They also elaborated integration between information process and creativity to enhance synergy as the highest flexibility and responsiveness. Hence, a successful organization should be able to manage various knowledge and develop it into its highest strategic value. Bose (2003) refers knowledge management capacity as how enterprises apply the existing knowledge and continuous learning to create new knowledge. Therefore, knowledge management capacity can stimulate the organization to create, share and reuse knowledge in order to achieve organization learning and corporate objectives (Papows, 1998). In other words, an enterprise with mature knowledge management capacity can identify, spread, protect, and reestablish knowledge. Therefore, this research assumes that knowledge chain is a process-oriented variable and not an outcome-oriented one and that it can mediate the relationship between the customer knowledge and service quality. Hence, this research proposes the following hypotheses:

**Hypothesis H₂. The association between the degree of customer knowledge and service quality is mediated by knowledge chain.**

### Research Methods

**Measures development**

The questionnaire was designed and developed using the results of the previous literature. The final questionnaire comprises four parts. The first part is customer knowledge, which includes five measurement items: (1) product quality, (2) customer service, (3) marketing specialist, (4) effective communication, and (5) social responsibilities adhocracy. The second part is knowledge chain, including (1) knowledge acquisition, (2) knowledge selection, (3) knowledge generation (4) knowledge internalization, and (3) knowledge externalization. The third part is service quality, including (1) tangibles, (2) reliability, (3)
responsiveness, (4) assurance, and (5) empathy. The last part is the demographics of the sample, which includes gender, age, education level, type of occupation, job position, years of experience and average monthly income. Table 1 contains all the measures, as well as their sources. Research constructs were operationalized by means of related studies and a pilot test. A seven-point Likert-type scale, ranging from 1 (strongly disagree) to 4 (neutral) to 7 (strongly agree), was used to measure the research variables.

<table>
<thead>
<tr>
<th>Theoretical constructs</th>
<th>Relevant problems</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer knowledge</td>
<td>Our company offers excellent high-quality products.</td>
<td>Wayland and Cole (1997); Gibber et al. (2002); Yeung et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>Our company’s products have fulfilled the customer’s demand.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s products are good value for customer’s money.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s products possess attractive design.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company can fulfill customer’s order (or purchase procedure) quickly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company is able to finish product delivery after receiving the order.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company has a reliable order process.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company provides customers with good after-sales service.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s front-line staff is well-equipped with knowledge on the products.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s front-line staff is equipped with the ability to understand customer demands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s front-line staff is equipped with the ability to help customers solve their problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s front-line staff shares their experiences and knowledge with their colleagues.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s front-line staff is able to immediately fulfill customers’ demands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s staff is equipped with excellent communication ability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s staff appreciates customers’ feedback.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company has a customer service center to collect feedback from customers face-to-face.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company complies with the Labor Standards Law.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company highly respects staff’s expertise.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company highly complies with work safety regulations to guarantee staff’s safety.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company possesses high environmental awareness.</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Our company is paying close attention on the market trend.</td>
<td>Our company has the latest service equipment.</td>
<td></td>
</tr>
<tr>
<td>Our company can maintain close relationship with the customers.</td>
<td>Our company’s service equipment is attractive.</td>
<td></td>
</tr>
<tr>
<td>Our company is paying close attention on external environmental changes.</td>
<td>Our company’s staff appearance is befitting.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to verify customer knowledge.</td>
<td>Our company’s service staff can realize their promise to our customers.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to evaluate customer knowledge.</td>
<td>Our company’s service staff can accomplish tasks on time.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to filter and select valuable customer knowledge.</td>
<td>Our company’s service staff can think on our customers’ shoes.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to display customer knowledge.</td>
<td>Our company’s service staff is reliable.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to apply knowledge.</td>
<td>Our company’s service staff can immediately respond to customers’ demands.</td>
<td></td>
</tr>
<tr>
<td>Our company is equipped with the ability to create new knowledge.</td>
<td>Our company’s service staff can help customers solve problems immediately.</td>
<td></td>
</tr>
<tr>
<td>Our company has established the culture of knowledge innovation.</td>
<td>Our company’s service staff has the willingness and passion to provide service to our customers.</td>
<td></td>
</tr>
<tr>
<td>Our company has established a comprehensive educational training mechanism.</td>
<td>Our company’s service staff can precisely tell our customers their waiting time.</td>
<td></td>
</tr>
<tr>
<td>Our company has established a conducive learning environment for our staff.</td>
<td>Our company’s service staff is equipped with the professional ability to provide service.</td>
<td></td>
</tr>
<tr>
<td>Our company periodically announces updated information.</td>
<td>Our company’s service staff can make our customers feel respected.</td>
<td></td>
</tr>
<tr>
<td>Our company has established a mature knowledge communication platform to assist staff coping with the most current information.</td>
<td>Our company’s service staff is polite and friendly.</td>
<td></td>
</tr>
<tr>
<td>Our company highly encourages staff to share knowledge among themselves.</td>
<td>Our company’s service staff can effectively communicate with our customers.</td>
<td></td>
</tr>
<tr>
<td>Our company periodically holds sessions for sharing experiences among the staff.</td>
<td>Our company’s service staff is proactive in understanding customers’ demands.</td>
<td></td>
</tr>
<tr>
<td>Our company can apply technology to assist us to store and display customer knowledge.</td>
<td>Our company’s service staff can provide customized service based on customer’s demands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s service staff can help customers solve problems immediately.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s service staff can think based on customers’ benefit.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our company’s service staff can provide service with empathy.</td>
<td></td>
</tr>
</tbody>
</table>
Sample and Data Collection

