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An Empirical Study of Technological Innovation, Organizational Structure and New Product Development of the High-tech Industry

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Abstract: This study considers the technological innovation, organizational structure and new product development of the Taiwanese semiconductor industry through analysis of a questionnaire survey. This study discovered that there are positive correlations between the three variables; different patterns of technological innovation have a significant impact on new product development, with an advantage being given to radically innovative companies. Apart from having a significant impact on technological innovation, organizational structures' independent variables could have an impact on new product development.

Key words: Competitive advantage, high-tech industry, organizational innovation

INTRODUCTION

Technological innovation is more and more important for the Integrated Circuit industry. Knowledge based capital provides a growing margin for companies in a modern economy. Technology, as an intangible asset, is becoming a critical factor for the survival and competition among companies of the IC industry (Ruiz-Mercader *et al*., 2006; Chung *et al*., 2010). Zahra and Bogner (2000) suggest that technological innovation may have an impact on the industry's structure or competitive advantage, as well as being an important edge for a company willing to challenge a well established competitor. Therefore, the widespread application of technology can be an important factor in structuring an industry, technological innovation can provide a competitive advantage for a company or even increase the profitability of all the companies within the industry.

While analyzing the impact of technological innovation for new and successful products, several researchers (Zahra, 1996; Zahra and Bogner, 2000; Cooper, 2000; Sofuoglu *et al*., 2007; Liu and Tsai, 2007) have also been studying how it impacts competitive advantage or changes existing rules by introducing new products or processes, sometimes even re-defining the frontiers of an industry. Moreover, by implementing a strategy for technological innovation, allocating the technical resources needed to achieve performance and by using technology to create a competitive edge; companies can create barriers to entry or attract new customers by introducing new products or processes (Utterback, 1994). Within a labor intensive industry, to be able to launch new products and survive, competition requires a certain level of technological development, however, this is not a guarantee of commercial success; satisfying communication and cooperation between internal services of the organization and teamwork are also needed. Le Pine *et al*. (2000) find that cooperation between the Marketing and the R and D department is especially important. Fluent internal communication and a sound cooperation between services are fundamental (Mathieu *et al*., 2000). Consequently, while increasing new product development, companies should not forget to reflect upon organizational issues, such as: building internal communication channels, emphasizing personnel skill-development and the measurement of cooperation between services. As much as it is complex, new product development strategy has always been one of the most considered and broadly studied topics, whether it is on the practical or the theoretical field. A successful company will have to combine equal skills in managing technological innovation and organizational structure.

This study implemented a questionnaire survey on the IC manufacturers in the semiconductor industry in Taiwan to collect empirical data, in order to discuss theoretical issues such as the relationship between a company's technological innovation, organizational structure and its performance in new product development. The scope and target issues of this study include: (1) the relationship between a company's technological innovation, organizational structure and its performance in new product development (2) whether

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different patterns of technological innovation and organizational structure can have a significant impact on a company in terms of technological innovation and new product development; (iii) discussing which aspects of a company's technological innovation or organizational structure might influence new product development.

Technological innovation: Rosenberg and Frischtak (1985) affirm that a company's technological capability is acquired through the process of designing and making new products. It is also the sum of the company's experience in problem solving through its existence. As a consequence, improving data collection and processing it means increasing its technological capability as well. Technology is an intangible asset, allowing its survival in a competitive environment. Apart from being the result of experience in production, manufacturing and R and D, being a good representation of a company's production skill is also a good indicator of a company's management and internal communication skills (Wong, 1995; Silva and Takeda, 2005; Akarsu, 2011). As described by Patel and Pavitt (1997), technology is actually one of the main sources of competitive advantage for a company. Within the same industry, companies with a technological edge will have better profitability, as well as being faster in developing new product lines or other technological innovation. According to numerous studies related to resource-based theory, such as Gallon *et al.* (1995) and Andersson (2003), technological innovation is at the core of the company's competitive capability. Gallon *et al.* (1995) suggest it is the most important core asset. Hafeez *et al.* (2002) attest that a company should develop its competitive edge, in order to acquire long lasting competitive advantages. Companies need to be constantly aware of the changing environment while keeping and developing new technological capabilities in order to survive. In a study by Walsh and Linton (2002), technological innovation is a unique technique or manufacturing process owned by a company which allows it to react quickly to an environmental shift. Burgelman *et al.* (2004) indicate that technological innovation designates the capability of an organization to choose, use, diffuse and then improve a technology; as such it is a progressive process of experience accumulation including the use of the technology, the improvement and application of existing technology and the independent development of new ones.

