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從產業組織學習狀況探討知識管理之應用

Exploring Knowledge Management Application through Industry Organizational Learning

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摘　　要

全球化以及知識經濟時代，企業所面臨的環境變化遠勝於過往。面對資訊與知識快速傳遞，知識的獲取、傳遞、開創是獲取競爭力的最大利器。面對當前動態且複雜的經營環境，組織學習的導入是為維持企業長期的競爭優勢。導入學習型組織並非一蹴可幾，需搭配導入階段的考量與衡量工具的選擇，然而組織在發展學習型組織的過程中，除了五項修練之外，知識管理亦是一項重要的發展策略。本研究即從二部分來探究，首先從產業角度，探討組織學習於不同產業中，發展的狀況與影響。進而深入組織，以半導體產業為例，實際瞭解知識管理之發展與面對之困境，並尋求一最佳模式，嚐試解決當前之問題。

就產業之分析面來看，高科以及金融產業在推動組織學習成效上，較傳產、服務以及其它產業來的顯著。成熟產業所造成人才的群聚效果，強化知識的獲取與交流，促使組織學習導入成效佳，由此可推論知識管理是帶動組織學習的策略方向。就組織面而言，隱性知識的萃取與外部化，是知識管理中面臨的最大課題。以半導體產業為例，本研究以統計多變量為工具，開發針對半導體製程之動態系統監測、故障檢測與分類模式，該模式可有效的判讀與分析，將隱性知識外部化。就製程方面可有效改善製程以提升良率；對設備而言，維護的週期與零件的更換，在維持製程品與成本降低上均有明顯的影響。除此之外，藉助此模式之引導研發工程師對於製程與設備之改善與研發，將更具功效。

Exploring Knowledge Management Application through Industry Organizational Learning

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ABSTRACT

Previous studies of learning organizations are mostly based on Peter M. Senge’s “The Fifth Discipline: The Art and Practice of the Learning Organization”, but there are more than five disciplines for developing learning organizations. Actually, knowledge management will be the sixth discipline to improve the formation of learning organizations and to advance organizational changes. In the knowledge economy generation, knowledge and keeping learning are the most important determinants of competitiveness. This research attempts to understand the general viewpoint of organizational learning from industry, and delves into learning organizations to understand the actual applied process of knowledge management.

In Part I, it is consistently shown from this part of the research that the success determinant of organization learning in different industries is talented individuals (human capital). On the one hand, the ability of knowledge acquisition for organizations is important. On the other, organizations can gain a competitive advantage by increasing the organization's intelligence through knowledge management. The research can infer that knowledge management is the strategy to push organizational learning forward. In Part II, the data of the trait knowledge of information can be applied as a predictor or an analyzer for semiconductor equipment. Knowledge management of fault detection and classification (FDC) is a typical application for finding faults and addresses their attribution. This model, which was developed using multivariable statistical monitoring, can successfully provide clear and exact information to engineers.

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交大六年，最愛的是，倚在游泳池畔享受著夏天的味道，漫天的彩霞伴著夏日午後的微風，飄散各式植物的香氣。金色的陽光如蜜糖般融於水中，吸一口氣，潛入水中如琉璃般的太虛幻境，仰望水上世界。何者是真實，何者是幻境，此時此刻，一切似乎不再重要。漫長的學習，如同登山，林道漫漫、箭竹海攸攸、陡上陡下，交雜烈日、汗水、雨水、淚水，但卻是心境、意志、體能磨練的過程，以及突破自我的轉捩點。攀上頂峰的剎那，體力上的負擔即蛻變為心靈上的澄淨、攸遠。

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于新竹交大管科

97 年 6 月

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Chapter 1 Introduction

Since Peter Drucker's seminal work (1993) addressed the emerging importance of knowledge workers, knowledge, beyond the physical capital and land, has been viewed as the most critical resource of a firm. OECD 1996 also reports that economies are increasingly based on knowledge and information. Knowledge is now recognized as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance. The term "knowledge-based economy" stems from this fuller recognition of the place of knowledge and technology in modern OECD economies. The term "knowledge-based economy" results from a fuller recognition of the role of knowledge and technology in economic growth. Knowledge, as embodied in human beings (as "human capital") and in technology, has always been central to economic development. In addition, tacit knowledge has been singled out as vital in gaining an emergent competitive advantage, mainly due to its difficulty in being expressed verbally or in being codified. Such difficulties also mean competitors cannot imitate, let alone duplicate, the tacit knowledge of a competitor (Winter, 1987).

Previous studies of learning organizations are mostly based on Peter M. Senge's "The Fifth Discipline: The Art and Practice of the Learning Organization", but there are more than five disciplines for developing learning organizations. Actually, knowledge management will be the sixth discipline to improve the formation of learning organizations and for advancing organizational changes. This study focuses on two areas: organizational learning and knowledge management.

PART I

With the historic handover of Hong Kong by Britain to China in 1997, economic development may be leading China towards democracy (Lewis, 1997). A large virgin market, dense population, cheaper labor, and its land and energy resources make China's presence felt in the global market, and a new economic resource flow is being formed. China is an attractive force for Taiwan, too. Because of historical events, Taiwan's economy has developed separately from that of Mainland China's for almost five decades. However, due to the advantages of geographical closeness, a similar culture, and shared language, Taiwan, this small island that lacks natural resources, acts as an entrance to the Chinese market. This economic activity is what keeps Taiwan running.

The management paradigm today is experiencing a shift. While cutting costs used to be a good strategy in stable times, it is no longer suitable in today's dynamic competition. Kim and Mauborgne (2005), the authors of Blue Ocean Strategy, contend that while most companies compete in (hostile) Red Oceans, strategies focusing on cost cutting to improve competitiveness are increasingly unlikely to create profitable growth in the future. Kanter (1983) argues that organizations cannot survive without innovating (cited by Mezias and Glynn, 1993). No industry and no firm can always be at the top without innovation; it is a key factor of survival and competitiveness. Knowledge is power and is the main driving force behind innovation (Swan, et. al., 1999). Organizational learning is the process by which new knowledge or insights are developed by a firm (Slater & Narver, 1995).

In today's competitive climate, where the only certainty is uncertainty, organizational learning is considered a key factor of business success, and is seen as the foundation of competitive advantage. In knowledge-based societies, knowledge has become the most important strategic asset. Organizations need to use knowledge to realize competitive advantages in the changing business environment (Sohal, Chung & Morrison, 2004). Many fields within academe (e.g., cognitive psychology, information sciences, educational psychology, etc.) have attempted to better understand the concepts of knowledge creation, storage and retrieval, knowledge sharing, and knowledge application. Senge also describes learning organizations as organizations in which people continually expand their capacity to create desired results, where new patterns of thinking are nurtured, and where people are continually learning how to learn together (Senge, et al., 1994). How firms acquire, store and share valuable knowledge among individuals or units in the highly competitive marketplace has recently become a hot topic.

The Chinese market, like a black hole, sucks in global investment directly. According to Charlene Barshefsky, a former US Trade Representative, "Over the next decade, China will become a hub of economic integration in Asia" (Business News, 2005). Facing such a challenge, a shift within management and economic paradigms is needed so that Taiwanese industries may stay competitive. A number of studies have pointed out that learning can make one more competitive (e.g. Grant, 1996; Lei, Hitt & Bettis, 1996; Simonin, 1997; Tippins & sohi, 2003); in order to keep up with the onslaught of challenges, organizations must continuously learn.

Some of the empirical research has found that organizational learning positively relates to organizational performance (Hrebiniak & Snow, 1982; Dess, 1987; Chen & Kuo, 2004; Wang & Hsiao, 2004). Lien (2002) also adopted Marsick and Watkins' 'Dimensions of the Learning Organization Questionnaire' (DLOQ) as an instrument for investigating high-tech firms in Taiwan, and found that the relationships between the learning organization and organizational performance were positive. Most research in this area, however, focuses on large businesses (Matlay, 2000) or specific industries (Lien, 2002; Wang & Hsiao, 2004). This literature suggests that organizational learning is one process that plays an important role in enhancing a firm's capabilities and competitive advantage. In this stage of our research, we aim to identify the organizational learning status of different Taiwanese industries. Through a survey of Taiwan's industries we wish to prove that performance, a critical element of competitiveness, is higher in industries where organizational learning is actively practiced. Proof of such a linkage would suggest that competitiveness could be enhanced not only by seeking opportunities for cost-cutting, but by actively promoting organizational learning.