This research collected data in Taiwan to test the above hypotheses by means of questionnaire. The questionnaire was mainly distributed through the Internet. The sampling frame was based on the top manufacturers listed in 2009 CommonWealth Magazine consisting of 1000 manufactures, 500 service providers, and 100 financial service providers. Among these samples, 100 manufacturers, 100 service providers, and 50 financial service providers were invited to take part in the survey via the hyperlink provided in the e-mail. With the same method, friends working in these companies were also asked to fill in the questionnaire and forward the link to their friends. Among them, 117 were valid; the other 4 were incomplete or unclear, and hence discarded. Table 2 shows the demographics of the respondents that include gender, age, education level, type of occupation, job position, years of experience and average monthly income.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Percentage</th>
<th>Variable</th>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>61.5</td>
<td>Job position</td>
<td>Basic-level staff</td>
<td>74.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>38.5</td>
<td></td>
<td>Basic-level manager</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle-level manager</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High-level manager</td>
<td>8.5</td>
</tr>
<tr>
<td>Age</td>
<td>≤ 22</td>
<td>8.5</td>
<td>Education</td>
<td>High school and lower</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>23-27</td>
<td>45.3</td>
<td></td>
<td>Undergraduate</td>
<td>61.6</td>
</tr>
<tr>
<td></td>
<td>28-32</td>
<td>9.4</td>
<td></td>
<td>Graduate</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>33-37</td>
<td>10.3</td>
<td></td>
<td>Post-graduate and above</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>38-42</td>
<td>18.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥43</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of work experience</td>
<td>&lt;1 year</td>
<td>29.0</td>
<td>Type of occupation</td>
<td>Manufacturing</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>1-3 years</td>
<td>32.5</td>
<td></td>
<td>High-tech industries</td>
<td>12.8</td>
</tr>
<tr>
<td></td>
<td>4-6 years</td>
<td>1.7</td>
<td></td>
<td>Financial services</td>
<td>45.3</td>
</tr>
<tr>
<td></td>
<td>7-9 years</td>
<td>7.7</td>
<td></td>
<td>Others</td>
<td>21.4</td>
</tr>
<tr>
<td></td>
<td>10-12 years</td>
<td>6.0</td>
<td>Average monthly income</td>
<td>≤ 19,999 NTD</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td>13-15 years</td>
<td>6.0</td>
<td></td>
<td>20,000-50,000 NTD</td>
<td>47.0</td>
</tr>
<tr>
<td></td>
<td>≥16 years</td>
<td>17.1</td>
<td></td>
<td>50,000-80,000 NTD</td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80,000-100,000 NTD</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≥ 100,001 NTD</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Reliability and Validity of the Constructs

This research applied items analysis to measure the relevance of each questionnaire item. Then, exploratory factor analysis was employed to verify the relevance of each default dimension variable. Based on the results of items analysis and exploratory factor analysis, this research eventually divided customer knowledge into quality and service, effective salesperson and communication, and social compliance; knowledge chain is divided into knowledge acquisition, selection, generation, internalization, and externalization; service quality is divided into tangibles, reliability, assurance, and empathy.

Table 3 outlines the results of the reliability and validity tests performed on the survey items. Internal consistency measures (Cronbach’s alpha) were obtained in order to assess the reliability of the measurement instruments. The item-to-total correlation, which was calculated between each
individual item and the sum of the remaining items, was used to determine the convergent validity. When the item-to-total correlation score was lower than 0.4, the case was eliminated from further analysis. The reliability level is acceptable if the value is at least 0.8 for the basic research and 0.7 for the exploratory research (Nunnally, 1978). The content validity of the instruments was established by adopting the constructs that have already been validated by other scholars and experts. From the analyses mentioned above, it was found that the survey items on each construct meet the requirements reliability and validity.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>The reliability results for each variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructs</td>
<td>Items</td>
</tr>
<tr>
<td>Customer knowledge</td>
<td></td>
</tr>
<tr>
<td>Quality and service</td>
<td>8</td>
</tr>
<tr>
<td>Effective salesperson and communication</td>
<td>8</td>
</tr>
<tr>
<td>Social compliance</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge chain</td>
<td></td>
</tr>
<tr>
<td>Acquisition</td>
<td>3</td>
</tr>
<tr>
<td>Selection</td>
<td>4</td>
</tr>
<tr>
<td>Generation</td>
<td>3</td>
</tr>
<tr>
<td>Internalization</td>
<td>4</td>
</tr>
<tr>
<td>Externalization</td>
<td>3</td>
</tr>
<tr>
<td>Service quality</td>
<td></td>
</tr>
<tr>
<td>Tangibles</td>
<td>3</td>
</tr>
<tr>
<td>Reliability</td>
<td>4</td>
</tr>
<tr>
<td>Assurance</td>
<td>8</td>
</tr>
<tr>
<td>Empathy</td>
<td>4</td>
</tr>
</tbody>
</table>

**Analysis and Results**

**Relationship between customer knowledge and service quality**

This study adopted Pearson’s correlation analysis to determine the correlation between customer knowledge and service quality. Table 4 shows the correlation coefficients between customer knowledge and service quality is 0.845. It shows highly positive correlation. The correlation coefficients of each customer knowledge factors—quality and service, effective salesperson and communication, and social compliance—with service quality are 0.806, 0.804, and 0.667, respectively. For the correlation among all customer knowledge factors, the result shows a strong correlation among them and reaches a significant level (**p < 0.01**). Thus, it means that customer knowledge had significant positive correlation with service quality. Moreover, the higher the degree of the quality and service, effective salesperson and communication, and social compliance of customer knowledge, the higher level of the service quality. Consequently, the research result favored Hypothesis H₁, thus, hypotheses H₁ was proven valid.
Table 4  Correlation between customer knowledge and service quality

<table>
<thead>
<tr>
<th></th>
<th>Service quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality and service</td>
<td>0.806**</td>
</tr>
<tr>
<td>Effective salesperson and</td>
<td>0.804**</td>
</tr>
<tr>
<td>communication</td>
<td></td>
</tr>
<tr>
<td>Social compliance</td>
<td>0.667**</td>
</tr>
<tr>
<td>Customer knowledge</td>
<td>0.845**</td>
</tr>
</tbody>
</table>

** P < 0.01

Testing the mediated effects of knowledge chain

The simple-regression analysis for customer knowledge on service quality and customer knowledge on knowledge chain are shown in Table 5. The multiple-regression analysis for customer knowledge and knowledge chain on service quality is shown in Table 6. Based on Table 5 and Table 6, this research found that the standardized coefficient of customer knowledge on service quality is 0.845, while the standardized coefficient of customer knowledge on knowledge chain is 0.829. The standardized coefficient of customer knowledge and knowledge chain on service quality is 0.457 and 0.469. The path coefficient of customer knowledge on service quality decreased from 0.845 to 0.457, showing that knowledge chain has partial mediating effect on customer knowledge and service quality. Furthermore, this implies that the influence of customer knowledge on service quality during the service process would partially affect knowledge chain and then affect the service quality. In other words, during the process of enhancing service quality, customer knowledge that possesses higher value will enhance the knowledge chain activity. After the enterprise has stronger ability of knowledge chain, the service quality provided by the enterprise will also increase.