Yam *et al.* (2004) state that technological innovation is the skill involved in realizing and supporting a company's technological innovation strategy. As such, it is a specific asset or resource which includes technology, products, expenditures, processes, knowledge and experience. In their study, they also propose seven dimensions for measuring technological innovation which are: technological learning, R and D, resource allocation, manufacturing ability, marketing skill, organizational skill and strategic and scale related ability. Archibugi and Coco (2005) point out that technological innovation is the ability to access and digest external knowledge into some unique skill or knowledge, then using it in a dynamic way to improve or develop a new product and launch it successfully. Therefore, it includes capability in product, process and personnel technology. In a document about technological innovation, Guan *et al.* (2006) while confirming the research results above, also remark that technological innovation is the combination of knowledge, techniques and management skills from different areas; by strengthening these areas the company can build its organizational competitiveness.

Consequently, one can see that technological innovation is a multi-dimensional concept which tackles the diffusion and application of technology in order to acquire commercial benefits. To sum up the point-of-view of the researchers mentioned above, technological innovation is the way in which an organization can efficiently select, implement and use a technology in comparison with a competitor. It may include the professional knowledge necessary for designing, manufacturing and assembling a product or the efficiency of the personnel in using the tools of production. It is indeed an integrated process incorporating manufacturing, production, R and D, expenditure, management and marketing functions in the company. This study analyzes new product development, in order to discover the essential aspects in technological innovation which can help companies to excel. Through understanding the studies above, this study found the following four factors to be relevant research variables: (1) the experience of technical staff, (2) the output standard, (3) the manufacturing equipment and (4) the provided budget.

Empirical and theoretical studies have shown that in a product-oriented company, having a different technological policy or strategy will result into a different level of technological innovation, thus having an impact on the new product development. Abernathy and Clark (1985) distinguish two types of technological innovation: radical product innovation and incremental product innovation. The first ones are based on the maximization of product performance, whereas the second one is based on small improvements of a product, a service or a production process. McDonough (1993) differentiates degrees of technological capability and indicates that the implementation of different types of innovation which is

to say routine or radical innovation, have a significant impact on new product development performance. Moreover, Stock *et al.* (2003) in a study about firm size and dynamics of technological innovation, affirms that product technological innovation is the result of using an innovative core technology in order to improve a product, a service or the production process of those goods.

A strategy using radical innovation may have an impact on the entire industry or even create a wave of industry-wide innovation (Marquis, 1982). Subrahmanya (2005) while studying European and American SME innovation types, also makes a distinction between continuous and disruptive innovations and between radical and incremental innovations, however, whatever the type of technological innovation, it will have an impact on the development of a new product or the improvement of an existing product. This is to say that companies with different patterns of technological innovation will have different performance in product innovation, with a clear advantage going to the radical innovation. In brief, a company built upon a core product technology, different thinking in its technological policies and strategies will result in a difference in its technological innovation, as well as a difference in new product development. In this study, quote Abernathy and Clark (1985), McDonough (1993), Stock *et al.* (2003) and Subrahmanya (2005) and several studies for reference in the argumentation to verify the hypothesis, by distinguishing two types of innovation: product technological breakthrough and process incremental innovation.

Organizational structure: Organizational structure is the necessary division of work and establishment of communication channels which allows an organization to reach its goal. It is often characterized as a combination of vertical and horizontal layers (Mintzberg, 1993) and can be used to describe a specific organization: how it is divided into services or functions with different fields of responsibility. Through structural engineering, management can define organizational goals and how to achieve them (Khatri and Budhwar, 2002). Robbins (1990) also considers that organizational structure designates division of work, cooperative mechanisms and orderly interactions, integrated into an organizational learning pattern. Consequently, Dodgson (1993) affirms that organizations encourage their personnel to learn through a structured strategy. Thus, organizational learning, as a whole, is the result of personnel's learning capability and attitude (Morgan and Rramirez, 1984; Fiol and Lyles, 1985; Levitt and March, 1988). Hult and Ferrell (1997) designed 17 organizational learning measurement scales by surveying personnel participation to the learning process. There are four divisions: team oriented, organization oriented, learning oriented and memory oriented (Hult *et al.*, 2000).

Kerfoot (2003) indicates managers must assume the roles of leader as well as the one of educator. They must grow with their staff and the organization. As a consequence, managers have to consider these four aspects while designing the organizational structure: (1) Decision making: whether employees will have a say or is every decision made by upper level management (2) Communication process: is the communication bottom-up? (3) Incentives: do the performers get the best incentives? (4) Degree of care toward personnel: does the company care about employee working environment, their mental and physical health or is it result-oriented, thus ignoring the costs of human resources. Through the studies mentioned above, one can see that the definition of organizational structure characteristics can greatly vary between different researchers. To define organizational structure characteristics as a combination of the number of layers in hierarchy, the relationship between employees and managers, the level of participation of the employees in the decision-making process and finally the interactions between services and participants of vertical and horizontal integration (Hult and Ferrell, 1997; Kerfoot, 2003; Al-Muharfi, 2010).