PART II

The definition of Research and Development (R&D) is to discover new knowledge regarding products, processes or services etc., and then apply that knowledge to create (or improve) new (or existing) products, processes and services that fill market needs. It is difficult to evaluate R&D performance, as it is a complex construct (Lin & Chen, 2005). Many studies on R&D project success factors (Balachandra & Brockhoff, 1995; Holtzmann 1972) have reported a set of factors leading to the success of R&D projects based on personal experiences. Therefore, one of the principal determinants of R&D project success is the mode of knowledge involved (tacit/explicit) (Gassmann & Zedtwitz, 2003).

The I.C. chip industry plays an important role in the national economy of Taiwan, and the IC manufacturing process involves complex systems and complex science. It takes one or two months and involves hundreds of processes, including the processes of diffusion, lithography, thin film and etching which are performed on hundreds of machines such as implanters, CVDs, PVDs, furnaces, steppers, wet benches etc., and is measured by related sensors or metrologies. Within each process, the parameters of control are the key factors leading to the yield rate. The duty of R&D here is to tune up optimal process parameters; in other words, it is to come up with optimal process recipes.

Deposition of coatings by plasma enhanced chemical vapor deposition is the most complex of all plasma surface treatment techniques (Dhar, 2003, p.7). The module development of the plasma enhanced chemical vapor deposition (PECVD) process includes several kinds of process parameters, such as R.F. power, total pressure inside the reactor, flow rates of gases involved, substrate temperatures, type of electrodes used, and reactor type or geometry (gases, flow rate, vacuum percentage, electric and magnetic field intensity). Most of these process parameters have corresponding physical (direct or indirect) sensors which monitor their real-time value. However, after the reaction of all the parameters (molecular formula) in the PECVD chamber, it forms plasma and decomposes into a state of high density ion and molecules. During this complex interaction of physics and chemistry in the chamber, which can be treated as a black box, direct physical sensors can only detect the specific states inside the chamber. To acquire more detailed information, indirect physical sensors such as RGAs (Residual Gas Analyzers), OESs (Optical Emitter Sensors) or VIProbers (Voltage & Ampere Probers) are employed. Thousands of individual pieces of information related to optical spectrum, voltage and ampere distribution, and the density of the magnetic field, etc. are acquired. This mass of information exceeds the ability of an engineer to handle, and s/he is therefore compelled to abandon all of it.

Applying multivariate statistical analysis to monitor the process can generate specific results corresponding to the core of the equipment or process, and gets rid of non-accurate information using experience rating. This could therefore be an efficient method to lead R&D projects in the right direction.

The second part of our research therefore explores the practices of PECVD processes, focusing on the requirements, formation, applications and extensions of the model. This model can effectively manage trait knowledge externalization for guiding R&D direction, and find a way to enhance the capability of the R&D process in the semiconductor industry.

Chapter 2 Literature Review

2.1 Organizational Learning

Organizational learning is a multifaceted concept, as reflected by the variety of perspectives used in theoretical and empirical works (Tsang, 1997; Douglas & Ryman, 2003; Lines, 2005). A general definition of organizational learning by Chauhan and Bontis (2004) is as follows: "… the development or dissemination of work-based knowledge that is perceived to be useful for improving organizational performance. The learning organization provides a blueprint for a rapid and fully integrated response to change, which indicates a learning organization has the systems, processes and structures for continuous responsiveness and improvement (Chauhan & Bontis, 2004). This definition also acknowledges that organizations learn in two ways: by sharing knowledge that already exists in the organization, and by generating knowledge that is new to the organization. Both forms of learning are potentially beneficial to the firm.

There are many other definitions and conceptualizations of organizational learning, but at a very basic level it is the process by which new knowledge or insights are developed by a firm (Tippins & Sohi, 2003; Slater & Narver, 1995). The existing literature indicates that organizational learning consists of four components: information acquisition, information dissemination, shared interpretation, and development of organizational memory (Tippins & Sohi, 2003).

Information acquisition

This is the process by which firms actively seek out and gather useable information (Kohli & Jaworski, 1990). Information may be acquired from direct experience, the experience of others, or organizational memory. Itself a fundamental outcome of organizational learning, organizational memory doubles as a warehouse for information within the firm (Tippins & Sohi, 2003; Sinkula, 1994). To a large extent, the content of a firm's memory plays a significant role in the type of market information that is acquired, and how it is interpreted (Moorman & Miner, 1997).

Information dissemination

For the learning process to be more effective, once a firm has acquired market information, it must be distributed to those individuals who need it. Information dissemination is the extent to which the information that is obtained by an organization is shared between its functional units, through formal and informal channels (Slater & Narver, 1995; Jensen, 2005).

Shared interpretation

This refers to the presence of consensus among members of the organization with regard to the meaning of information (Sinkula, 1994). Once the information is disseminated throughout the firm, consensus regarding the meaning of the information evolves. Shared interpretation also plays a role in the future acquisition and interpretation of information. Future information is evaluated in light of what already exists, as the shared understanding of information is committed to organizational memory (Tippins & Sohi, 2003).

Organizational memory

Organizational memory is the final organizational learning component to deal with (Slater & Narver, 1995; Walsh & Ungson, 1991). Memory “refers to the amount of stored information or experience an organization has about a particular phenomenon.” (Moorman & Miner, 1997)

Akgun, Lynn and Byme (2003) propose that organizational learning is an outcome of reciprocal interactions of the processes of information/knowledge acquisition, information/knowledge dissemination, information/knowledge implementation, sense making, memory, thinking, unlearning, intelligence, improvisation, and emotions. For the purposes of this study, this research follows the concept of organizational learning developed by Tippins and Sohi (2003).

2.2 Organizational Performance

Performance is one outcome of knowledge acquisition (Janz & Prasarnphanich, 2003; Grover & Dickson, 2001) which is considered as evidence that knowledge has been gained. It is also a kind of competitive ability by which to estimate a firm’s value. This research intends to prove that organizational performance can be directly linked to organizational learning.

There are many works on performance evaluation, including by the following authors:

Quinn and Rohrbaugh (1983) divide their performance evaluation index into three dimensions:

(1) *Focus*: may be organization internal and external; includes productivity, profit, work satisfaction, and growth.

(2) *Structure*: expressed in terms of control and flexibility, it includes the speed of

response when confronted with changes in the environment, and the ability to deal properly with the organization's internal problems such as conflict and solidifying agreement.

(3) *Advantage*: includes management processes and results, such as information process flow and management, and employee training and development.

Ford and Schellenberg (1982) provide three dimensions of evaluating performance:

(1) Goal, which is measured by what percentage of the scheduled progress has been achieved;

(2) System, the percentage of resources gotten; and

(3) Process indicates the learning and solving behavior of employees.

Woo and Willard (1983) argued that profit rate, comparative market position, sales volume and market share may be used to effectively evaluate performance. According to Venkatraman and Ramanujam (1986), measuring financial, business, and organizational performance are three dimensions of performance evaluation. Miler (1990), on the other hand, defined performance evaluation in terms of return on investment (ROI), cash flow of investment, market share, and productivity.

More recently, researchers have been considering both financial and work aspects when evaluating a firm's performance. According to Dyer and Reeves (1995), high performance is a kind of resource that depends on, among other things, the turnover rate and the rate of absenteeism, individual or group performance; organization, productivity, quality and service; and, in financial terms, the return on assets

(ROA) and the return on investment (ROI). Lumpkin and Dess (1996) claim that performance evaluation has two dimensions: the financial, as expressed by the growth in sales, market share, and the profit rate; and the non-financial, "total performance", which includes shareholder satisfaction, reputation, image, employee honor, commitment, and employee satisfaction. Delaney and Huselid (1996) also claim that performance evaluation has two dimensions. Organization performance describes product or service quality, the development of new products or services, the ability to attract talent, customer satisfaction, and the management relationship between manager and employees. Market performance, the second of the dimensions, includes the growth rate of business volume, market share, profit, and marketability.

