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The Effects of Knowledge Management and Technology Innovation on New Product Development Performance -An Empirical Study of Taiwanese Machine Tools Industry-

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Abstract

With the coming of the era of knowledge economy, research and innovation, the intangible assets, have mostly become the key source of enterprise's competitive advantage; this is especially important to the machine tool industry which generally lacks for research and development capabilities. Knowledge and technology have been gradually considered as a kind of strategic asset and the main source of creating competitive advantages. The reason is that enterprise develops distinct products and service with its innovative technology to create profits from markets, and successful technology innovation has to rely on the solid knowledge foundation. This research intends to investigate whether knowledge management could enhance technology innovation and how it affects the performance of new product development in machine tools industry. We use the questionnaire survey to collect firm's information and opinions that can verify the constructs of cause effect relations. The Socioeconomic variables are also used to find out the determinants that will affect the performance of knowledge management, technology innovation and new product development performance.

Keywords：Machine tools, Knowledge management, Technology innovation, New product development

1. Introduction

The machine tools industry in Taiwan is one of the few domestic industries that does not rely on foreign technology, incorporates the features of Taiwanese industries, and has developed international competitiveness. Its completeness in labor division networks is rarely compared to other industries. Its industrial structure has the machine tools manufacturing factories as central factories, forming a radial network structure in cooperation with other vendors. Central factories focus on research and development, manufacturing, and sales of machines, but its components are generally all obtained by cooperating

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vendors. According to the 2010 statistics of the Taiwan Association of Machinery Industry, there are currently about 1,200 companies in Taiwan in machine tools or related components. Most are mid- to small-scale manufacturing factories, and nearly 70% are clustered in central Taiwan. Since the technology of machine tools is generally copied from foreign companies, it results in the inability to form higher entry thresholds. This has resulted in intense competition among existing vendors, and they have almost no ability to negotiate prices with the suppliers of key components. Thus, how to focus on further breakthrough in technology innovation and product research and development, to promote elevation of quality and competitiveness, should be a common issue for all vendors in the industry.

Knowledge and technology have increasingly been seen as strategic assets and as the primary source of creating a competitive advantage. When the content of products、services and manufacturing processes have become more complex and professional, the basis of corporate competition has also evolved from property resources to knowledge resources. Corporations must engage in technology innovation to develop unique products and services to create profit on the market, and successful technology innovation needs to be based on a good foundation of knowledge resources. Thus, there should be a high degree of correlation between the two constructs of *knowledge management*(KM) and *technology innovation*(TI). A review of past literature shows that there are many studies that explore the effect of KM on *new product development*(NPD) performance (Nonaka & Takeuchi 1995; Liu, 2002; Koskinen, et al, 2003), or on the correlation between KM and TI (Afuah, 1998; Gan et al., 2003; Carrillo & Gaimon, 2004; Chou et al., 2004), but only a few studies have discussed the effect of KM and TI on NPD performance. There are also no studies on the correlation of these aspects in the machine tools or machinery-related industries.

Thus, with the increasing importance of KM and TI to corporations, what is the current perception of machine tools vendors regarding KM, and what are the forms of TI they adopt? Also, whether the process of KM can enhance the extent of TI and influence NPD performance? Thus, this study will explore the effect of KM and TI on NPD performance based on related theory and empirical verification, in hopes of verifying or making new findings, to contribute to the theory and practice of management.

2. Literature review

Knowledge Management(KM). KM has become the optimal tool used by corporations in maintaining a competitive advantage. Review of related literature shows that KM is the acquisition and creation of knowledge by organizational members from inside and outside the organization (Nonaka & Takeuchi, 1995; Beckett et al., 2000), to disseminate and integrate and accumulate in the interchange of three stages, which are used to establish effective knowledge assets and advantages to create maximum profit. Thus, after referring to various scholarly perspectives, this study establishes the nature and content of KM mechanisms, defining them as the following three dynamic processes: (1) *Knowledge creation and acquisition*(KMC)；(2) *Knowledge diffusion and integration*(KMI)；(3) *Knowledge storage*(KMS) these three dynamic processes are used to explore KM mechanisms in the machine tools industry, using them as research variables.