Studies about the impact of organizational structure on company performance usually make a distinction between three variables in an organization's structure: formalization, specialization and centralization (Matsuno *et al.*, 2002; Nanimi and Nezhad, 2009). Nahm *et al.* (2003) indicate five variables in describing organizational structure characteristics: (1) Nature of formalization: discussing whether systematic conformism to the existing rules and processes among employees will reduce the ability to innovate, learn or be autonomous. (2) Number of levels in hierarchy. (3) Level of horizontal integration: related to the degree of specialization of each service on the same level, the higher the specialization, the lower the level of horizontal integration. (4) Level of decision making: at which level are decisions made? (5) Level of communication: including horizontal and vertical communication. In this study, distinction between decentralized and centralized organization will be used. Decentralized organizations have a reduced number of levels in the hierarchy, a low degree of concentration, fewer formalized rules, a wide range of control, horizontal communication consisting of advice giving and information sharing, relationships based on cooperation and interaction. Meanwhile, centralized organizations have a high number of levels in the hierarchy, a high

degree of concentration, many formalized rules, a narrow range of control, vertical communication consisting of guidance giving and decision making, relationships based on regulations and independent roles.

New product development: Concerning the relationship between organizational structure characteristics and new product development, Thomas (1993) suggests that leaders should unify organizational members, set up a new product development team and encourage the personnel to achieve their goals, at the same time; a smooth interaction within the organization will also have a certain impact and help the development of the new products. Souder *et al.* (1998) have reached the same conclusions concerning the relationship between inter-service integration and new product development, in noting that the integration of R and D and marketing services and the interdependency of those services have been repeatedly cited as being critical to the success of product development. Consequently, in this study, we will select the most commonly used aspects for our analysis which are: (1) organizational flexibility mechanism (2) a leader in the concept (3) manager's capabilities (4) interaction and integration between services.

Much of the empirical literature agrees that the relationship between organizational structure and technological innovation is interdependent. Damanpour (1991) documented that there was a positive correlation between functional differentiation and technological innovation, whereas vertical differentiation has a negative impact on innovation because of the number of hierarchical levels which can become an obstacle to communication and creativity. Knott *et al.* (1996) point out that technology is one of the characteristics of an organization depending on some external and internal factors; it can more or less transmit values within the organization. Karaomerlioglu (1998) on the other hand emphasized that technology should not be considered separately with other dimensions of the organization, such as management, investment, internal communication or marketing. A smooth integration of technology into the organization can optimize the benefits for an organization. Wang *et al.* (2004) suggest connecting internal resource with external knowledge, thus creating value-adding capability. In an organization in favor of innovation, it is then possible to exploit employee potential creativity, while a flattened hierarchy will allow unrestricted communication at greater speed, thus permitting the organization to collect market information quickly and integrate the information with internal technology and resources, in order to make their product better suited to the needs of their customers in comparison with their competitors (Tuominen *et al.*, 1997). As a consequence, the more innovative the atmosphere of an organization, the better interaction there is between personal or team creativity and this innovative working environment (Amabile, 1997).

New Product Development (NPD) is the processing of market demands information into production knowledge (Oliver *et al.*, 2004; Mohammadjafari *et al.*, 2011). However, concerning the task of evaluating and measuring performance, researchers are still divided. For example: Cooper and Kleinschmidt (1996) distinguish 10 standards of measurement, including the rate of successful product and sales speed in order to find the key factors in product development. Bowersox *et al.* (2000) suggest performance indicators such as customer satisfaction, cost management, quality, productivity and asset management for product development, emphasizing on the need to apply corrective action as soon as one of the indicators goes the wrong way. And Im and Workman (2004) measure market orientation, creativity, new product performance, high tech industry should use comparative market shares, sales numbers, return on investment, profitability and corporate global goal achievement rate as indicators. Along with the studies mentioned above, this study will measure new product development performance of the Taiwanese IC industry, according to its actual and future developmental needs, by (1) corporate global performance (2) the performance of market development (3) sales performance and (4) the performance of customer satisfaction.

To wrap-up the findings of the studies mentioned above, different organizational structures clearly have an impact on a company's technological innovation. As companies have different organizational structures and reactions toward the environment, organizational structure is different; consequently, its employee technological innovation will also be different, thus having an impact on new product development. As a consequence, the articulation between organizational structure and technological innovation while being the subject of this theoretical study is also of great concern to practitioners in the semiconductor industry.

MATERIALS AND METHODS

Research structure: Along with this research goals, the literature review above and studies by Karaomerlioglu (1998), Kerfoot (2003), Wang *et al.* (2004) and Subrahmanya (2005), the following research framework has been decided to discuss how different types of technological innovation and organizational structure as independent variables can impact new product development as dependent variables (Fig. 1).