Table 5 The simple-regression analysis for customer knowledge on service quality and knowledge chain

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>Std. E</th>
<th>Beta</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.696</td>
<td>1.225</td>
<td>1.358</td>
<td>0.169</td>
<td></td>
</tr>
<tr>
<td>Customer knowledge</td>
<td>1.214</td>
<td>0.072</td>
<td>0.845</td>
<td>16.980</td>
<td>0.000**</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.712</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>Std. E</th>
<th>Beta</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.057</td>
<td>1.563</td>
<td>1.956</td>
<td>0.053*</td>
<td></td>
</tr>
<tr>
<td>Customer knowledge</td>
<td>1.451</td>
<td>0.091</td>
<td>0.829</td>
<td>15.900</td>
<td>0.000**</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.685</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** P < 0.05

Table 6 The multiple-regression analysis for customer knowledge and knowledge chain on service quality

<table>
<thead>
<tr>
<th>Variables</th>
<th>Service quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
</tr>
<tr>
<td>Constant</td>
<td>0.520</td>
</tr>
<tr>
<td>Customer knowledge</td>
<td>0.656</td>
</tr>
<tr>
<td>Knowledge chain</td>
<td>0.385</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.780</td>
</tr>
</tbody>
</table>

** P < 0.05
Conclusions

This research applied a questionnaire method and statistical analysis to investigate the influence and relationship amongst customer knowledge, knowledge chain, and service quality. This research found that customer knowledge has positive influence on service quality. Furthermore, this research also found out that the aspects of customer knowledge—quality and service, effective salesperson and communication, and social compliance—have positive influence on service quality. In other words, enterprises can gain support and recognition from both customers and staff if they can: understand customer’s demand on product quality and after-sales service; provide professional marketing specialists who are able to communicate and fulfill customers’ requirements; abide the Labor Standards Law and work safety regulations, as well as possess environmental awareness.

This research suggested that enterprises should effectively gain customer knowledge regarding their perceptions of product quality and customer service, the effectiveness of sales personnel and related communications, as well as social compliance, so that they can properly manage customer dynamics and market trends in order to increase customer relationships, improve overall service quality, and advance corporate competitiveness (Claycomb, Dröge and Germain, 2005). This research also found that knowledge chain is the partial intervening variable between customer knowledge and service quality. On the other hand, customer knowledge has a positive influence on knowledge chain, while knowledge chain also has a positive influence on service quality. This shows that if enterprises can acquire adequate levels of customer knowledge, they will enhance their internal activities related to knowledge chain. If the operation of knowledge chain is better, then service quality respectively will also increase.

References


On the added virtual mass incremental (AVMI) factor for the transversely isotropic magneto-electro-elastic plates in contact with fluid

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Abstract

In this paper, mathematical formulation on the determination of added virtual mass for water-contacting magneto-electro-elastic (MEE) rectangular plates with uniform thickness is performed. Based on the recently proposed differential equation governing the dynamical responses of the MEE rectangular plates, a fluid-structure interaction model is established and analyzed. On the fluid-structure interface, some techniques will be adopted to deal with the relationships between the velocity potential and the mode shapes, then by imposing the double Fourier transform, one can derive the formulations of the reference kinetic energy for both the fluid and the plate itself. After these two energies have been obtained, the added virtual mass incremental factor (AVMIF) could be obtained rapidly and the added virtual mass can thus be acquired.

Keywords: Magneto-electro-elastic (MEE) plates; Added virtual mass; Fluid-structure interaction; Added virtual mass incremental (AVMI) factor

Introduction

It is well known that the fluid motion will be induced by the vibrating movement of the water-contacting structure and thus a remarkable increase in the kinetic energy to the whole system will be provoked. The added virtual mass incremental factor (AVMI factor) is often used
to denote the ratio between the kinetic energy of the fluid and that of the structure, furthermore, the natural frequencies of the structure coupled with fluid can be determined by using the added virtual mass, which can be calculated following the determination of AVMI factor. Chang and Liu [1] studied the free vibration behavior of a rectangular isotropic plate in contact with liquid by using the double Fourier Transform. Amabili [2] discussed the solution to the fully coupled problem of the vibrations of circular plates resting on sloshing liquid. Later on, Chang and Liu [3] performed the forced vibration analysis of a rectangular composite plate in contact with fluid as well as discussed the variation of AVMI factor for different plates with various widths and length. Besides, Liu and Chang [4] studied the vibration behavior of a varying-thickness circular plate in contact with fluid by adopting the Galerkin’s method in conjunction with Hankel transform.

Recently, many researchers have paid their attentions to the mechanics problems associated with the so-called magneto-electro-elastic materials. It is found that a wide class of crystals and emerging composite materials will possess simultaneously piezoelectric, piezomagnetic and magneto-electric effects, which are thereby classified as magneto-electro-electric solids. Pan [5] derived an exact three-dimensional solution of a simply supported multilayered orthotropic magneto-electro-elastic plate using a propagator matrix method. Wang et al. [6] extended the previous works on elastic and piezoelectric plates to study the bending of multi-layered orthotropic magneto-electro-elastic rectangular plates by adopting the state space formulations. The free vibration investigation was recently performed by Pan and Heyliger [7], who found that some natural frequencies of a multi-field plate were identical to the ones of the corresponding elastic plate. They argued that certain vibration modes of the plate were insensitive to the coupling effects among elastic, electric, and magnetic fields. More recently, Liu and Chang [8] have offered a compact form expression for the transverse vibration of a magneto-electro-elastic (MEE) thin plate, in which a new and simplified differential equation is presented.

The objective of this investigation is to calculate the added virtual mass incremental factor (AVMIF) of a transversely isotropic magneto-electro-elastic (MEE) rectangular thin plate with general boundary conditions, which is in contact with fluid.