Work performance has often been used as an index when evaluating performance (see Mikkelsen & Gronhaug, 1999, and Mikkelsen et al., 2000, as cited by Janz & Prasarnphanich, 2003). Henderson and Lee (1992) claimed that efficiency, effectiveness, and timeliness are the three dimensions by which shareholders evaluate organizations' performance.

Based on the above literature review, two dimensions of work and financial performance are defined in this study, according to Lumpkin and Dess's (1996) research.

2.3 Knowledge Management

Knowledge management uses theories of organizational learning as a platform for providing insight into how organizations can acquire, interpret, distribute, and acculturate knowledge to facilitate and create competitive distinction (Thomas, Sussman & Henderson, 2001). Thomas, Clark and Gioiak (1993) indicate that how top managers categorize and interpret the information and knowledge they accumulate has been shown to have a systematic linkage with differential organizational performance (Thomas et al. 1993).

Research classifies human knowledge into two categories: explicit and tacit (Badaracco, 1991; Hamel, 1991 & Polanyi, 1996, 997). Explicit knowledge refers to knowledge that is transmittable in formal, systematic language. Tacit knowledge has a personal quality, which makes it hard to formalize and communicate, and which is deeply rooted in action, commitment, and involvement in a specific context. In Polanyi's words, it "indwells" in a comprehensive cognizance of the human mind and body.

Tacit knowledge involves both cognitive and technical elements. The cognitive elements are called mental models (Johnson-Laird, 1983) in which human beings form working models of the world by creating and manipulating analogies in their minds. By contrast, the technical element of tacit knowledge covers concrete know-how, crafts, and skills that apply to specific contexts. Tacit knowledge is a continuous activity of knowing, and embodies what Bateson (1973) has referred to as an "analogue" quality. By contrast, explicit knowledge is discrete or "digital" (cite as Smith, 2000, p.8).

Tacit knowledge, following Polanyi's (2003: 95) or Husserl's (1982: 70) terminology, is that 'halo of consciousness' or background against which meaning emerges as intended, conscious and focal. Individuals can acquire tacit knowledge without language, and the key to acquiring tacit knowledge is experience. Without some form of shared experience, it is extremely difficult for people to share each others' thinking processes.

Tacit knowledge plays a vital role in many professional fields, such as in medical, militarily, legal and managerial areas (Sternberg & Horvath, 1999), while the role is more obvious in the R&D field (Kusunoki et al. 1998; Mascitelli, 2000; Nonaka & Takeuchi, 1995). In fact, tacit knowledge forms the basis of valuable individual human skills (Berman et al. 2002). R&D tasks are too complex for any single employee, and the need of specialization and division of labor means that each individual lacks the full knowledge to undertake the role of others (Berman et al. 2002, Postrel, 2002; Weick & Roberts, 1993). For R&D personnel, the archetypal knowledge worker, tacit knowledge flow and knowledge creation capability is crucial in the context of new product development (Huang, Liu & Warden, 2005).

2.4 Hypothesis Development

A number of learning theorists have pointed out that behavior can be changed by learning; however, there is no evidence to suggest that there is, indeed, a connection between learning and performance (Chauhan & Bontis, 2004; Fiol & Lyles, 1985). Drucker (1992) thought that when a firm beats the competition, it is due to continuously learning new information about the technology, markets, the business environment, and customers. New knowledge and creativity are the most important keys to staying alive in a competitive environment (Inkpen & Crossan, 1995). Some researchers have found that the corporation with the ability to learn may have a bright performance (Fiol & Lyles, 1985; Levitt & March, 1988; Huber, 1991). Some of the empirical research on consensus has found it to be positively related to organizational performance (Hrebiniak & Snow, 1982; Dess, 1987). The hypotheses are reiterated, as follows:

Hypothesis 1: performance is positively affected by organizational learning

In a dynamic environment, each industry, and each sector in the economy has a different background and features; therefore, different industries may adopt different strategies. According to their specific characteristics, we have divided industries into five categories, as defined in Table 1.

Table 1 Industry Classification

	Industry Classification				
	High-tech	**Traditional Manufacturing**	**Financial**	**Service**	**Other**
Sample Elements	Electronic and Semi-conductor Production	Construction	Financing and Auxiliary Financing	Recreational Services	Health Care Services
	Equipment Manufacturing and Repair	Manufacturing	Securities and Futures	Legal and Accounting Services	Public Agencies and National Defense
	Computer, Communications, and Audio and Video Electronic Product Manufacturing	Yarn Spinning Mills	Insurance Carriers	Consultation Services	
	Electronic Parts and Component Manufacturing	Machinery and Equipment Manufacturing and Repair			
ISIC Rev.3, 1989*	D	D	J	HIKO	NPL

*International Standard Industrial Classification of All Economic Activities, Third Revision, (ISIC, Rev.3)

Hypothesis 2: The category an industry belongs to is the moderator between organizational learning and performance

The assumption of the direct model (H1) is that organizational performance is directly (and positively) influenced by organizational learning. The secondary assumption (H2 – the partial model) is that certain industries apply the principles of organizational learning better than others. We, therefore, wanted to identify which industries are best in terms of organizational learning.

Hypothesis 3: Trait knowledge externalization is an essential factor in enhancing the I.C. manufacturing industry's competitiveness.

Knowledge management as a competitive asset is one of the strategies of driving organizational learning. In the I.C. manufacturing process, there are many complex messages involved. Most of the process parameters can be observed by physical sensors, but, to obtain the best recipe, some of them are tuned up by R&D engineers using their accumulated experience. It is difficult to make this tacit knowledge concrete, which is one of the most important issues of R&D management in the I.C. manufacturing process (Niu and Chang, 2008). Therefore, knowledge management acts as an essential factor which is fundamental in driving organizational learning, especially the externalization of trait knowledge from explicit knowledge.

Research hypotheses 1 and 2 will be verified by Part I of the experiment. This research will use real case studies in Part II to verify and illustrate hypothesis 3, thus attempting to understand the managerial problems of organizations, not only from their theoretical but also from their practical perspectives.

Chapter 3 PART I Experimental Study

3.1 Respondents

The names of firms belonging to the different industries were chosen from a publicly available list compiled by the Taiwan Stock Exchange Corp. Convenience sampling was utilized in this study. A total of 300 prospective respondents were contacted by telephone and their agreement to participate was solicited. About 70% of the subjects contacted agreed to take part in the study.

Questionnaires were administered via mail with a self-addressed stamped envelope. After one reminder by telephone, 198 completed questionnaires were received, giving a response rate of 94%. Tests for non-response bias did not indicate any differences between respondents and non-respondents in terms of company size, industry, or managerial position.

3.2 Measurement

All variables were measured using multi-item Likert-type scales. The scale items used in the study are given below. Almost all of the scales were adopted from previous literature, including the performance scale.

3.2.1 Organizational learning

Based on a thorough search of the literature, it was concluded that no published, validated measurement instruments were available for the variables of interest in this study. Thus, new scales were developed based on the theoretical definitions of Huber (1991) who described the process of organizational leaning, and taking into account the views of Tippins and Sohi (2003), who divided organizational learning into four dimensions, as explained earlier.

Five-point Likert scales were used to measure the dimensions of organizational learning. Information acquisition was measured by a scale adopted by Baker and Sinkula (1999). Items used to measure information dissemination were also adopted by Baker and Sinkula (1999) and Kohli, Jaworski, and Kumar (1993). The scales were developed for measuring shared interpretation, while organizational memory scale items were based on Slater and Narver (1995) and Moorman and Miner (1997).

3.2.2 Organizational performance

As is the case of obtaining other types of sensitive data, identifying optimal measures for an organization's performance is inherently problematic. Given the potential competitive implications of revealing such information, it is not surprising that many respondents are hesitant to report information pertaining to such indicators as profitability and ROI.

As mentioned earlier, organizational performance was measured in terms of financial and work performance. Similar to the case of organizational learning, five-point Likert scales were also used to measure the dimensions of organizational performance. For financial performance, a three-item measuring tool was used, which included sales growth, profitability, and return on investment. The scale was adapted from Tippins and Sohi (2003). To measure work performance, a nine-item measurement tool was used; its three dimensions: efficiency, effectiveness, and timeliness, were adapted from Henderson and Lee (1992) and Janz and Prasarnphanich (2003).