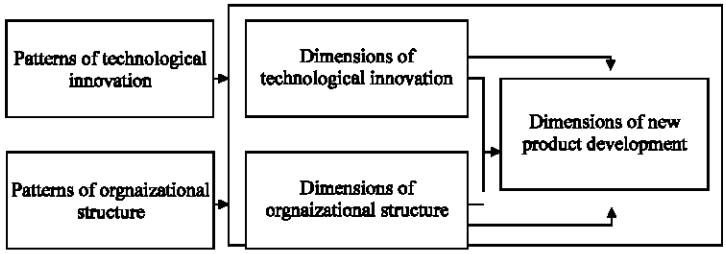

Fig. 1: Research framework

Research hypotheses: In order to discuss the importance of technological innovation within companies, as well as the relationship between organizational structure and new product development, this study along with the research framework cited above, will propose the following 9 hypothesis for verification:

- **Hypothesis 1:** Technological innovation, organizational structure and new product development are significantly related
- **Hypothesis 2:** Different patterns of technological innovation have significant impacts on dimensions of technological innovation
- **Hypothesis 3:** Different patterns of technological innovation have significant impacts on new product development
- **Hypothesis 4:** Different patterns of organizational structure have significant impacts on dimensions of technological innovation
- **Hypothesis 5:** Different patterns of organizational structure have significant impacts on new product development
- **Hypothesis 6:** Different patterns of technological innovation and organizational structure have significant impacts on new product development, with a clear advantage being given to disruptive and decentralized innovative organization against the three other patterns of innovative organization
- **Hypothesis 7:** Technological innovation as an independent variable has a positive and significant correlation with new product development
- **Hypothesis 8:** Organizational structure as an independent variable has a positive and significant correlation with new product development
- **Hypothesis 9:** Technological innovation and organizational structure as independent variables have a positive and significant correlation with new product development as a dependent variable
- **Hypothesis 9-a:** Four independent variables of technological innovation have a positive and significant correlation with new product development
- **Hypothesis 9-b:** Four independent variables of organizational structure have a positive and significant correlation with new product development

Research variables

Technological innovation: When measuring technological innovation variable, this study will consider each variable using the five point Likert scale, giving 1~5 points which corresponds with answers ranging from 'strongly disagree' to 'strongly agree'. For the measurement of dimensions of technological innovation, this study is based on Burgelman *et al.* (2004), Archibugi and Coco (2005) and Guan *et al.* (2006).

Organizational structure: When measuring organizational structure variable, this study will consider each variable using the five point Likert scale, giving 1~5 points which corresponds with answers ranging from 'strongly disagree' to 'strongly agree'. When measuring organizational structure, this study will use the most common dimensions defined by Kerfoot (2003).

New product development: When measuring new product development variable, this study will consider each variable using the five point Likert scale, giving 1~5 points which corresponds with answers ranging from 'strongly disagree' to 'strongly agree'. When measuring new product development, this study uses the dimensions defined by Cooper and Kleinschmidt (1996), Bowersox *et al.* (2000) and Im and Workman (2004).

Empirical analysis

Questionnaire design: This study used the IC manufacturers in Taiwan's semiconductor industry as the original sample based on the 2008 catalog of the TEEMA (Taiwan Electrical and Electronic Manufacturers Association). The sampling was conducted by picking one of every five companies in the catalog; 400 companies were selected this way for the study's sample pool. Apart from the three measured dimensions which are technological innovation, organizational structure and

new product development, our questionnaire has a fourth part for keeping a record of the participating company's basic data. All items of the three studied dimensions were measured using the five point Likert scale in order to understand innovation and its impact in the semiconductor industry in Taiwan.

Statistical analysis: For this study, we have mainly used the SPSS for Windows 12.0 software pack as our statistical analysis tool for all the data. First, we used Pearson's analysis to verify the relationship between technological innovation, organizational structure and new product development and then we used t-testing, ANOVA and regression analysis to verify our hypothesis. In this study, we have made a descriptive statistical analysis for each variable, using the technological innovation total score to classify companies into a high score group and a low score group. Also a distinction was made about technological innovation patterns, differentiating them as radical or incremental. For organizational structure, it was differentiated decentralized and centralized organizations into two groups. Afterwards, using discriminate analysis to separate technological innovation and organizational structure patterns into two groups each, evaluating the coefficient of their discriminative function and then using Wilks' Lambda distribution as a reference to find the discriminative function. When Lambda's value is close to 0, it means that the averages of each sample pool are quite different. In this study, when using Wilks' Lambda distribution, the study obtained a Lambda value of 0.353 and 0.325 with a degree of significance of 0.000 which means that our classification of technological innovation and organizational structure have pointed out two groups of companies with quite significant performance variation. Table 1 and 2 show that the discrimination rate is, respectively 98.7 and 94.3%, indicating that our classification of technological innovation and organizational structure, after going through a discriminate analysis, shows a high discriminative ability meaning that the groups are significantly differentiated.