**Formulation**

Consider the physical model of a transversely isotropic Magneto-Electro-Elastic (MEE) rectangular plate in contact with fluid as illustrated in Fig. 1, where 2a and 2b represent the width and length of the MEE rectangular plate, and h is the thickness respectively. F denotes the fluid domain, \( S_F \) denotes the surface between the fluid and an infinite rigid wall and \( S_B \) denotes the surface between the fluid and the plate, also \( S_R \) denotes the surface at infinity.
By neglecting the effects of rotatory inertia and transverse shear deformation, and utilizing the differential equation for MEE rectangular plates stated in Ref. [8], the governing equation of the undamped free vibration of a transversely isotropic Magneto-Electro-Elastic (MEE) rectangular plate in contact with fluid can be written as follows:

$$\left( D + E + M \right) \nabla^4 w + (\rho_p h + M_f) \frac{\partial^2 w}{\partial t^2} = 0.$$  

where $w$ is the transverse deflection of the plate, $\rho_p$ is the mass density of the plate, $h$ is the thickness of the plate, $M_f$ denotes the fluid-added mass and $D = \frac{c_0 h^3}{12}, \quad E = \frac{c_0 h^3}{12} \frac{\Delta_i}{\Delta}$, $M = \frac{q_0 h^3}{12} \frac{\Delta_2}{\Delta}$ represent the plate rigidity, effective rigidities due to the presences of electricity and magnetism, respectively. Here, 

$$\Delta = \varepsilon_{33} \mu_{33} - q_3^2, \quad \Delta_i = (\varepsilon_{33} \mu_{33} - d_{3i} q_{3i})$$

$$\Delta_2 = (\varepsilon_{33} q_{31} - d_{33} e_{31}), \quad c_{ij}, \quad e_{ij}, \quad q_{ij}, \quad d_{ij}$$

and $\mu_{ij}$ are the elastic, dielectric, piezoelectric, piezomagnetic, magnetoelectric, and magnetic constants, respectively. For free vibration analysis in the air, Eq. (1) yields

$$\left( D + E + M \right) \nabla^4 w + \rho_p h \frac{\partial^2 w}{\partial t^2} = 0.$$  

By adopting the separation of variables, the solution of Eq. (2) can be expressed as follows:

$$w(x, y, t) = \sum_{m=1}^{\infty} \sum_{n=1}^{\infty} W_{mn}(x, y) T(t) = \sum_{m=1}^{\infty} \sum_{n=1}^{\infty} W_{mn}(x) Y(y) T(t).$$  

where

$$T(t) = \sin \omega t.$$  

and $X_m(x), Y_n(y)$ are the orthogonal mode shape functions which satisfy the boundary conditions of Magneto-Electro-Elastic (MEE) rectangular plate in the x and y directions individually. In addition, the natural frequency $\omega$ can be computed from the boundary conditions of the MEE rectangular plate.

In the present study, the MEE rectangular plate is considered to be in contact with fluid on one side only, and the fluid is assumed to be incompressible and inviscid. Furthermore, the fluid flow is considered as irrotational under plate vibration only so that its velocity potential can be represented as
\[
U(x, y, z, t) = \phi(x, y, z) \frac{dT}{dt},
\]

where \( \phi \) is the spatial distribution of the velocity potential and "\( \cdot \)" denotes the derivative with respect to time. Based on the assumption of the fluid, \( \phi \) has to satisfy the Laplace equation as follows:

\[
\nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} = 0 \quad \text{in } F,
\]

where \( F \) denotes the fluid domain. As described in Fig. 1, \( S_F \) denotes the surface between the fluid and an infinite rigid wall and \( S_B \) denotes the surface between the fluid and the plate, besides \( S_R \) denotes the surface at infinity. The condition of the rigid wall on \( S_F \), can be stated in the following:

\[
\frac{\partial \phi(x, y, z)}{\partial z} \bigg|_{z=0} = 0 \quad \text{on } S_F. \tag{7}
\]

In addition, the interaction between the fluid and the plate can be expressed as follows:

\[
\frac{\partial \phi(x, y, z)}{\partial z} \bigg|_{z=0} = -\bar{W}(x, y) \quad \text{on } S_B, \tag{8}
\]

where \( \bar{W} \) denotes the "wet" mode shape of the MEE plate vibrating in contact with the fluid. Moreover, we must impose the conditions that the velocity potential \( \phi \) and the velocities \( \frac{\partial \phi}{\partial x}, \frac{\partial \phi}{\partial y} \) and \( \frac{\partial \phi}{\partial z} \) approach zero on \( S_R \), that is,

\[
\frac{\partial \phi}{\partial x}, \frac{\partial \phi}{\partial y}, \frac{\partial \phi}{\partial z} \to 0 \quad \text{as } x, y, z \to \infty \quad \text{on } S_R. \tag{9}
\]

Based on the results verified by several researchers [9], it is assumed that the "wet" mode shape of the MEE plate in contact with the fluid is the same as the "dry" mode shape of the MEE plate when vibrating in the air. Hence, the approximation \( \bar{W}(x, y) = W(x, y) \) will be used in the following derivations.

First of all, denote the double Fourier transform in the following:

\[
\tilde{\phi}(u, v, z) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \phi(x, y, z) e^{i(ux + vy)} dy dx. \tag{10}
\]

Utilizing double Fourier transform on Eq. (6) and applying the boundary conditions stated in Eq. (9), then the velocity potential \( \phi(x, y, z) \) can be represented as

\[
\phi(x, y, z) = \left( \frac{1}{2\pi} \right)^2 \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \tilde{\phi}(u, v, z) e^{i(ux + vy)} dudv \nonumber
\]

\[
= \left( \frac{1}{2\pi} \right)^2 \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \bar{B}(u, v) e^{-(u^2 + v^2)/2} e^{i(ux + vy)} dudv. \tag{11}
\]

Applying the boundary conditions specified in Eqs. (7) and (8), \( \bar{B}(u, v) \) in Eq. (11) can be determined in the following:

\[
\bar{B}(u, v) = (u^2 + v^2)^{-1/2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} X_m(x)Y_n(y) e^{i(ux + vy)} dx dy. \tag{12}
\]

Generally \( \bar{B}(u, v) \) is a complex function of both \( u \) and \( v \).