Technology Innovation(TI). In the corporate world, there are many types of innovation. OSLO Manual (1997) defined TI as brand new products and processes in adopted technology and products or processes with significant technological improvement. Such innovation may fully renew technology, may incorporate new uses of existing technology, or is the result of applying new knowledge. Thus, this study's definition of TI is more similar to the one proposed by the OSLO Manual (1997), that TI refers to innovation in product, manufacturing process, or related procedures through technology, including making new products and operational procedures through adopted technology or making products and operational procedures with significant technological improvements. The scope of this study uses TI at its center, and uses categories of (1) *Flow innovation*(TIF)；(2) *Product innovation*(TIP)；(3) *Manufacturing innovation*(TIM) as the research variables.

New Product Development(NPD). Measurement of NPD performance can be divided into two major types of financial and non-financial indicators (Cooper, 1994), so performance measurement should combine financial indicators and non-financial indicators. For instance, Olson et al. (1995) and Verona (1999) all proposed combining quantitative and qualitative indicator items, using the product and market, project flow, and technological manufacturing procedures as the main variables for measuring innovative performance. This study divides the measurement aspects of NPD performance into three variables of: (1) *Market performance*(NPDM) ; (2) *Product performance*(NPDP) ; (3) *Project and flow performance*(NPDF) accommodating the measurement aspects of other scholars.

Exploring the correlation among constructs. In a knowledge economy, the process of corporate TI has resources of technological knowledge at its core (Gan et al., 2003). Nonaka & Takeuchi (1995) proposed that innovation is the primary form of knowledge creation, and through the operations of the knowledge spiral, when the latent and exhibited knowledge of an organization interact, the result is innovation. Carrillo & Gaimon (2004) suggested that KM is the main method to lower the uncertainty of changes in the technological systems. Guan et al., (2006) proposed that TI capability can enhance organization performance. From the scholars cited above, it is known that new activities must be based on knowledge, and at the same time they rely on new knowledge; how corporations apply KM to obtain or create new knowledge, which would naturally affect the performance of innovative activity. Thus, it can be known that TI and knowledge activities are intimately connected. Thus, hypothesis 1 is proposed as follows:

- *H1: KM has a significant positive effect on TI*

The primary purpose of KM is to carry out information exchange in efficient and cost-effective methods, to efficiently shorten development time in the process of new product development. Oliver et al. (2004) pointed out that NPD refers to the process by which a series of information processing activities are combined to convert market opportunities and needs into knowledge in production. (Nonaka & Takeuchi, 1995; Liu, 2002) all indicated that strengthening KM is a means to enhancing NPD performance. In sum of the literature above, it is known that NPD is actually an environment of knowledge exchange and creation, with members in the organization working on the task of product development, increasing their exchange and interaction, eliciting massive need for knowledge and producing diverse knowledge activities and in turn knowledge integration. Thus, it is known that KM and NPD activities have connective factors, thus hypothesis 2 is proposed as follows:

- *H2: KM has a significant positive effect on NPD performance*

Rapid changes in technology and changes in customer preferences promote continuous innovation by organizations, so that they can quickly push the new products or services onto the market. Thus, continuous effort in innovation can promote organizational learning and shorten the time a product enters the market, and in turn enhance the overall profitability of the organization. Walsh & Linton (2002) found that NPD would have different performance results based on the different degree of TI in the new product. For instance, in organizations of industrial products, a higher degree of TI can help the new product have better performance. Petroni & Panciroli (2002) explored the role of TI ability in partner-ships and found that corporate innovation ability positively and significantly influence corporate product development, organizational flexibility, and organizational performance. The literature above shows that TI and ability in products, manufacturing processes, or procedures indeed are key factors that influence NPD performance, so hypothesis 3 is proposed as follows:

- *H3:TI activity has a significant positive effect on NPD performance*

In terms of the relationships among KM, TI, and NPD, Afuah (1998) suggested that innovation is a method by which new knowledge is applied to the elevation of corporate ability, and in turn, developed new products and new services to create corporate value. Nonaka & Takeuchi (1995) indicated that corporate innovation generally arises from members contributing latent technology and knowledge to create and ascertain the concept for the new product; then the product prototype is established. The knowledge obtained in the innovation process is disseminated to different departments or even different organizations. Anderson (2003) suggested that the diffusion and transmission of management knowledge

within corporations can promote the speed of organizational TI and enhance its quality. Elevation of TI ability can also improve the ability and speed of NPD by corporations, in turn constructing corporate competitive advantage. The literature above shows that TI, application of knowledge, and executive accommodation by organizations are indeed crucial factors that influence NPD performance. Thus, this study argues that KM, TI, and NPD are significantly correlated and influential, thus hypothesis 4 is proposed as follows:

- *H4: KM and TI have a significant positive effect on NPD performance*

Due to differences in industry characteristics and company features, there may be differences when conducting internal knowledge integration and operations as well as in the interaction of constructs of the innovation forms. The study by Chen, et al, (2006) points out differences caused by different industrial characteristics and company features, thus hypothesis 5 is proposed as follows:

- *H5:different company characteristics show significant differences among the constructs*

3. Methodology

3.1. Research framework

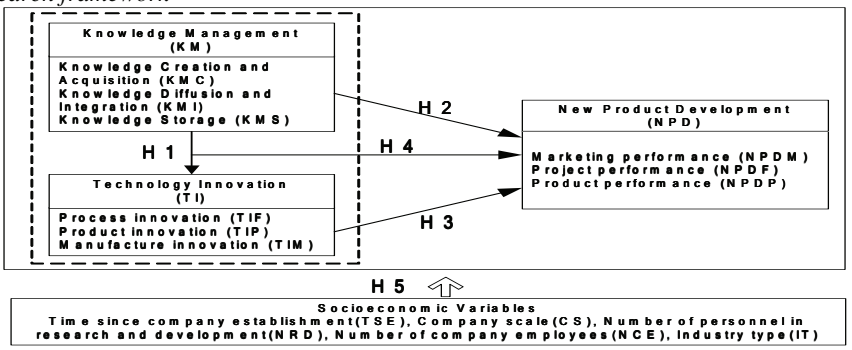

Fig. 1. Research framework

3.2. Operational definitions of variables and measurement

In this study are primarily based on review of previous literature, and refers to research procedures and limitations of foreign and domestic scholars. These are developed according to the research purposes of this thesis, carefully considering the choices and definitions of the variables in order to benefit research significance. In addition, considering the willingness to fill out the questionnaire, the number of questions was lowered as much as possible. In terms of item design, the Likert 5-point scale is used. The operational definitions of the variables are as follows: (1)KM is based on the studies of various scholars (Nonaka & Takeuchi, 1995; Grant, 1996; Beckett et al., 2000) for exploration, dividing KM into three variables, including: five categories including KMC, KMI and KMS with a total of 15 questions; (2)TI is based on the studies of various scholars for the usage of TIF, TIP and TIM as research variables, referring to the related measurement indicators by Tsai (1997) and Chuang (2002) as the operational variables, with 15 questions in five question categories; (3) as for the evaluation of NPD performance, the viewpoints of Olson et al. (1995) and Verona (1999) are used as the foundation, dividing the measurement variables of NPD performance into three variables, which are: 5 questions in NPDM, 8 questions in NPDF, and 7 questions in NPDP, referring to the measurement variables of other scholars; (4) socioeconomic variables are used to measure the nominal scales, including *time since company establishment*(TSE), *company scale*(CS), *number of personnel in research and development*(NRD), *number of company employees*(NCE), *industry type*(IT), for a total of 5 items.

3.3. Research Subjects and Sampling Design

The research population of this study includes the manufacturing factories of the Taiwanese machine tools industry and related component manufacturing. According to the statistical data from the Taiwanese machine tools general directory of 2010, there are currently around 1,200 machine tools and components factories, and 20% or 240 of these companies are used as survey samples for the questionnaire. The implementation method is survey research, and questionnaires are used to collect data to explore the influence of KM and TI on NPD performance, and further explore their correlations. This study uses the stratified random sampling method from among sampling principles, vendors with similar characteristics in the machine tools industry are used in stratifying, dividing them into the two types of key components and manufacturing and processing. Some samples are selected instead of overall implemented survey, and results of the survey are used to deduce overall conditions. In terms of data research, the sample in this study uses on-site survey and postal questionnaires, and the questionnaire subjects are primarily heads of research and development departments or senior engineers in research and development.

4. Research Results Analysis

4.1. Samples Collections

After completing the draft of the questionnaire in this study, the machine tools vendors and scholars familiar with the author are invited to engage in pre-test activities surrounding the questionnaire. The main intention of this is in hopes that the experts and scholars can focus on the questionnaire items that may be confusing or difficult to understand, so they can be modified, in order to lessen the obstacles encountered when filling out this questionnaire, and these can be applied to the release and retrieval of the questionnaire and well as its empirical analysis. In terms of data collection, a portion of samples in this study utilize on-site surveys (20%), another portion is conducted using postal questionnaires (80%). 109 questionnaires were retrieved, and 5 invalid questionnaires are discarded, so there are 104 valid samples with a valid retrieval rate of 43.3%.