In this study the author has constructed research variables for measurement according to the studies already mentioned. As a measure of reliability Cronbach α was used to measure the internal consistency of the study. For Cooper and Emory (1995) if Cronbach α is between 0.7~0.98, then the reliability is higher but if it is lower than 0.35, then the results are not reliable and should be refused. For this study, Cronbach α are 0.9388 for technological innovation variable, Cronbach α = 0.9091 for organizational structure variable and Cronbach α = 0.8597 for new product development variable. Consequently, the results of the survey are all well within the parameters of reliability.

Table 1: Theoretical and empirical classifications of technological innovation

	Theoretical		
Empirical	Radical	Incremental	Total
Radical	108 (98.2%)	2 (1.8%)	110 (100%)
Incremental	7 (7.1%)	92 (92.9%)	99 (100%)
Total	115 (55.02%)	94 (44.98%)	209 (100%)

The rate of correct discrimination is (108+92)/209 = 95.7%

Table 2: Theoretical and empirical classifications of organizational structure

	Theoretical		
Empirical	Decentralized	Centralized	Total
Decentralized	113 (95.0%)	6 (5.0%)	119 (100%)
Centralized	6 (6.7%)	84 (93.3%)	90 (100%)
Total	119 (56.94%)	90 (43.06%)	209 (100%)

The rate of correct discrimination is (113+84)/209 = 94.3%

RESULTS AND DISCUSSION

The study only processed empirical analysis on the IC manufacturing industry. Its conclusion may not be able to represent all semiconductor industries. The study framework constructed by the study may have processed empirical analysis on Taiwan's IC industry, however the semiconductor industry is an industry that involves a wide range and continuously expands the field along with the technology development. It is not easy to process objective analysis and comparison between different industries and therefore the study selected the IC manufacturing industry as the study object and issued 400 questionnaires. There are 227 questionnaires collected and 18 are invalid, 209 are effective and the questionnaire recycle rate is 52.25%.

The relationship between technological innovation, organizational structure and new product development: In order to verify hypothesis 1, this study used K. Pearson's product-moment correlation analysis, to outline the relationship between technological innovation, organizational structure and new product development. Table 3 shows the positive correlation which exists between these three dimensions. These results support research hypothesis 1.

Impact of different patterns of technological innovation on dimensions of technological innovation: By using t-testing on the 4 variables of technological innovation (Table 4), the study discovered that companies with a pattern of radical innovation have an edge in their technological innovation when compared with companies with a progressive innovative pattern. Their personnel also have better scores in terms of the experience

Table 3: Relationship between three variables

Variables	Technological innovation	Organizational structure	New product development
Technological innovation	1		
Organizational structure	0.842**	1	
New product development	0.913**	0.874**	1

*p<0.05, **p<0.01, ***p<0.001

Table 4: T-testing on the four variables of technological innovation

	Patterns of technological innovation			
Variables	Radical n = 110	Incremental n = 99	T-value	p-value
Experience of technical staff	3.9227	2.6835	17.38	0.000***
The output standard	3.7909	2.6828	17.23	0.000***
The manufacturing equipment	3.8273	2.6035	15.16	0.000***
The provided budget	3.8614	2.5732	16.53	0.000***

*p<0.05, **p<0.01, ***p<0.001

Table 5: Technological innovation on the variables of new product development

	Patterns of technological innovation			
Variables	Radical n = 110	Incremental n = 99	T-value	p-value
Corporate global performance	3.6909	2.4646	14.793	0.000***
Performance of market development	3.4295	2.3990	14.431	0.000***
Sales performance	3.6000	2.2828	13.014	0.000***
Performance of customer satisfaction	3.6564	3.0768	9.068	0.000***

*p<0.05, **p<0.01, ***p<0.001

Table 6: Organizational structure on the variables of technological innovation

	Patterns of organizational structure			
Variables	Decentralized n = 119	Centralized n = 90	T-value	p-value
Experience of technical staff	3.7913	2.7333	153.312	0.000***
The output standard	3.6521	2.7556	126.541	0.000***
The manufacturing equipment	3.7332	2.6056	162.335	0.000***
The provided budget	3.6933	2.6667	114.159	0.000***

*p<0.05, **p<0.01, ***p<0.001

of technical staff, the ability to output, the ability to process and the ability to budget. While using t-testing on the 4 variables of technological innovation, p values were 0.000, meaning that Taiwanese IC manufacturers are actually divided into two groups with different technological innovation. These results support research hypothesis 2.