Based on the previous assumption that the wet mode shapes are almost the same as the dry mode
shapes, the natural frequency of the MEE plate in contact with fluid $\omega_f$ can be evaluated as follows [6]:

$$\omega_{mn} = \omega_{mn} \sqrt{1 + \gamma_{mn}}, \quad (13)$$

where $\omega_{mn}$ is the natural frequency of the MEE plate in the air. Utilizing Eq. (2) in conjunction with the general boundary conditions for the MEE plate, it is quite feasible to determine $\omega_{mn}$ in the following form:

$$\omega_{mn} = \frac{(D + E + M)}{\rho_p h} (\alpha_m^4 + 2\alpha_m^2\beta_n^2 + \beta_n^4), \quad (14)$$

in which $\alpha_m$ and $\beta_n$ are the corresponding eigenvalues according to the MEE plate’s boundary conditions along the x and y directions, respectively. Also $\gamma_{mn}$ in Eq. (13) is the AVMI factor that denote the ratio between the reference kinetic energy of fluid induced by the plate vibration and that of the plate which can be expressed as

$$\gamma_{mn} = \frac{T_F}{T_p}, \quad (15)$$

The reference kinetic energy of the MEE plate can be calculated as

$$T_p = \frac{1}{2} \rho_p h \int_a^b \int_0^\pi X_m^2(x) Y_n^2(y) \, dx \, dy, \quad (16)$$

Employing the assumption on the irrotational movement of the fluid flow, the reference kinetic energy of the fluid can be determined as follows from its boundary condition:

$$T_F = -\frac{1}{2} \rho_p \int_0^\infty \int_0^\infty \frac{\partial \phi(x, y, 0)}{\partial z} \phi(x, y, 0) \, dx \, dy \cdot \quad (17)$$

Substituting Eq. (7), (8) and (11) into Eq. (17) yields

$$T_F = \frac{1}{2} \left(\frac{1}{2\pi}\right)^2 \rho_p \int_0^b \int_a^\pi \int_\infty^\infty X_m(x) Y_n(y) B(u, v) e^{-i(\alpha x + \beta y)} \, du \, dv \, dx \, dy \quad (18)$$

To calculate the above multiple integral, reverse the order of integration, thus Eq. (18) can be simplified as follows:

$$T_F = \frac{1}{2} \left(\frac{1}{2\pi}\right)^2 \rho_p \int_0^\infty \int_\infty^\infty \left[\int_b^x \int_a^\pi X_m(x) Y_n(y) e^{-i(\alpha x + \beta y)} \, du \, dv \right] B(u, v) \, du \, dv \quad (19)$$

where $*$ is the complex conjugate and it is noted that $B(u, v)$ can be evaluated from Eq. (12) as long as the dry mode shapes of the MEE plate are available. Hence, once $T_F$ and $T_p$ are calculated, $\gamma_{mn}$ (AVMI factor) can be determined from Eq. (15) and finally the natural frequency $\omega_{mn}$ of the MEE plate in contact with fluid are readily obtained from Eq. (13).

**Numerical examples and discussions**

In this section, we perform the free vibration analysis of the MEE plate in contact with fluid by considering a bi-layered $\text{BaTiO}_3 - \text{CoFe}_2\text{O}_4$...
composite with variable volume fraction (v.f.) of \( \text{BaTiO}_3 \). The dimensions of the plate are assumed as follows: length \( a = 2\text{m} \), width \( b = 2\text{m} \) and height \( h = 0.05\text{m} \). The density of the bi-layer plate is assumed to be proportional to the volume-fraction of these two materials, i.e.

\[
\rho_p = \rho_{\text{BaTiO}_3} \ast \text{v.f.} + \rho_{\text{CoFe}_2\text{O}_4} \ast (1-\text{v.f.}) .
\]

Besides, the density of the fluid is assumed as \( \rho_f = 1000\text{kg/m}^3 \). The numerical computations are carried out by selecting six different plates with volume fractions in steps of 20%, i.e. 0%, 20%, 40%, 60%, 80%, 100%. The magneto-electro-elastic material properties are listed in Table 1 with different volume fraction as given by Annigeri et al. [10]. The boundary conditions for the MEE plate are selected to be simply-supported on four sides (SSSS) or clamped on four sides (CCCC), nevertheless, any other kinds of boundary conditions can be considered without any difficulties.

\[
\begin{array}{cccccc}
\text{v.f.} & 0\% & 20\% & 40\% & 60\% & 80\% & 100\% \\
C_{11} & 286 & 250 & 225 & 220 & 175 & 166 \\
C_{12} & 173 & 146 & 125 & 110 & 100 & 77 \\
C_{13} & 170 & 145 & 125 & 110 & 100 & 78 \\
C_{33} & 269.5 & 240 & 220 & 190 & 170 & 162 \\
C_{44} & 45.3 & 45 & 45 & 45 & 50 & 43 \\
e_{31} & 0 & -2 & -3 & -3.5 & -4 & -4.4 \\
e_{33} & 0 & 4 & 7 & 11 & 14 & 18.6 \\
e_{15} & 0 & 0 & 0 & 0 & 0 & 11.6 \\
e_{11} & 0.08 & 0.33 & 0.8 & 0.9 & 1.0 & 11.2 \\
e_{33} & 0.093 & 2.5 & 5.0 & 7.5 & 10 & 12.6 \\
\mu_{11} & -5.9 & -3.9 & -2.5 & -15 & -0.8 & 0.05 \\
\mu_{33} & 1.57 & 1.33 & 1.0 & 0.75 & 0.5 & 0.1 \\
g_{31} & 580 & 410 & 300 & 200 & 100 & 0 \\
g_{33} & 700 & 550 & 280 & 260 & 120 & 0 \\
g_{15} & 560 & 340 & 220 & 180 & 80 & 0 \\
d_{11} & 0 & 2.8 & 4.8 & 6.0 & 6.8 & 0 \\
d_{33} & 0 & 2000 & 2750 & 2500 & 1500 & 0 \\
\rho_p & 5300 & 5400 & 5500 & 5600 & 5700 & 5800 \\
\end{array}
\]