The organizational learning measurement tools used by Tippins and Sohi (2003) were created by combining some studies, and the organizational performance scale in this study includes two separate aspects of performance. Because of this, we decided to subject those items to exploratory factor analysis to determine the underlying constructs. During this process, we used factor analysis with both orthogonal and oblique rotation to explore ranging from two factor solutions. A minimum factor loading of 0.50 was required for the inclusion of any factor. The ultimate criterion was conceptual meaningfulness. Tables 2 and 3 show the results of the exploratory factor analysis.

As a result of the exploratory factor analysis of organizational learning and performance, the independent variable, organizational learning, was identified as "information acquisition", "information dissemination", "shared interpretation" and "organizational memory"; the dependent variable, organizational performance, was identified as "financial performance" and "work performance". The variables comprising these factors were combined into additive indices, and the reliabilities were calculated, with the following results:

Organizational learning (see Table 2):

(1) "Information acquisition", reduced from three items: Cronbach's alpha=0.799;

(2) "Information dissemination", reduced from three items: Cronbach's alpha=0.810;

(3) "Shared interpretation", reduced from two items: Cronbach's alpha=0.918;

(4) "Organizational memory", reduced from three items: Cronbach's alpha=0.822).

Organizational performance (see Table 3):

(1) “Financial performance”, reduced from three items: Cronbach’s alpha=0.909;

(2) “Work performance”, reduced from six items: Cronbach’s alpha=0.836.

Table 2 Organizational learning – factor analysis and reliability

Factors	Times	Factor loading	Communality	Items to total	Cronbach’s α
	We regularly collect information concerning our customers’ needs.	0.852		0.5791	
Information acquisition	We regularly meet with our customers in order to find out what their needs will be in the future.	0.848	62.809%	0.4878	0.799
	We often ask our customers what they want or need.	0.772		0.5864	
	Representatives from different departments within our firm meet regularly to discuss our customers’ needs.	0.817		0.7587	
Information dissemination	Within our firm, information about our customers is easily accessible to those who need it most.	0.810	67.455%	0.6777	0.810
	When one department obtains important information about our customers, it is circulated to other departments.	0.693		0.6218	
Shared Interpretation	There is often disagreement among our firm’s managers with regard to what our customers want.	0.928	76.491%	0.7196	0.918

	When faced with new information about our customers, our managers usually agree on how the information will impact our firm.	0.905		0.7234	
Organizational memory	We have learned from past experience how best to deal with “hard to please” customers.	0.866	68.132%	0.7857	0.882
	We have standard procedures that we follow in order to determine the needs of our customers.	0.797		0.7030	
	Experience has taught us what questions to ask our customers.	0.745		0.7113	

Table 3 Organizational performance – factor analysis and reliability

Factors	Items	Factor loading	Communality	Items to total	Cronbach’s α
Financial performance	Sales growth	0.882	71.678%	0.7667	0.909
	Profitability	0.876		0.7886	
	Return on investment	0.777		0.7003	
Work performance	The efficiency of team operations.	0.841	62.335%	0.6553	0.836
	The team’s adherence to schedules.	0.833		0.6447	
	The team could have done its work faster with the same level of quality.	0.810		0.6606	
	The team’s adherence to budgets.	0.806		0.5880	
	The amount of work the team produces.	0.797		0.6664	
	The team’s ability to meet the goals of the project.	0.788		0.6889	

3.3 Data analysis

3.3.1 Description of the sample

The profile of the sample (see Table 4) is described by the following variables:

(1) Organizational variables: industry category, firm size, the length of time the firm has been in existence;

(2) Demographics of participants: gender, position within firm, seniority.

The number of firms in each industry was very close. About 67% of participating companies have less than 1,000 employees; 49% of participating companies have been in existence for 16 years or more. In terms of demographics, 77% of the respondents were male, 48% of the participants were either the owner or in high-level management positions, and 57% of them had worked at the company for more than 11 years.

The first model (direct effects) examined the direct relationship between organizational learning and organizational performance, while the second (partial) model examined the same relationship with industry category acting as a moderator. The moderator effect of industry category on the relationship between organizational learning and organization performance is supported when:

(1) There is a significant relationship between organizational learning and organizational performance (as observed in the direct model).

(2) The moderator model explains more variance in organizational performance than the direct model.

Table 4 Profile of Sample

Items		High-tech	Traditional	Financial	Service	Other	Total
Size of Firm	Under 100 employee	14	10	12	10	9	55
	101-1000employee	17	12	14	12	11	66
	1001-5000employee	7	5	6	5	5	29
	5001-10000employee	2	1	1	1	1	6
	Over 10001 employee	6	4	5	5	4	24
Years of Existence	Under 5 years	6	4	5	5	4	24
	6-10 years	8	6	7	6	5	32
	11-15 years	9	6	8	7	6	36
	16-20 years	14	10	11	10	9	54
	Over 21 years	9	6	7	6	6	34
Gender of Respondent	Male	35	25	29	26	23	138
	Female	11	7	9	8	7	42
Job Category	Owner	5	4	4	4	3	20
	High-level Manager	17	12	14	12	11	66
	Mid-manager	8	5	6	5	5	29
	Manager	10	7	8	8	7	40
	Employee	6	4	6	5	4	25
Seniority	Under 1 year	2	2	2	2	1	9
	1-5 years	7	5	6	5	5	28
	6-10 years	8	6	7	6	5	33
	11-15 years	14	10	11	10	9	54
	16-20 years	12	7	9	9	8	45
	Over 20 years	3	2	3	2	2	12
Total		46	32	38	34	30	180

3.3.2 Relationships between learning and performance

In the direct model, the relationship between organizational learning and performance was proven by Equation 1 as having a significant positive relationship (p<0.05). We also tested the partial model of performance, including financial and work performance. The p-value for the partial model was also significant (p<0.05). Given the support we found for the hypothesis, we may deduce that performance can be explained by organizational learning. This result is also supported by the more detailed analysis of the partial model.

$$P1(\text{Organizational Performance}) = \alpha 1+\beta 11*OL1+\beta 12*OL2+\beta 13*OL3+\beta 14*OL4+e1$$

$$\beta ij=slop, ei=error$$ *<equation 1>*

$$P1.1(\text{Financial Performance})= \alpha 1+\beta 11*OL1+\beta 12*OL2+\beta 13*OL3+\beta 14*OL4+e1$$

$$\beta ij= slope, ei=error$$ *<equation 2>*

$$P1.2(\text{Work Performance})= \alpha 1+\beta 11*OL1+\beta 12*OL2+\beta 13*OL3+\beta 14*OL4+e1$$

$$\beta ij=slop, ei=error$$ *<equation 3>*

Table 5 Organizational learning – financial performance

Model		Performance	Financial performance	Work performance
Organizational Learning	(OL1)Information acquisition	0.541**	0.594**	0.516**
	(OL2)Information dissemination	0.203**	0.214**	0.198**
	(OL3)Shared interpretation	0.103	0.184	0.096
	(OL4)Organization memory	0.024	0.020	0.035
Adjust R^2		0.192	0.310	0.189
P value		0.002**	0.000***	0.002**

3.3.3 The effect of industry category on learning and performance

We used ANCOVA (analysis of covariance) to test the main and interaction effects of categorical variables on a continuous dependent variable, controlling for the effects of selected other continuous variables that may covary with the dependent. ANCOVA employs built-in regression using the covariates to predict the dependent, then does an ANOVA (analysis of variance) on the residuals (the predicted minus the actual dependent variables) to see if the factors are still significantly related to the dependent variable after the variation due to the covariates has been removed.

Next, in equation 4 we included an industry dummy variable as a moderator variable. With this model, we could indicate how much each industry's performance was related to organizational learning. Table 6 shows the results from the analysis of the moderator model. The overall model is significant ($p\text{-value}<0.05$), but when the individual industries were tested, only the high-tech and financial industries have shown a significant positive correlation ($p\text{-value}<0.05$) between organizational learning and organizational performance.

$$P2\ (\text{Organizational performance}) = \alpha 1+\beta 11 * OL\ (\text{Organizational Learning})+\beta 12 * OL\ (\text{High-tech})+\beta 13 * OL\ (\text{Traditional}) +\beta 14 * OL\ (\text{Financial})+\beta 15 * OL\ (\text{Service})+\beta 15 * OL\ (\text{Other})+e1$$

βij=slop, ei=error *<equation 4>*

Table 6 Industries – organizational learning and performance

Model	Performance
OL(Organizational Learning)	0.314**
OL(High-tech)	0.486**
OL(Traditional manufacturing)	0.133
OL(Financial)	0.247**
OL(Service)	0.021
OL(Other)	0.043
Adjust R^2	0.182
P value	0.005**

3.4 Discussion

The objective of this research was to determine the relationship between organizational learning and performance in practice. We hoped to gauge to what extent performance is a function of organizational learning in Taiwanese industry. According to the findings, only high-tech and financial companies apply the processes of organizational learning consistently among the five industries. Both of these industries are capital-intensive and do not belong to the category of small business. These companies therefore have more resources than small businesses to develop and gather competitive talents.