Impact of different patterns of technological innovation on new product development: To verify research hypothesis 3, t-testing of technological innovation on the variables of new product development was used. Table 5 shows that there is a significant difference between a radically innovative company and a progressively innovative company in terms of corporate global performance, performance of market development, sales performance and customer satisfaction. Radically innovative companies have significantly better new product development; in general, they have better scores in every variable of new product development. As there is fierce competition in the semiconductor industry and the market changes rapidly, only technological innovation can create new competitive advantages for companies (Brown, 1992). This conclusion supports research hypothesis 3, at the same time it also concurs with Subrahmanya (2005) who insists that different patterns of technological innovation have a significant impact on new product development.

Impact of different patterns of organizational structure on dimensions of technological innovation: Decentralized organizational structures perform significantly better in the 4 variables of technological innovation when compared to centralized organizational structures. This result shows that different patterns organizational structure have a significant impact upon dimensions of technological innovation ($p<0.001$). Therefore, the results of supporting research hypothesis 4. Table 6 also indicates that the ability to budget for decentralized organizational structures is better on average compared to centralized ones (3.6933>2.6667). Thomas (1993) indicates that the more frequent communication is between horizontal services and vertical levels of hierarchy, the more the organization will be inclined to innovate; it also states that an organization's internal environment, including interactions between services and expenditure support will both influence the content of the company's

Table 7: Organizational structure on the variables of new product development

	Patterns of organizational structure			
Variables	Decentralized n = 119	Centralized n = 90	F-value	p-value
Corporate global performance	3.5777	2.4917	135.963	0.000***
Performance of market development	3.3361	2.4194	132.481	0.000***
Sales performance	3.5294	2.2444	150.637	0.000***
Performance of customer satisfaction	3.6739	2.9956	128.510	0.000***

*p<0.05, **p<0.01, ***p<0.001

Table 8: Regression analysis of different patterns of technological innovation and organizational structure on new product development

Types	Corporate global performance	Performance of market development	Sales performance	Performance of customer satisfaction
Radical-decentralized	3.7717	3.5000	3.7120	3.7543
Radical-centralized	3.2778	3.0694	3.0278	3.1556
Progressive-decentralized	2.9167	2.7778	2.9074	3.4000
Progressive-centralized	2.2951	2.2569	2.0486	2.9556
F-value	97.415	92.477	85.985	52.600
p-value	0.000***	0.000***	0.000***	0.000***

*p<0.05, **p<0.01, ***p<0.001

innovation. In comparison, the more the personnel are involved in decisions about R and D expenditure, the more budget support it will have, thus increasing the company's technological absorption capability. At the same time, R and D may succeed more easily, having a positive influence on technological innovation (Granstrand, 1998).

Impact of different patterns of organizational structure on new product development: Table 7 shows that the impact of different patterns of organizational structure on new product development is significant, as the p values are equal to 0.000. During the new product development process, the better the interaction with different patterns of organizational structure, the better the performance of the whole process, as there is a positive correlation between the two. Lovelace *et al.* (2001) use the point-of-view (hyphens) of conflict communication to discuss the relationship between 'means of communication' and 'team performance' within the new product development team. Their results show that a cooperative means of communication and a decision making process involving the personnel have a positive impact on the organizational innovation. This result supports research hypothesis 5.

Analysis of the impact of different patterns of technological innovation and organizational structure on new product development: In order to verify research hypothesis 6, this study uses ANOVA with technological innovation and organizational structure as independent variables and new product development as dependent variables. The results are shown in Table 8. Different patterns of technological innovation and organizational structure are divided into 4 types: Radical-Decentralized, Radical-Centralized, Progressive-Decentralized and Progressive-Centralized, then comparing the impact of different patterns of technological innovation and organizational structure on new product development. The findings are as follows:

- When comparing Radical-Decentralized and Radical-Centralized organizations, the former perform better in terms of the 4 variables of new product development, thus indicating that rigid organization structures are obstacles to knowledge exploration and organizational changes (Miller, 1993). Consequently, the more participation in the decision-making process, the faster and sensitive the new product development and the less resistance there will be against change. These results concur with the findings of Baker and Sinkula (1999) saying that organizational learning is favorable to product innovation
- When comparing Progressive-Decentralized and Progressive-Centralized organizations, the former perform better in terms of the 4 variables of new product development. In their study about leadership in the new product development team and its relevance to organizational learning and team-work performance, Sarin and McDermott (2003) indicate that a more democratic leadership in which the leader is an educator as well as a learner, growing with its organization and personnel, will have a positive effect on organizational learning. Therefore, centralized management seems be an obstacle for a timely resolution of technological innovation related problems (Damanpour, 1991). Ruppel and Harrington (2000) the more decentralized the organizational structure, the better the

communication channels will be, at the same time, if the personnel feels being cared for, internal communication will be more fluent, thus improving innovation