( Unit: elastic constants, \( C_{ij} \), in \( 10^9\text{N/m}^2 \), piezoelectric constants, \( e_{ij} \), in \( \text{C/m}^2 \), piezomagnetic constants, \( q_{ij} \), in \( \text{N/Am}^2 \), dielectric constants, \( \varepsilon_{ij} \), in \( 10^9\text{C}^2/\text{Nm}^2 \), magnetic constants, \( \mu_{ij} \), in \( 10^6\text{Ns}^2/\text{C}^2 \) and magnetoelectric coefficients, \( d_{ij} \), in \( 10^{12}\text{Ns/VC} \) )
Based on Eq. (15), we can determine $\gamma_{mn}$ (AVMI factor) of a MEE rectangular plate in contact with fluid. In particular, a bi-layered $\text{BaTiO}_3 - \text{CoFe}_2\text{O}_4$ MEE plate with 40% of $\text{BaTiO}_3$ is considered. Table 2 and Table 3 show the values of added virtual mass incremental factor (AVMI factor) for such a MEE plate with the simply supported boundary conditions. In addition, Table 4 and Table 5 present the values of added virtual mass incremental factor (AVMI factor) for the same MEE plate with the clamped boundary conditions. It can be detected from these tables that the values of $\gamma_{11}$ is much larger than those of the other modes for both boundary conditions.

This implies that $\gamma_{11}$ plays a dominant role as far as AVMI factor is concerned; besides it can be found that $\gamma_{mn}$ decreases with the mode order, meaning the effect of fluid also decreases with the mode order. Generally speaking, AVMI factor $\gamma_{mn}$ of the lower mode number is larger than that of the higher mode number since the fluid movement stroke of the lower mode number is larger than that of the higher one. Hence, the fluid movement stroke will be reduced as the mode number increases, which will end up with the reduction of the added mass and AVMI factor. The similar phenomenon can be detected in the free vibration of a liquid-filled circular cylindrical shell [11].

**Table 2:** The values of $\gamma_{mn}$ for odd mode of a bilayered square plate (40% of $\text{BaTiO}_3$) in contact with fluid with simply supported boundary conditions

<table>
<thead>
<tr>
<th>$\gamma_{mn}$</th>
<th>$m=1$</th>
<th>$m=3$</th>
<th>$m=5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n=1$</td>
<td>3.084426</td>
<td>0.999956</td>
<td>0.578724</td>
</tr>
<tr>
<td>$n=3$</td>
<td>0.999956</td>
<td>0.618340</td>
<td>0.436316</td>
</tr>
<tr>
<td>$n=5$</td>
<td>0.578724</td>
<td>0.436316</td>
<td>0.349497</td>
</tr>
</tbody>
</table>

**Table 3:** The values of $\gamma_{mn}$ for even mode of a bilayered square plate (40% of $\text{BaTiO}_3$) in contact with fluid with simply supported boundary conditions

<table>
<thead>
<tr>
<th>$\gamma_{mn}$</th>
<th>$m=2$</th>
<th>$m=4$</th>
<th>$m=6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n=2$</td>
<td>0.962513</td>
<td>0.581607</td>
<td>0.403931</td>
</tr>
<tr>
<td>$n=4$</td>
<td>0.581607</td>
<td>0.440930</td>
<td>0.341378</td>
</tr>
<tr>
<td>$n=6$</td>
<td>0.403931</td>
<td>0.341378</td>
<td>0.286101</td>
</tr>
</tbody>
</table>

**Table 4:** The values of $\gamma_{mn}$ for odd mode of a bilayered square plate (40% of $\text{BaTiO}_3$) in contact with fluid with clamped boundary conditions

<table>
<thead>
<tr>
<th>$\gamma_{mn}$</th>
<th>$m=1$</th>
<th>$m=3$</th>
<th>$m=5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n=1$</td>
<td>2.627170</td>
<td>0.995919</td>
<td>0.593630</td>
</tr>
<tr>
<td>$n=3$</td>
<td>0.995919</td>
<td>0.600151</td>
<td>0.428420</td>
</tr>
<tr>
<td>$n=5$</td>
<td>0.593630</td>
<td>0.428420</td>
<td>0.341156</td>
</tr>
</tbody>
</table>
Conclusions

In this paper, the fluid-structure interaction problem is studied. In particular, the vibration characteristics of transversely isotropic Magneto-electro-elastic (MEE) rectangular plates in contact with fluid are investigated. It is well known that the natural frequencies of the uniform plate in contact with fluid can be calculated by using the added virtual mass incremental (AVMI) factor, which represents the kinetic energy due to the fluid. In the present study, the mathematical formulation on the determination of added virtual mass for water-contacting MEE rectangular plates with uniform thickness is performed. A recently proposed differential equation governing the dynamical responses of the MEE rectangular plates is introduced, and the attempt to extend the system into a fluid-interaction model in order to account for the water influence is achieved. On the fluid-structure interface, some techniques are adopted to deal with the relationships between the velocity potential and the mode shapes, and then by imposing the Fourier transform, one can derive the formulations of the reference kinetic energy for both the fluid and the plate itself. After these two energies have been computed, the added virtual mass incremental (AVMI) factor can be obtained rapidly and the added virtual mass can thus be acquired. It is noted that the natural frequencies based on the proposed method are very useful for those engineers or researchers who are engaged in the vibration analysis of the MEE plate in contact with fluid.

Acknowledgement

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References


Abstract

This study investigates the relationship between buyers and sellers from the perspective of relationship marketing and focuses on association among relational distance, relational quality, and relational performance. The relational distance is applied frequently to explain the initiating, sustaining, and developing of social relationships. Social psychology/exchanging literatures adopt trust and commitment but ignore connection of relational distance, relational quality, and relational performance to examine buyer-seller relationship. Depending upon sentiment of social exchange, this research concentrates on the importance of relational distance in relationship marketing and links relational quality and relational performance to propose the concept of optimal relational distance and some notions of relationship marketing.