4.2. Sample structure and analysis of reliability and validity

In terms of sample validity of the retrieved questionnaires, since the measurement of variables all refer to exploration of related literature, and department heads who participate in research and development as well as senior engineers are invited to fill them out, so there is a considerable degree of validity. In terms of reliability, this study uses item analysis to discard items without significant difference, and uses principal component analysis to calculate the Cronbach's α value (as in Table 1), which are all greater than 0.7, so there is considerable reliability; the correlation analysis also shown in Table 1.

Table 1. Reliability analysis of variables and Pearson Correlation

Variable	α	Means	St. D	KMC	KMI	KMS	TIM	TIP	TIF	NPDM	NPDF	NPDP
KMC	0.868	3.629	0.716	1								
KMI	0.832	3.776	0.621	.612***	1							
KMS	0.801	3.744	0.632	.575***	.615***	1						
TIM	0.833	3.529	0.659	.626***	.515***	.437***	1					
TIP	0.893	3.591	0.616	.606***	.636***	.522***	.618***	1				
TIF	0.847	3.504	0.642	.473***	.457***	.460***	.478***	.496***	1			
NPDM	0.909	3.639	0.647	.311**	.277**	.169	.359***	.540***	.350***	1		
NPDF	0.849	3.502	0.623	.622***	.509***	.451***	.657***	.636***	.553***	.475***	1	
NPDP	0.879	3.394	0.706	.472***	.380***	.393***	.417***	.588***	.513***	.583***	.621***	1

*P＜0.05, **P＜0.01, ***P＜0.001 (samples＝104)

4.3. Using regression analysis to verify hypotheses

- *H1,H2: KM has a significant positive effect on TI and NPD performance*

The results of analysis show that Table 2, the coefficients of model 1 reached significant effect, which means that there is a significant linear correlation between KM and TI, which also means that KM has a significant positive effect on TI. Coefficients in models 2, 3, 4 are also significant, which means KM has a significant positive effect on TIM, TIP, TIF thus this supports H1. The coefficients in models 5, 6, 7, and 8 reach significant effect, which means that the linear relationship between KM and NPD performance is significant, thus this supports H2.

Table 2. Regression analysis of KM to TI and NPD performance

Variable	Model 1 (TI)	Model 2 (TIM)	Model 3 (TIP)	Model 4 (TIF)	Model 5 (NPD)	Model 6 (NPDM)	Model 7 (NPDF)	Model 8 (NPDP)
Constant	0.999	0.978	0.802	1.216	1.559	2.406	1.053	1.215
KMC	0.420***	0.486***	0.313**	0.241*	0.443***	0.253*	0.545***	0.334**
KMI	0.299**	0.194	0.376***	0.180	0.159	0.174	0.148	0.084
KMS	0.144	0.038	0.110	0.211	0.047	-0.088	0.046	0.149
F	42.899***	24.228***	31.573***	13.840***	17.385***	4.243**	28.026***	11.014***
R^2	0.563	0.421	0.486	0.293	0.343	0.113	0.457	0.248
Adj. R^2	0.550	0.404	0.471	0.272	0.323	0.086	0.440	0.226

*P＜0.05, **P＜0.01, ***P＜0.001

- *H3,H4: KM and TI have a significant positive effect on NPD performance*

The results of analysis show that Table 3, the coefficients in models 9, 10, 11, and 12 also reach significant levels, which means TI has a significant positive effect on the variables of NPD performance, including NPDM, NPDF and NPDP thus this supports H3. The coefficients in models 13, 14, 15, 16 have reached significant effects, which means that the linear relationship between KM, TI and NPD performance is significant, and has a significant positive effect on aspects of NPD performance, such as NPDM, NPDF and NPDP, thus this supports H4.