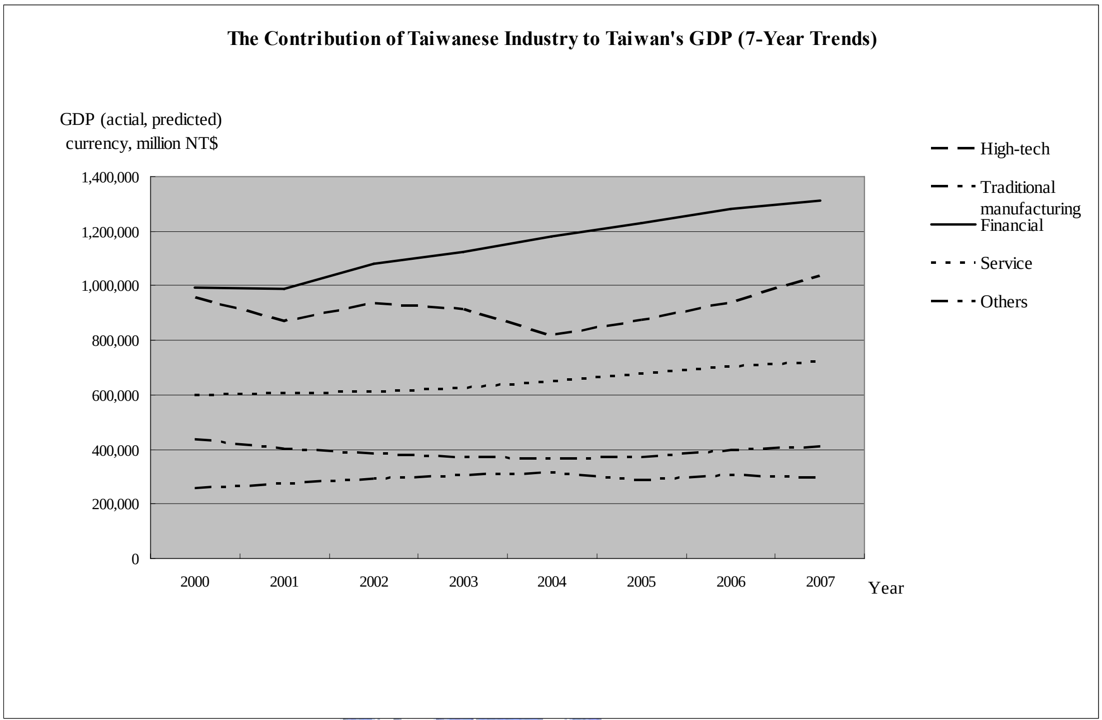
Nonaka and Takeuchi (1995) developed a four stage spiral model of organizational learning. In this model, knowledge creation and organizational learning take a path of socialization, externalization, combination, internalization . . . etc. in an infinite spiral. Therefore, most research in organizational learning focuses on large businesses (Matlay, 2000). Chaston, et.al. (2001) stated a common conclusion from many studies. Small firms often have limited ability to either acquire adequate information and/or utilize such information (Langley & Traux, 1994; Robertson et al., 1996). On the other hand, Tippins and Sohi (2003) mentioned that information technology (IT) is one of the useful tools of organizational learning, but one which requires significant amounts of money.

Moreover, blooming industries have more resources to support organizational learning. According to Argyris and Schon (1978), "organizations consist of individuals; therefore, the hallways of organizational learning are made up of the talent of individuals." Talent begets talent. When comparing how the various sectors have contributed to Taiwan's GDP (value of outcome), we find that both the high-tech and the financial industry's contributions to the GDP are higher than those of other sectors' (see Table 7 and Figure 1). High GDP values mean these industries can provide a lot of valued job opportunities and a good work environment; therefore, they can attract talented individuals. Talent will create more output, thus increasing performance. Learning and training can improve performance, but they take time and money.

Table 7 Taiwan's GDP (million NT$)

Industry	Year							
	2000	2001	2002	2003	2004	2005	2006	2007
High-tech	956,961	869,660	938,334	913,494	818,567	875,524	941,236	1,036,507
Traditional manufac-turing	439,013	401,490	383,761	373,401	368,730	373,137	398,056	411,507
Financial	991,006	990,657	1,081,848	1,122,604	1,181,219	1230651	1282008	1313982
Service	601,431	607,213	610,600	623,956	650,537	677,761	706,045	723,654
Other	256,354	276,267	295,073	307,883	316,004	290,516	308,200	299,243

Figure 1 The Contribution of Taiwanese Industry to Taiwan's GDP (7-Year Trends)



In Peter Senge's "The Fifth Discipline" (1990), he introduced the business community to the notion of the learning organization. The topic of the book has regained much attention lately as companies refine their soft skills such as leadership, knowledge management and learning. As is consistently shown in this part of the research, the success determinant of organizational learning in different industries is talented individuals (human capital). On the one hand, the ability of knowledge acquisition for an organization is important. On the other hand, organizations can gain competitive advantage by increasing the organization's intelligence through knowledge management.

From the above, we can infer that knowledge management is the strategy to push organizational learning forward. In Part II, a real case in the high-tech industry will be used to explore the contribution of knowledge management (trait knowledge acquisition, storage, dissemination and shared) to organizational learning.

Chapter 4 PART II Case Study

In general, the thin film process involves PVD, CVD and Planarization. A lot of physical and chemical reactions take place during this process, including absorption, surface migration, nucleation and desorption. Chemically reactive plasma discharges are often used to modify the surface properties of materials. Processing by plasma-assisted techniques is being increasingly used in various areas of production and manufacturing as diverse as the automotive, aerospace, biomedical and micro-electronic industries (Figure 2).

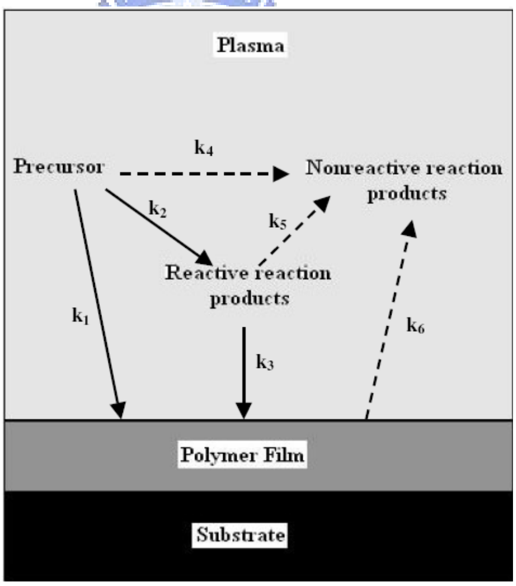


Figure 2 Different Reactions during Plasma Polymerization

(k1 –k6 are the rates of the different reaction schemes)

The plasma sustained in the mixture of gas or vapors, vacuum, electricity and magnetism contains a multitude of different neutral and charged particles. A large number of process parameters have to be controlled in plasma deposition, such as power, total pressure inside the reactor, the flow rates of the gases involved, substrate temperatures, type of electrodes used, and reactor type or geometry. These controlled parameters are often interdependent and interact mutually in determining the material properties and deposition rates (Figure 3).

Plasma can induce several chemical reactions that may be considered an advantage because it allows the formation of new materials, but it also has a disadvantage as it makes studying the parameters of reaction control and reproducibility of composition difficult.