Key words: relational distance, relational quality, relational performance, social exchange

Background

The strategies of establishing, developing, and sustaining a long-term buyer-seller relationship is one of important topics in marketing, or more specific, relationship marketing. Some researchers treat relationship marketing as a marketing process between buyers...
and sellers which is different from traditional transaction marketing and regarded as a new marketing model [1], [2]. The exchange theory of marketing highlights the importance of relationship exchange, especially for consuming exchange among four parties. Two of the parties are when, where, why, and how the relationship exchange occurs for behavior between suppliers and consumers [3]. Theories related to relationship marketing attempt to clarify the main driving factors influencing results of relationship exchange so that salespersons or enterprises understand relationship among these factors [4]. Suppliers realize that it is crucial to establish harmonic relation with and obtain loyalty of consumers [5], and keeping original customer relation costs much lower than building new relation to gain competing dominance during the relationship evolution [6]. However, most of previous research about relationship marketing focuses on the formation of customer relation. The solid customer relation not only improves communicating with buyers but also increases sales and acts as a key barrier for switching to other brands. Therefore, developing proper customer relation can make significant profits for salespersons and acquire special treatments for customers such as extra products, services, privileges, or discounts [7]. Building and developing appropriate relation is beneficial for both buyers and sellers.

The relationship implies concepts of connection and distance while building relationship is to create connection and shorten distance. The relationship marketing intensifies the building, developing, and sustaining relationship with customers. For example, Parvatiyar and Sheth [8] concluded that formation, management, and performance evaluation of relationship with customers are three stages for relationship developing. A relational activity schemes was investigated during the shaping process of relationship to produce relation links so that sellers improve marketing efficiency and performance and create joint values shared with customers by relationship exchange which is the ultimate goal of relationship marketing [2]. Nevertheless, is a shorter relational distance better than a longer one? Keeping suitable relational distances may be a proper customer relationship marketing strategy for sellers to make common cost benefit for both parties if decreasing relational distances results increasing costs and the price to pay for shortening and maintaining such relational distances is higher than true profit of transaction.

### Theoretical Models and Propositions

#### Construct of Relational Distance

The distance is one of fundamental factors of relationship processing by which illustrates interrelations among people [9], [10]. Instead quantitative interpretation of space in regular sense, the distance is a measurement of extent for lack of close relation in interpersonal relationship and describes the sensation of segregation with others [11], [12]. The degree of relationship interaction is treated as a continuum in marketing researches [13] while relational
distance is a continuum as well based on relational characteristics of economic and social exchanging [14]. The calculation of difference for economic and social significance between buyers and sellers is a relational distance. Smaller continuum implies longer relational distance and indicates one party involved in the relationship concentrates on economic more than social sense and thus transactional marketing is favored. On the other hand, larger continuum suggests closer relational distance and demonstrates one party included in the relationship values social but neglects economic sense and relational marketing is preferable. Social commonality defines amount of subjective goals, values, experiences, and foes, and objective history, families, peoples, regions, and languages shared by a community. The strong social commonality between buyers and sellers exhibits a short relational distance. We therefore introduce the proposition.

Proposition 1: The higher social commonality exists between buyers and sellers, the shorter relational distance is.

Social Competence, Relational Distance, and Relational Quality

Reciprocity is the nature of relationship. Most people return equivalent compensation and modify positively their trust and emotion to those who do their favor first [9]. This is especially important and true for insurance services depending heavily on trustworthy products. There are intangible, hard to evaluate, and tremendous benefits from products based on relationship with customers [15]. Since relationship marketing comprises all kinds of relationship exchange activities to establish trusty relation and promote mutual understanding during frequent buyer-seller interaction and transaction process, relational quality is considered as a key factor of successful relationship marketing [16], a decision criterion of whether a transactional relation exists, and an entire appraisal of relationship strength [17]. The eventual assessment satisfies demand and expectation found on either successful or fail events encountered both for buyers and sellers [18]. In other words, relational quality is a perception, represented by satisfaction experience and extent of trust awareness for whole cooperation procedure through interaction practice in marketing activities between customers and salespersons. The relational quality plays a critical role in the buyer-seller relationship.

The dimensions of relational quality are trust and commitment originated from social exchange theories [9]. Trust and commitment are major moderators for building good relationship in commitment-trust model [16] and being have positive effects for relational performance and behavior evolution. The solid trust will extend influencing relationship and effect of long-term exchanging procedure [5], [19]. Hence, improving marketing performance and raising more profits rely on establishing fine relational quality with customers to intensify continuing interaction.

Theories of social exchange explain the dynamics of voluntary reward caused by others’
active altruistic behavior. The paths of forming trust are fulfillment of obligation and gradually expansion for period of exchange. Social exchange is characterized by several perspectives described below that are different from economy, i.e. (a) May combine with external profits with economic value such as useful information or suggestion, or connect to internal profits without explicit economic value such as social supporting. The external profits are usually in forms of support or friendship, and thus contain internal profits as well. (b) Altruistic behavior is volitional though there are profits involved in exchange behavior. (c) Altruistic behavior does not assure corresponding reward and hence has extraordinarily high initial relationship risk. The profit exchange and relationship evolve from small to large scale slowly.

Verbeke et al. claimed that social competence is perspicacity of salespersons to affect or control people’s behavior under various environments so that they can grasp customers [20]. Social competence accomplishes certain influence and result by observing interpersonal interaction and allowing consciousness of response from other persons. Consequently, our second and third propositions are

Proposition 2: The better social competence arises between buyers and sellers, the shorter relational distance is and creates better trust and commitment to induce positively and directly the perception of relational quality.

Proposition 3: Relational distance is a moderator of social competence and relational quality. A shorter relational distance magnifies stronger social relational quality effect from social competence.

**Professional Competence, Relational Quality, and Relational Performance**

Social exchange and cooperation procedure often prompt internal social factors and external economic factors [9]. Gassenheimer et al. mentioned that most long-term relationship exchanges base on social and economic values [14]. To retain a certain relationship, it is important to realize that relationship includes much implicit social or economic reliance so that buyers and sellers desire to keep the relationship intentionally. Both parties collaborate and exchange social and economic values to sustain the relationship and mutual dependence. Relationship originates from purposive behavior model caused by social and economic values [5].