Table 3. Regression analysis of KM, TI, and NPD performance

Variable	Model 9 (NPD)	Model 10 (NPDM)	Model 11 (NPDF)	Model 12 (NPDP)	Model 13 (NPD)	Model 14 (NPDM)	Model 15 (NPDF)	Model 16 (NPDP)
Constant	0.736	1.343	0.427	0.439	0.847	1.673	0.394	0.474
KMC					0.180	0.017	0.300**	0.146
KMI					-0.092	-0.077	-0.024	-0.125
KMS					-0.065	-0.181	-0.031	0.043
TIM	0.142	0.012	0.363***	0.005	0.098	0.038	0.260**	-0.034
TIP	0.485***	0.481***	0.297**	0.439***	0.494***	0.570***	0.225*	0.438***
TIF	0.251**	0.106	0.232**	0.293**	0.255**	0.159	0.200*	0.280**
F	42.166***	14.344***	41.722***	23.251***	21.938***	7.996***	24.017***	11.988**
R^2	0.558	0.301	0.556	0.411	0.576	0.331	0.598	0.426
Adj. R^2	0.545	0.280	0.543	0.393	0.549	0.290	0.573	0.390

*P＜0.05, **P＜0.01, ***P＜0.001

4.4. Variance analysis of the various variables

This section explores whether different “socioeconomic variables” in companies in the machine tools industry show differences to the various variables of this research. The results of analysis show that Table 4, company variables such as IT, CS, and TSC has been established don’t show significant differences for the various variables. However, the different NCE and NRD and development show significant differences in the variables of KM, TI and NPD performance, so it partially supports H5.

Table 4. ANOVA and T-test variance analysis of the research variables

Variable	IT	NRD	NCE	CS	TSE
KMC	1.670	10.454***	6.012**	1.982	0.154
KMI	0.964	8.329***	10.972***	2.050	0.828
KMS	0.054	3.961**	4.390**	0.147	1.017
TIM	0.484	5.676***	6.549***	1.869	0.034
TIP	0.072	5.232***	5.647**	1.239	0.909
TIF	0.451	3.829**	1.490	1.586	1.084
NPDM	0.077	4.037**	6.348**	2.107	0.615
NPDF	1.018	4.813**	7.885***	2.553	0.536
NPDP	0.000	2.435	2.868*	0.586	1.7

*P＜0.05, **P＜0.01, ***P＜0.001

5. Conclusions

This study explored the correlation of variables KM, TI and NPD performance in the machine tools industry. Based on the results of empirical analysis, this section discusses the main findings and important implications. In terms of KM and TI, aspects of KMC and KMI in the construct of KM have a significant effect on TI, and it can be known that in the process of KM, the creation, acquisition, diffusion, and integration of knowledge is correlated to TI; the empirical research results of regression analysis show that among variables of KM, the two important elements including KMC and KMI can affect the performance of TI, which is consistent with the views of Anderson (2003), that managing the diffusion and transmission of knowledge within corporations can promote organizational speed and quality of TI. It also proves the views of Nonaka & Takeuchi (1995) that innovation is the operation of the knowledge spiral, and results from the interaction between organizational latent knowledge and exhibited knowledge. It represents the cognition in the machine tools industry; in order to have TI, the process of knowledge creation and acquisition and knowledge diffusion and integration is indispensable.

In addition, in terms of KM and NPD performance, in the construct of KM, only KMC has a significant effect on NPD performance. In the process of KM, knowledge acquisition is correlated to NPD performance; empirical research results of regression analysis show that, among the variables of KM, only the element of KMC would affect NPD performance. This is consistent with Twiss (1986) there are two variables for good results in product development: the knowledge of corporate research and development personnel, latent and exhibited, including customer needs that exist as latent knowledge. This means that cognition in the machine tools industry requires good NPD performance, and it is indispensable in the knowledge acquisition process of related knowledge.

In terms of TI and NPD performance, in TI, TIP and TIF has a significant effect on NPD performance. Companies that are proactive in product and procedural innovation correlate with the performance of NPD. Empirical research results of regression analysis show that in TI, TIP and TIF would influence NPD performance. This is consistent with the study by Walsh & Linton (2002) in industrial product organizations; higher degrees of TI are beneficial for better performance by new products. This is consistent with Guan et al. (2006) the improvement in TI can enrich the competitive ability and performance of an organization. This means that in the cognition of the machine tools industry, those who can continue TI, or those who can continue to innovate in products and procedures, there would be a clearer influence on elevating NPD performance.

In terms of the overall model, empirical research results of regression analysis show that, KM and TI would influence NPD performance, which conforms to the views of Afuah (1998) innovation is the elevation of corporate ability in applying knowledge, and in turn developing new products and new services to create corporate value. This is consistent with Anderson (2003) that the diffusion and transmission of knowledge managed by corporations can promote the speed and quality of organizational TI. This is because elevation of TI ability also enhances the ability and speed of corporate NPD, and in turn constructs the corporation's competitive advantage. This means that in the cognition of the machine

tools industry, knowledge acquisition and elevation of product innovation and procedural innovation, it can predict and have a significant positive effect on NPD.