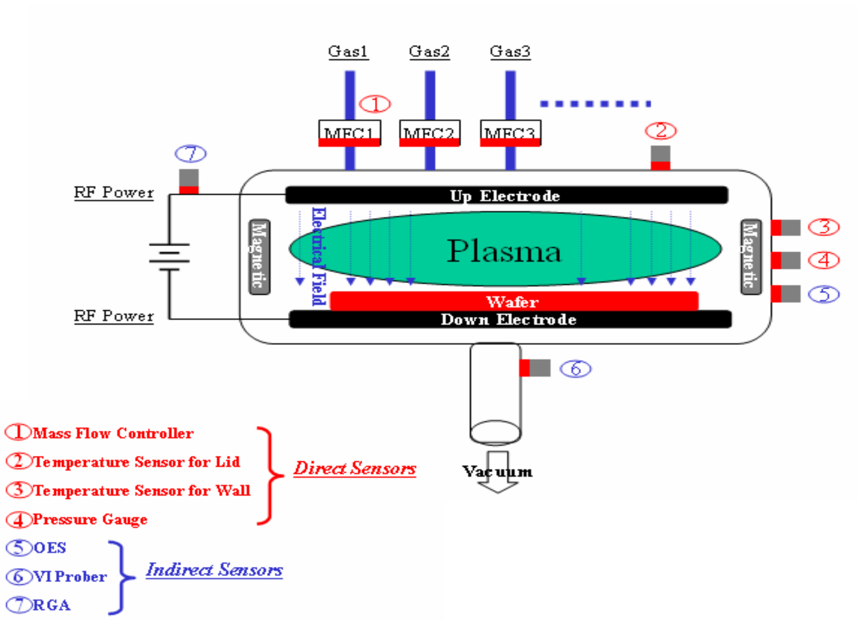


Figure 3 PECVD Chamber

In this process, R&D engineers can only acquire the information from direct and indirect physical sensors (e.g. optical spectrum, voltage and ampere distribution, and the magnetic density etc.). That information includes both explicit and tacit knowledge. It involves correlation to process the results. Traditional methods only yield the results which are inferred from the explicit knowledge, and omit the portion related to the tacit knowledge. However, the most important message always hides in the tacit knowledge. Using multivariable statistical analysis to complete knowledge management provides a way to guide R&D engineers and to bring to light the essence of the whole process.

The major R&D work in semiconductor manufacturing is process development and finding the optimal recipes. The purposes are to enhance the quality and increase the yield rate of I.C.s during the process. R&D engineers work with hundreds of parameters in the process. A great deal of money, instruments and time are invested to help them with the data acquisition. Most of the time, bottlenecks exist in the area of tacit knowledge due to the complex chemical and physical reactions which can not be abstracted during the process (Table 8).

Table 8 Description of the Process Transaction

	Input (Controllable)	Process	Output (Process Results)
Location	Peripheral	Chamber	Wafer
Parameter	Gas flow Temperature Power Pressure electrodes RF power geometry	Chemical & Physical reaction ⇩ **Plasma**	Deposition rate Uniformity Film stress Electrical characteristics Film thickness
Knowledge Type (without virtual sensors)	Explicit	Tacit	Explicit → **Incomplete Information**
Knowledge Type	Explicit	(Multivariable Statistical ⇩) Explicit	Explicit → **Complete Information**

4.1 Experimental Environment

This work is dedicated to the shallow trench isolation (STI) CVD process, performed on the commercially available Applied Material 300mm HDP CVD tool. The purpose of this process is to deposit a USG stack using high-density SiH4/Ar plasma. The process is composed of a series of 17 steps (e.g. Yang, Chang, Niu, & Wu, 2008). The first three steps stabilize the wafer load and the pressure. Step 4 is a brief plasma ignition step. Steps 5 to 8 cause the gas to flow and heat the chamber. Steps 9 to 11 are the main steps for depositing the STI layer. Steps 12 to 17 shut off the gases, cool the chamber, shut off the RF and unload the wafer. The process chemistry is identical from steps 9 to 11. This work focuses only on the main deposition steps, which are key to the whole process; all the analyzed data are based on these steps (steps 9 to 11).

A data collection module was installed in an HDP CVD tool to collect real-time tool state variable parameters (SVIDs) during the processing of the wafer. Forty-five parameters were used in the collection plan. The sampling rate of the collection was set to 1Hz.

4.2 Design of Experiment (DoE)

The data of one hundred normal wafers were collected as golden wafer data to build the boundary of the virtual sensor. Five wafers (Nos. 101~105) were picked and designed to study the effects of gas flow, pressure, voltage and temperature variation. We set 3% deviation for those parameters to acquire the variation during the main deposition (Table 9).

Table 9 The Controlled Information in the Design of the Experiment

Wafer No.	101	102	103	104	105
Parameters	Pressure	Ar (Top)	E-Chuck (Volt)	CNT Dome (Temp)	He (Side)
Setting	+ 3%	+ 3%	+ 3%	+ 3%	+ 3%

4.3 Empirical Model

It is sometimes difficult or even impossible to develop a mathematical model that explains a certain situation. However, if data exists, we can often use this data as the sole basis for an empirical model. The empirical model consists of a function that fits the data. The graph of the function goes through the data points approximately. Data are crucial for an empirical model. We can use data to suggest the model, to estimate its parameters, and to test the model. To summarize, an empirical model is based only on data and is used to predict, not explain, a system. An empirical model consists of a function that captures the trend of the data. In this part, we consider the development of an empirical model.

Sometimes with a derived model that explains a process, it may be difficult or impossible to differentiate or integrate a function to perform further analysis. In this case, too, we can derive an empirical model, such as a polynomial function, that is able to be differentiated and integrated.

We employ PCA and Hotelling T^2's mathematics command with the fit function. However we must be careful not to employ this predictive function beyond the range of the data. With an empirical model, the data drives the model. Outside the range of the data, we cannot depend on the data behaving in a similar manner to observations within the range.

4.4 Principal Components Analysis & Hotelling T^2

4.4.1 Principal Components Analysis (PCA)

Principal components analysis (PCA) is a technique for simplifying multidimensional data sets for analysis. It is also a technique for forming new variables which are linear composites of the original variables. The maximum number of new variables that can be formed is equal to the number of original variables, and the new variables are uncorrelated among themselves (Sharma, 1996). Otherwise, PCA can be used for dimensionality reduction in a data set by retaining those characteristics of the data set that contribute most to its variance, by keeping lower-order principal components and ignoring higher-order ones. Such low-order components often contain the "most important" aspects of the data.

If the tool parameters as a function of time are considered as a data matrix X, then this data matrix can be modeled using PCA as

$$X = 1 * \overline{X} + T * P' + E$$

where $\overline{X}$ is the average matrix; T is the score matrix, P' is the loading matrix, and E is the residual matrix.

The principal component scores (t1, t2, t3,….) are columns of the score matrix T. The residual matrix E can be used to calculate the distance to the model in X space (DModX). The residual standard deviation (RSD) of an observation in X space is proportional to the observed distance to the hyper plane of the PC model in X space. The observed distances to the PC model in X space (DModX) are presented as linear plots. A DModX that exceeds the critical DModX reveals that the observation may be an outlier in X space. Normally, such distances are determined after all components have been extracted.

The distance to the model (DModX) of an observation in a worksheet which is part of the model is

$$s_i = \sqrt{\frac{\sum e_{ik}^2}{(K-A)}} \times v$$

where *v* is a correction factor (which is the function of the number of observations and the number of components), and slightly exceeds unity. This correction factor takes into account the fact that the *DModX* is expected to be slightly smaller than the actual value for an observation in part of the training set because it has affected the model.

The normalized distance to the model is the observed absolute DModX divided by the pooled RSD of the model s0.

$$s_0 = \sqrt{\frac{\sum \sum e_{ij}^2}{(N-A-A_0)\times(K-A)}}$$

where A0=1 if the model is centered at zero; otherwise

(si/s0)2 has an approximate F distribution from which the probability of membership to the model can be determined.

The distance to the model in X space (row RSD), after A components (the selected dimension), for the observations is used to fit the model. If you select component 0 which is the standard deviation of the observations with scaling and centering as specified in the worksheet (without row means subtracted); that is, it is the distance to the origin of the scaled coordinate system.

In complex tool state monitoring, the Hotelling T^2 control chart is employed as a tool for detecting and classifying faults. It summarizes all the process variables and all the model dimensions, indicating how far from the center (target) of the process they are along the principal component model hyper plane.