- When comparing Radical-Decentralized and Progressive-Decentralized companies, the former perform better in terms of the 4 variables of new product development. Table 8 shows that the 4 types of companies do perform on a significantly different level in terms of all the new product development variables ($p<0.001$). On average, Radical-Decentralized companies perform better than the 3 other types of companies. Slater and Narver, 2000 remark that an organization with an innovative spirit will have an edge when developing new products or searching for new markets, when building a competitive advantage. Audretsch (2004) points out the relationships between entrepreneurial spirit, technological innovation and organizational growth. In particular, it is said that technological and product innovations produced by an innovative organizational atmosphere, can improve operational performance for the company. These results support research hypothesis 6

Impact of technological innovation as an independent variable on new product development as a dependent variable: Table 9 shows that the experience of technical staff has a positive effect upon all the variables of new product development, it is particularly significant in the case of corporate global performance ($\beta = 0.846$, $p<0.001$), with the explanatory value of the regression analysis being 0.986. This means that new product development personnel, with better technological knowledge and experience should adapt more easily to the entire process, thus improving the performance of new product development. Booz *et al*. (1982) findings state that past technological development experiences can diminish the occurrence of new mistakes, thus diminishing developmental costs. The result of this analysis partially supports research hypothesis 7.

Impact of organizational structure as an independent variable on new product development as a dependent variable: Table 10 shows that interaction and integration between services with a p-value of 0.000, has a significant impact on all 4 variables of new product development. Tashman and Nadler (1986) the level of functional integration within an organization will influence its innovative potential, with a strong integration being a synonym of greater innovation. Of course, a good integration between operational teams in a company will bring more operational results (Morgan and Turnell, 2003; Maccoby, 2003). With regard to customer satisfaction, the most significant impact comes from management capability ($\beta = 0.377$, $p<0.001$). Shapiro and Varian (1998) share that the competitive advantage of the high tech industry lies in its ability to launch new products according to the market and the needs of its customers, the best examples being IBM, Microsoft and Intel. Those companies rely on the ability of their upper management to build an organizational culture in favor of knowledge management and innovation, thus empowering knowledge exchanges and cooperation within the organization, also

Table 9: Regression analysis of the impact of technological innovation on new product development

	Dependent variables			
Independent variables	Corporate global performance	Performance of market development	Sales performance	Performance of customer satisfaction
Experience of technical staff	0.846***	0.460***	0.280**	0.387**
The output standard	0.353***	0.242**	0.309***	0.132
The manufacturing equipment	0.179	0.008	0.294***	0.159
The provided budget	0.028	0.247***	0.030	0.132
R^2	0.986	0.816	0.762	0.587
F-value	3720.40	226.11	163.19	74.80
p-value	0.000	0.000	0.000	0.000

*p<0.05, **p<0.01, ***p<0.001

Table 10: Regression analysis of the impact of organizational structure on new product development

	Dependent variables			
Independent variables	Corporate global performance	Performance of market development	Sales performance	Performance of customer satisfaction
Organizational flexibility	0.173*	0.259**	0.095	0.117
Leader nnderstanding	0.236***	0.248***	0.119*	0.162**
Management abilities	0.013	0.095	0.034	0.377***
Interaction and integration	0.525***	0.315**	0.639***	0.254**
R^2	0.715	0.667	0.695	0.688
F-value	118.65	102.37	116.02	112.40
p-value	0.000	0.000	0.000	0.000

*p<0.05, **p<0.01, ***p<0.001

Table 11: Regression analysis of the impact of technological innovation and organizational structure on new product development

	Dependent Variables			
Independent Variables	Corporate global performance	Performance of market development	Sales performance	Performance of customer satisfaction
Experience of technical staff	0.766***	0.425***	0.324*	0.081
The output standard	0.178*	0.169*	0.031	0.421***
The manufacturing equipment	0.371***	0.180**	0.229*	0.131
The provided budget	0.09	0.314***	0.168	0.075
Organizational flexibility	0.095	0.189**	-0.192	0.278***
Leader nnderstanding	0.054	0.031	0.138*	0.135**
Management abilities	0.023	0.007	0.011	0.234**
Interaction and integration	0.316***	0.121	0.578***	-0.095
R^2	0.893	0.867	0.802	0.718
F-value	141.55	135.55	101.53	63.70
p-value	0.000	0.000	0.000	0.000

*p<0.05, **p<0.01, ***p<0.001

increasing organizational and personal learning (Earl and Scott, 1999) leading to their survival and success.

Multinational firms in the modern economy, misunderstandings and even conflicts usually occur between management levels because of cross cultural issues. Consequently, if leadership can enhance organizational learning to avoid misunderstandings and internal rows about organizational goals, it will improve the organization's competitiveness and performance (Milliman *et al*., 2002). Mayfield and Mayfield (2004) find that managers by encouraging personnel and communicating in a positive way boosts innovation; this can also lower the uncertainty involved in the process of innovation. As a consequence, managers play an important part (Daft, 2002). Table 10 shows that leaders in understanding and interaction and integration between services have a positive correlation with new product development. Jamrog *et al*. (2006) indicate an organization with an innovative atmosphere will have a smooth integration of all functions; leadership may also use new ways of thinking in favor of value adding. Ultimately, improving the organizational skills needed in order to be more competitive. Regression analysis shows partial support for research hypothesis 8.