The main objective of relationship marketing is increasing marketing efficiency and performance and intensifying joint values of buyers and sellers [21]. The performance of relational marketing is contributed by both parties rather than any single group [5] and not only aspects related to sales but also non-sales should be considered for performance evaluation. As a result, the relational performance can be used to describe relationship between salespersons and customers and measured by agreement from both parties about the value and satisfaction for the relationship and possibility of future cooperation. From viewpoint of social exchange, there are
not widely accepted dimensions of relational performance till today [9]. Cook and Emerson argued that general relational cooperation benefits such as satisfaction is the key of social exchange [22]. Previous empirical research demonstrates that professional competence brings better performance, e.g. Theodosiou and Katsikea tested that controlling behavioral factors for sales management and screening salesclerks’ personality trait evokes positive influence and better performance and [23]. Relational performance can reduce transaction cost and uncertain risk and provide economic benefits such as professional services and special prices by way of social values characterized by mutual trust, pleasure, and belonging so that several propositions may be introduced as below.

**Proposition 4:** Sellers with higher professional competence make better economic profit and create positive influence to relational performance.

**Proposition 5:** Sellers’ professional competence is a moderator between relational quality and relational performance. Higher professional competence raises better relational quality and hence generates better relational performance.

**Relational Risk and Relational Distance**

The attempt to lower relational distance with customers is salespersons’ first step in the initial period of developing relationship characterized by lowest trust and commitment between both parties. Any activities to increase trust and commitment are crucial during this period. Since the evolution of relationship could be interfered by factors of relational risk owing to buyers and sellers care for different issues, sufficient information from salespersons will delete uncertain factors [5] for the new relationship and customers perceive continuing reduction of relational distance [24]. As buyers and sellers cannot predict, or predict properly for the prospective relationship owing to high uncertainty caused by long relational distances, the relational risk increases. The dominant relational risk then even decay relational quality so that both parties spend more time and energy to collect information, negotiate, and resolve conflicts and result more difficulties to establish trust and gain commitment. On the contrary, the relational risk decreases because of short relational distance induces solid relational quality and steady long-term relationship. Buyers encounter ambiguity usually originates from complex, intangible, inconsistent and time-consuming delivery services [18]. The perceived relational quality of buyers can be measured by customer service staffs’ the capability to diminish ambiguity. The relational distance will be shortened and uncertainty of purchase decision is decreased when customers receive plentiful product or service information during transaction process [5], [16]. From above literatures review and Leonidou et al.’s [25] work showing that the trust of buyer-seller relationship decreases due to longer relational distance and insufficient communication, we propose below proposition
Proposition 6: Both buyers and sellers make efforts to reduce relational distance and perception risk to intensify relational quality when they recognize existing high uncertainty and risk.

Optimal Relational Distance

Buyers and sellers have to pay a certain amount cost to reduce and keep relational distance while decreasing relational distance diminishes operation cost and risk and earns interest of special prices or services. It may not need post purchase services because of transaction contents with low net value or product risk, e.g. the cost of decreasing and retaining relational distance would be higher than interest for purchasing such as soft drinks, pens, newspapers, and salts. In addition, products with high value or risk like iPhone may possess moderate benefits due to decreasing relational distance since sellers provide impressive brands and product guarantees. Therefore, shorter relational distance brings higher profit for high value, uncertainty or risk, and sustaining purchasing or long-term post purchase services products while longer relational distance gets higher profit for low value, steady, and one-time purchasing products. Here prompt the last proposition

Proposition 7: Products with high net value, uncertainty, and risk and necessary sustaining purchasing or long-term post purchase services decrease optimal relational distance between buyers and sellers, otherwise increase optimal relational distance.

Conclusions and suggestions

The relational distance between buyers and sellers can be shortened effectively by raising social commonality and holding better social competence. Positive relationship development connects salespersons and customers’ purchasing behavior. Buyers satisfy the relationship growing as they acquire high quality from sellers’ efforts. Salesclerks having better performance frequently own relationship with customers based on mutual trust and information exchange. From viewpoint of response of social exchange, customers obtaining interactive relational quality from sales staffs will feedback high relational performance [26]. The relational performance for insurance salespersons attribute to professional perception for customers and interactive communication quality [18] and thus professional competence can apparently strengthen relational performance.

Trust is a latent belief that salespersons are reliable and having actions centered in customers’ long-term interests [18]. It is extremely
important for customers to build trust in case of high uncertainty and risk since trust declines or deletes the uncertainty. The positive buyer-seller interaction not only fortifies customers’ confidence for firms but also decreases ambiguity and increases degrees of trust. Moreover, the superior interaction quality between salespersons and customers helps promoting cooperation, influencing customers’ decision making, and raising sales performance.

Because the buyer-seller optimal relational distance is affected by net value, uncertainty, and risk of transaction and sustaining purchasing or long-term post purchase services, products with famous brands, high stability, and need not post purchase services can make peak profits by way of long relational distance such as internet marketing. Otherwise, profits come from short relational distance caused by social and professional competence of both parties.

References

14. “The role of economic value, social


Opportunities from NSC

• NSC Research Program
  1. For more information, please visit: http://web1.nsc.gov.tw/mp.aspx
  2. Deadline for proposal: January 2, 2012

• 2012 NSC/CNRs Joint Research Cooperation
  1. For more information, please visit: http://www.nsc.gov.tw/int/ct.asp?xItem=20291&ctNode=1212

• 2012-2013 NSC/FWF Joint Research Cooperation and Symposium
  1. For more information, please visit: http://www.nsc.gov.tw/int/ct.asp?xItem=20253&ctNode=1212
     Joint Symposium B - July 31, 2012
     Joint Research Cooperation - January 31, 2012

• 2012 NSC/BA Joint Research Cooperation
  1. For more information, please visit: http://www.nsc.gov.tw/int/ct.asp?xItem=20376&ctNode=1212
  2. Deadline for proposal: February 8, 2012
• 2012-2013 NSC/RFBR Joint Research Cooperation and Symposium

1. For more information, please visit: http://www.nsc.gov.tw/int/ct.asp?xItem=20378&ctNode=1212

• Science Vanguard Research Program

1. For more information, please visit: http://www.nsc.gov.tw/int/
2. Deadline for proposal: October 24, 2011

• NSC/NSF “Materials World Network: Cooperative Activity in Materials Research between US Investigators and their Counterparts Abroad (MWN)”

1. For more information, please visit: http://www.nsc.gov.tw/int/
2. Deadline for proposal: November 11, 2011