Hotelling T^2 for observation i, based on A components is,

$$T_i^2 = \sum_{a=1}^{A} \frac{t_{i_a}^2}{s_{t_a}^2}$$

where $s_{t_a}^2$ is the variance of t_a according to the class model

$$T_i^2 \times N(N-A)/A(N^2-1) \sim F_\alpha(A, N-A)$$

where N is the number of observations in the model training set, and A is the number of components in the model or the selected number of components.

Therefore, if

$$T_i^2 > A(N^2-1)/N(N-A) \times F_\alpha(p=0.05)$$

then observation i lies outside the 95% confidence region of the model.

The confidence region of a two-dimensional score plot of dimension a and b is an ellipse with axis

$$\left[s_{t_a \text{ or } t_b}^2 \times F_\alpha(2, N-2) \times 2(N^2-1) / N(N-2)\right]^{1/2}$$

At zero significance level, the confidence region becomes infinite and is not shown on the plot.

4.4.2 Hotelling T^2

Goodlin, et al. (2002) proposed a simultaneous fault detection and classification technique that utilizes the fault vector approach to minimize the time to find, classify and correct the faults. To find out the principal component in forming the PC-space which archives the observation in chamber, the next step is to limit the boundary.

Hotelling T^2 is the method which reveals that different faults occur with different vector units in the space, and so provides a means of concurrently detecting and classifying faults. The Hotelling T^2 control chart is employed as a tool for detecting and classifying faults by summarizing all the process variables and all the model dimensions, and indicating how far from the center (target) of the process they are along the principal component model hyper plane.

4.5 Model Sensor

The data of one hundred normal wafers were collected as golden wafer data to build the boundary of the sensor model by engineering statistics software— Simca P (Figure 4). Five wafers (Nos. 101~105) were picked and designed to study the effects of gas flow, pressure, voltage and temperature variation. Figure 4 plots the PCA scores of the first two principal components (t1, t2), where the oval-shape is the boundary of the model. The cycled wafers represent gas flow, pressure, voltage, and temperature DoE wafers and those wafers are the strong outliers, at a 95% confidence level. This indicates that the five parameters may have stronger correlations with other parameters and thus impact the process results (Figure 5, 6). This demonstrates the feasibility of the empirical model and shows its ability to extract tacit knowledge.