Impact of technological innovation and organizational structure as independent variables on new product development as a dependent variable: This study used regression analysis to verify hypothesis 9. Table 11 shows that the experience of technical staff has the most significant impact on corporate global performance ($\beta = 0.766$, $p<0.001$), as well as a positive correlation with performance of market development ($\beta = 0.425$, $p<0.001$). This suggests that in an era of knowledge management, IC manufacturers should focus their efforts on building a knowledge database, online access, pushing personnel into learning and sharing knowledge, in order to increase the experience of technical staff (Zack, 1999). This result concurs with research hypothesis 7. On the other hand, experience of technical staff, ability to process, a leader in understanding and especially the interaction and integration between services ($\beta = 0.578$, $p<0.001$) have significant impacts on sales performance. Geser (1992) remarked that the horizontal communication within a company is realized mainly through coordination as bridges between different functional services and operational processes or activities. Kahn and McDonough (1997) discover that in a knowledgeable working teanı, coordination and teanı performance are clearly of relevance, efficient coordination and cooperation leading to better results. This result concurs with research hypothesis 8. Table 11 shows that the 4 independent variables of technological innovation have a positive correlation with new product development, thus supporting research hypothesis 9-a. Moreover, the 4 independent variables of organizational structure also present a positive correlation with new product development, thus supporting research hypothesis 9-b.

CONCLUSIONS

It can be seen from Table 3 that the correlation coefficient of technology innovation and new product development is 0.913 ($p<0.01$) after comparing the relationship between technology innovation and new product development and the relationship between organization structure and new product development. Because the correlation coefficient is positive and the value is closer to '1', it means there is a stronger positive correlation between the two variables. It is found through the above mentioned study that Taiwan's IC manufacturing industry should have profound experience and understanding technology innovation and new product development are the necessary conditions which the semiconductor industry must have (Amendola and Gaffard, 1994). Technology innovation is one of the driving factors of industry competition. It is very important for an industry to have core technology

capability in the competitive advantages of the IC industry and it is also the new thinking and development direction in operation management. Therefore, enterprises should also make commitments toward enhancing technology innovation ability, so the new product development performance will be better.

The conclusion can also reflect that when developing the IC industry, Taiwan mostly depends on the Industrial Technology Research Institute, Electronics Research Laboratories and Radio Company of America (RCA) to process technology cooperation in several products and does not obtain the technology by directly contacting foreign manufacturers. Currently, there are many manufacturers who engage in OEM service in Taiwan. However, more diverse, high value-added and technological capacity innovation should be strengthened in the future. Applying ERP (Enterprise Resource Planning) or SCM (Supply-Chain Management), etc. information and management technology and not just relocating in Mainland China to lower the production cost but integrating various related products, having all-round development and production bases all over the world to provide European, American and Japanese customers with the lowest cost is the only way to compete with competitors and obtain the competition advantage regarding new product development performance. The well-known strategy management master Porter (1985) indicates that Taiwan started with the manufacturing industry in the past. The manufacturing and product design capability is undoubtedly, however in the era of new economy and knowledge management, strengthening the speed of product launching the market and technology innovation capability is the necessary condition of enterprises strengthening their competitiveness. Therefore, the Taiwan IC industry should make good use of new Internet technology, be devoted to the enhancement of technology innovation capability and product innovation, get rid of OEM models and positively grasp innovation R and D to meet future challenges.

The empirical result also shows that in the four variables of technology innovation, decentralized organizations are all better than centralized organizations. In the new economic trend, how IC manufacturing industries respond and adjust has become the popular management issue. When facing the impact of global economic downturn, the most crucial issue for IC manufacturing industry is to continue enhancing the R and D capability and organization restructuring of technology innovation, strengthening the improvement of the organization and management system and move towards applying technology as the major body of the industrial structure. Therefore, when enterprises are devoted to technology R and D, the more positive the encouragement attitude the enterprise high-rank managers uphold for the organization members to participate in the decision making level, the more they care and pay attention to the investment operation of technology R and D capability and the better the technology innovation performance they can obtain. It can be found from the study focusing on the impact of different types technology innovations and organization structure on new product development, in the four variables of new product development, Radical-Decentralized organization is better than the other three types which shows that in facing the new economic era, Taiwan's IC manufacturing industry should apply Radical-Decentralized organization, guide the global production marketing system of the domestic semiconductor industry with innovation R and D. In this way, it can effectively improve Taiwan's IC industry to upgrade from manufacturing to the innovative and breakthrough knowledge industry development model.

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