In terms of variance, analytical results of the study show that when the NCE increases, the NRD would also increase, so in the promotion and implementation of KM, or in TI and NPD performance, larger companies outperform companies with fewer employees in research and development; this also conforms to the views relating to "economies of scale."

References

[1] Afuah, A. *Innovation management: Strategies, Implementation, and Profits.* NY: Oxford University Press; 1998.

[2]Andrson U. Managing the transfer of capabilities within multinational corporations: The dual role of the subsidiary. *Scandinavian Journal of Management*; 2003, p. 425-442

[3]Beckett AJ, Wainwright CER, Bance D. Knowledge management: strategy or software? *Management Decision*; 2000, p. 601-606

[4]Carrillo JE, Gaimon C. Managing knowledge-based resource capabilities under uncertainty. *Management Science*; 2004, p. 1504-1518

[5]Chen CC, Chang SC, Wang SL. The Study of Influence on Technological Innovation Strategy and Innovation Performance in Taiwan, *Chaoyang Business and Management Review;* 2006, p. 21-52

[6]Chou YH, Zhang ZG, Liu KJ. A Study on the Motive Mechanism of Knowledge Management in the Process of Enterprise Technological Innovation. *R&D Management;* 2004, Vol. 16, p. 201-204

[7]Chuang LM. *An Empirical Study on the Construction of Organizational Innovation Model in Taiwanese Information and Electronic Industry*, National Cheng Kung University Department of Business Administration Doctoral Dissertation; 2002.

[8]Cooper RG. New products: The factors that drive success. I*nternational Marketing Review*; 1994, p. 60-76

[9]Gan LM, Pan H, Liu JJ, Chen. Studies in technological knowledge management of the corporation. *Studies in Science of Science;* 2003,Vol.21 No.2 p.15-22

[10]Grant RM. Toward a knowledge-based theory of the firm. *Strategic Management Journal*; 1996, p. 109-122

[11]Guan JC, Yam RCM, Mok CK, Ma N. A study of the relationship between competitiveness and technological innovation capability based on DEA Models. *European Journal of Operational Research*; 2006, Vol.170, p.971-986

[12]Koskinen KU, Pihlanto P, Vanharanta H. Tacit knowledge acquisition and sharing in a project work context. *International Journal of Project Management;* 2003, p. 281-290

[13]Leonard-Barton D, Gore C, Core R. A Paradox in Managing New Product Development. *Strategic Management Journal;* 1992, p. 111-125

[14]Liu CY, Fu QF, Li FZ. The Impact of Knowledge Management Capability on the Performance of New Product Development. *Journal of Sun Yatsen University;* 2002. Vol.42, p.119-127

[15]Nonaka I, Takeuchi H. *The Knowledge-Creating Company.* New York: Oxford University Press, 1995.

[16]OECD. *OSOL MANUAL.* The Measurement of Scientific and Technological Activity, 1997.

[17]Olson EM, Orville CW, Roben WR. Organizing for New Product Development: The Moderating Role of Product Innovativeness. *Journal of Marketing;* 1995, p. 48-62

[18]Oliver N, Dostaler I, Dewberry E. New Product Development Benchmarks: The Japanese, North American, and UK Consumer Electronics Industries, *The Journal of High Technology Management*; 2004, Vol.23, p.371-388.

[19]Petroni A, Panciroli B. Innovation as A Determinant of Suppliers' Roles and Performances: an Empirical Study in The Food Machinery Industry, *European Journal of Purchasing & Supply Management;* 2002, Vol.8, p.135-149.

[20]Taiwan association of machinery industry, http://www.tami.org.tw/

[21]Tsai CT. *Organizational Factors, Creativity of Organizational Members and Organizational Innovation.* Nation Taiwan University Department of Business Administration Doctoral Dissertation;1997.

[22]Twiss B C. *Managing Technological Innovation*, New York: Pitman, 1986.

[23]Verona G. A Resource-Based View of Product Development. *The Academy of Management Review;* 1999, Vol.24, p. 133

[24]Walsh S, Linton JD. The Measurement of Technical Competencies. *Journal of High Technology Management Research;* 2002, Vol.13, p. 63-86

[25]Zack MH. Developing a knowledge strategy. *California Management Review;* 1999, p. 125-145