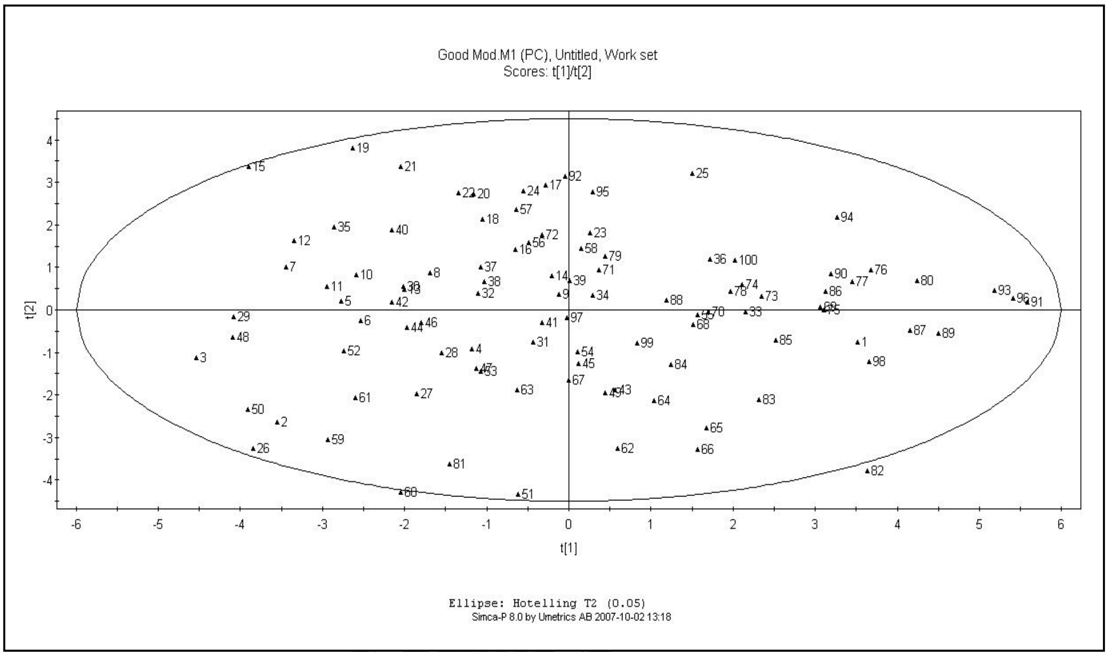


Figure 4 Golden Wafer Data of the Empirical Model

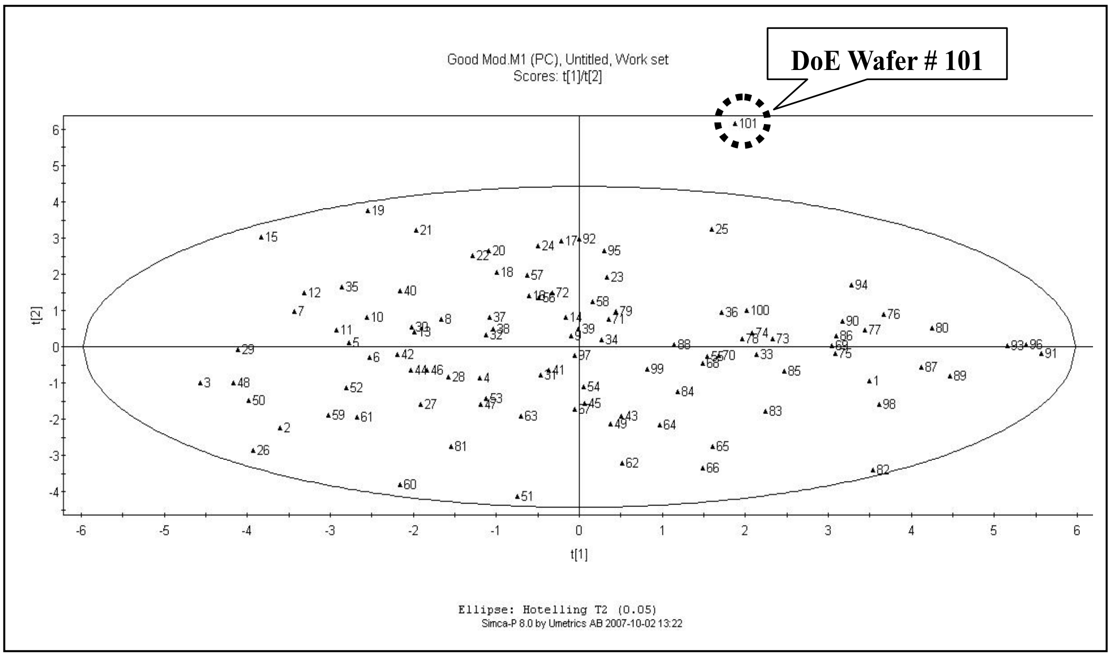


Figure 5 Parameters of Wafer No. 101

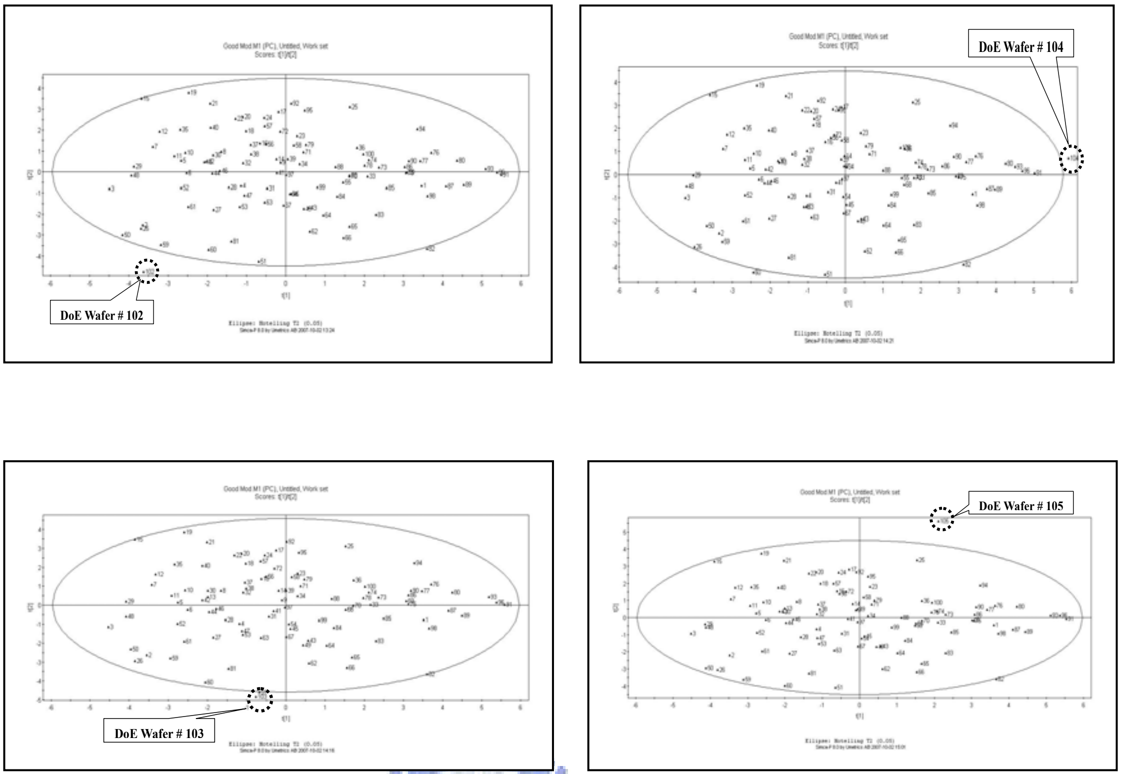


Figure 6 Parameters of Wafer No. 102-105

4.6 Discussion

This summary has been provided to allow R&D managers and executives a rapid appreciation of the content of this part. This study addresses some advantages for R&D management, as follows:

- Understand the root causes of process problems
- Predict process results before physical instrument measurement results
- Predict properties during processing which cannot be measured on-line (in-situ)

- Obtain process results faster, and make corrections sooner to avoid process problems

- Decrease the number of physical sensors used in the process to reduce costs.

- Empirical modeling is a feasible method of fault detection and classification (FDC)

Besides, this process can be employed in chamber matching to decrease the variation of the same kind of chambers, enhance the abilities of real-time correlation and feedback and feed forward compensation within station to station. It can also increase the robust design of the production line. In summary, process stabilization and cost saving are the main advantages of knowledge management by applying multivariable statistical analysis and monitoring. It can be applied not only in the semiconductor industry but also in the optoelectronics industry.

Chapter 5 General Discussion

5.1 Summary

In the knowledge economy generation, knowledge and keeping learning are the most important determinants of competitiveness. This research has attempted to understand the general viewpoint of organizational learning from industry, and has delved into learning organizations to understand the actual applied process of knowledge management.

Three hypotheses were developed in this dissertation and were supported by two other studies. Based on the three studies, we concluded as follows:

(a) This study reconfirms previous research findings that organizational learning is one of the essential determinants of improved organizational performance.

(b) Soft skills for organizations such as knowledge management and learning are the success determinants of organizational learning. However, talented individuals (human capital) are the source determinant of superior knowledge in different industries. On the one hand, the ability of knowledge acquisition is important for organizations. On the other, organizations can gain competitive advantage by increasing the organization's intelligence through knowledge management.

(c) In a real case study of the semiconductor industry, the data of the trait knowledge of information can be applied as a predictor or an analyzer of semiconductor equipment. Knowledge management of fault detection and classification (FDC) is a typical application of finding faults and addressing their attribution. This model, developed using multivariable statistical monitoring, can successfully provide clear and exact information to engineers.

5.2 Research Contributions

From the beginning of the 1990s, the business world has been talking about knowledge. Being a learning organization and driving knowledge management is the power of competition nowadays. Knowledge is cumulative experience, together with information gathered from outside sources, constituting one of a firm’s critical resources. Companies have been trying to find ways to gain knowledge from years of experience in such things as manufacturing, engineering and sales. They need to locate, organize, transfer and leverage the knowledge throughout their entire organization.

Knowledge, as primarily tacit, is something not easily visible or expressible. Tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or share with others (Polanyi, 1962; Winter, 1987; Hamel, 1991; Nonaka, 1994; Von Hippel, 1994; Stein and Zwass, 1995; Civi, 2000). Externalization of trait knowledge to explicit knowledge, i.e. knowledge management, is the fundamental way to approach effective organizational learning. Knowledge management is essential for organizations. However, in practice, knowledge management is not always effective or easy to access. In general, identification of clear and understandable goals and objectives and what is the root cause of the externalization of knowledge is difficult to approach and is thus often ignored.

The contributions of this research are: first, the consolidation of talent and knowledge is essential for accessing effective organizational learning. In Part I, this study has supported the argument that individual talent is the hallmark of an organization, and that blooming industries have more resources to support organizational learning. Secondly, it was verified that the "bottle up trouble shooting" approach is a feasible way to identify clear and understandable goals and objectives. Traditionally, problem solving uses theory to identify problems first, and then finds a method to solve the problems. When the problem is too complex this kind of approach may not work. Part II of this study supports the empirical model, the "bottle up trouble shooting" method, as a feasible way to identify clear and understandable goals and objectives for semiconductor R&D. In Part II, the model proposed by this research is shown to be effective in the externalization of knowledge. Management is easier to talk about in theory than to put into practice, but in practice there is a great deal of work to be faced in the area of semiconductor manufacturing, especially in building an expert system. How to integrate expert engineers' experience and IT system engineers' specialization to compose an effective system is an important issue for consideration. However, in Part II of this study, the researcher successfully composes a sensitive model for effective externalization of knowledge and direction for R&D departments in semiconductor manufacturing.

5.3 Implications of Knowledge Management

Organizational learning has become an increasingly important concept and practice in today's knowledge economy business world. Thus, learning and knowledge management are two key aspects of judging a successful company (Civi, 2002).

Knowledge management as a competitive asset is one of the strategies of driving organizational learning. Consistent with previous research, this current study proves that the externalization of trait knowledge from explicit knowledge may enhance organizational learning systems and allow for the extraction of more valuable knowledge. Moreover, applying multivariable statistics is a feasible method of fault detection and classification (FDC).

This application is one of the supportive R&D activities, and is an essential activity in R&D development. The applications and categories of using multivariable statistics depend on the input of different data segments or parameter types. In this study, the data of the trait employed can be applied as a predictor or an analyzer of semiconductor equipment. FDC is a typical application to find faults and address their attribution. It provides clear and exact information to engineers.

During processing, plasma status can be treated as a black box in a chamber. It is difficult to apply real-time metrology to understand the dynamic status of plasma. In contrast, real-time information via applying multivariable statistical monitoring can determine deviate parameters (dimension-reduction) and classify attributions (attribute-classification) to contribute a concise result. This assists R&D engineers in knowing the details of the whole process and developing optimal process recipes.

5.4 Study Limitations and Future Research

Several limitations to this study exist. First, the sample is unrepresentative of the general population. Due to time and financial constraints, the researcher selected a convenient sample of individuals within certain companies. Thus, the results must be interpreted with considerable caution. Second, this study is based on cross-sectional data; thus, no causal relationship should be inferred. More longitudinal studies across organizations are needed. Third, the experimental results might be restricted to extend to an extensive semiconductor manufacturing process.

Fault diagnosis and prediction of semiconductor equipment are more difficult than that of other traditional equipment due to their more complex structure. However, applying multivariable statistical monitoring can execute a tool health report in an assigned period of time. Evaluating the optimum equipment maintenance within the process revolution can make the best use of the periodic maintenance time (PM). That is the best equilibrium of cost and time.

However, in practice, most parameters will be thrown into the model and will result in a data jam. Also, interactions within parameters can not be easily identified. The characteristics of independent variables become ambiguous and affect the accuracy of the model. Finally for future research, first, different methods have to be tried to fit empirical data; therefore researchers have to pay more attention to the fundamentals of methodological theory. Second, the process segment axis identifies which process segments are selected for specific application. The parameter axis shows what parameters appear in selected process segments. This can make the model more concise and enhance its reliability and the validity of the analysis results.

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