THE IMPACT OF LEARNING ON ORGANIZATION PERFORMANCE OF THE ORGANIZATIONS

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by

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To my family for their endless love and patience…

APPROVAL PAGE

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Arts.

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This is to certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

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ABSTRACT

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THE IMPACT OF LEARNING ON ORGANIZATION PERFORMANCE OF THE ORGANIZATIONS

In order for companies to survive in the fast changing, uncertain and unsystematic competitive conditions, the companies must use their sources in an effective way. Actually, to survive is a short-term solution. The long-term survival can only be achieved by cost minimization. To minimize costs, those factors that produce the maximum output in a given unit of time must be utilized.

"Knowledge Economy" and / or "Knowledge Management" are hence accepted by many economists and management scientists who believe that information and data must be acquired, used and developed as a resource. These are many examples of companies which reach leadership status in the market by successful application of knowledge management.

The process from acquiring knowledge till the development is called "Organisational Learning". Learning, sharing what they have learnt and using that learning whenever the need arose construes "Organizational Learning". Finally the companies started to learn, store what they have learnt and use it at the respective departments whenever needed.

In this paper, the theoretical background of organizational learning is discussed first. Subsequently, two practical and empirical casses are presented to indicate the results of organizational learning on organizational performance.

Key words:

Knowledge Management, Knowledge Economy, Organizational Learning, Technical Learning

KISA ÖZET

CEBRAİL ALTINDAĞ **Kasım 2006**

ÖRGÜTSEL ÖĞRENMENİN ÖRGÜT PERFORMANSINA ETKİSİ

Hızla değişen, belirsiz ve düzensiz rekabet şartlarında firmalar ayakta kalabilmek için, ellerinde bulundurdukları kaynakları etkin bir şekilde kullanmalıdırlar. Aslında, ayakta kalabilmek kısa vadeli bir çözümdür. Uzun vadede firma devamlılığı sağlamak, sadece maliyet minimizasyonu ile gerçekleştirilebilir. Maliyetleri minimize etmek için, birim sürede maksimum çıktı sağlayan üretim faktörleri kullanılmalıdır.

Bilginin ve verilerin bir kaynak gibi kazanılıp, kullanılıp, geliştirilmesine inanan işletim bilimcilerin ve ekonomistlerin fikirleri birçok şirketin "Bilgi Ekonomisi" ve / veya "Bilgi Yönetimi"ni benimsemesini sağlamıştır. Bilgi ekonomisini başarıyla uygulayarak piyasada lider konuma gelmiş birçok örnek şirket bulunmaktadır.

Firmalarda bilginin edinilmesinden geliştirilmesine kadar geçen süreç, beraberinde "Örgütsel Öğrenme" kavramını getirmiştir. Öğrenmek, öğrenileni paylaşmak ve öğrendiklerini yeri gelince kullanmak örgütsel öğrenmeyi oluşturur. Artık şirketler öğrenmeye, öğrendiklerini depolamaya ve gerektiğinde ilgili bölümlerde kullanmaya başlamışlardır.

Bu makalede, öncelikle örgütsel öğrenmenin teorik altyapısı detaylı incelenmiştir. Ardından, örgütsel öğrenmenin örgüt performansı üzerindeki etkilerini vurgulamak için iki tane uygulamalı ve deneysel vakaya yer verilmişti.

Anahtar Kelimeler

Bilgi Yönetimi, Bilgi Ekonomisi, Örgütsel Öğrenme, Teknolojik Öğrenme

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LIST OF ABBREVIATIONS

BBS	Bulletin Board System
CSKLICT	China State Key Lab of Industrial Control Technology
CSERCIA	China State Engineering Research Center of Industrial Automation
DCS	Distributed Control Systems
ERP	Enterprise Resource Planning
IT	Information Technologies
MRP	Material Requirements Planning
PAT	Patent Productivity
PTO	Patent and Trademark Office
R&D	Research and Development
RDS	Research and Development Spending
ROA	Return on Assets
SMOTL	Startegic Management of Technological Learning

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INTRODUCTION

As the 21st century dawns, business environments and the general societies that provide their context are being transformed by a number of factors including increasing globalization, technological developments, the increasingly rapid diffusion of new technology and the knowledge revolution. Uncertainty, dynamism and volatility of the new competitive landscape are altering the fundamental nature of competition as the 21st century begins. The world has changed dramatically with the development of information technology and the increasing importance of knowledge.

This transformation is causing firms to reconsider the ability of traditional methods of competition to create value. For perhaps many companies, the new competitive landscape's uncertainty, dynamism and volatility can be daunting. Various labels and terms are used to identify the 21st century's new competitive era. Among the most prominent and frequently used ones are the new competitive landscape, hypercompetitive environments, the postindustrial society and the new frontier.

In the 21st century competitive landscape, virtually all organizations seek to exploit product-market opportunities by using proactive and innovative behaviors. Thus, to survive and prosper in this era, firms must learn how to minimize the negative effects of discontinuities, uncertainty and ambiguity while simultaneously creating dynamic core competencies to exploit the host of environmental opportunities. To generate value, firms must be able to identify, create and continuously manage knowledge (especially technological knowledge).

Knowledge may be the most strategically significant resource the firm can possess and on which sustainable competitive advantages can be built. Some scholars believe that competition is becoming more knowledge-based and that the sources of competitive advantage are shifting to intellectual capabilities from physical assets. Thus, being able to develop, maintain or nurture and exploit competitive advantages depends on the firm’s ability to create, diffuse and utilize knowledge throughout the company. The increasing competitive importance of knowledge has led to the development of the knowledge-based view of the firm. This evolving perspective, suggesting that the primary rationale for the firm’s existence is to create, transfer and apply knowledge, is an extension of the resource-based view of the firm .

Some recent works include a greater focus on dynamism and differences in firms as key determinants of competitive advantage. Examples include the developmentof the “dynamic capabilities” theory, attempts to identify the differences among firms with greatest strategic significance.

In the first chapter, after defining technology and knowledge, their relation is examined. The second chapter covers organizational learning. The literature survey on organizational learning helps indicate the types of organizational learning and the relationship between learning, knowledge and organizational creativity.

In chapter three, technological learning concept is examined. Objects of technological learning, its sources, subjects, methods and media are explained. Technological learning as a source of competitive advantage completes this chapter.

The fourth chapter introduces a multidimensional theory of technological learning so that its effects on firm-market performance can be analyzed.

Two cases are introduced in the fifth chapter as examples of the practical effects of technological learning. The first one is the ZDZK automation Ltd Co. which illustrates the positive impact of technological learning on sales. The second one is a survey conducted by Carayannis and Alexander on a sample of 24 firms. The conflicting results are compared.

CHAPTER 1

THE RELATION BETWEEN TECHNOLOGY AND KNOWLEDGE

Learning and knowledge are linked closely; knowledge is a critical outcome of learning.. If knowledge is a power, learning is a key of this power(KOH,2000, p.94). Evidence suggests that knowledge is central to how organizations learn and manage technologies.Beyond this, how knowledge is managed influences the selection and implementation of the firm's strategies.

Among the many factors that will influence the firm's performance in the 21st century's Competitive landscape the most significant ones are,

- Globalization
- Technological Advances
- Knowledge

These three factors have both independent and interactive effects on the shape of the competitive landscape.

Technology can be defined as "a systematic body of knowledge about how natural and artificial things function and interact". It follows that technology is a form of knowledge and that technological change can be understood by examining knowledge development.Furthermore, as competition in global markets becomes driven more intensely and frequently by technology, technological knowledge may be even more important for firms with global ambitions. (Ireland and Hitt, 2000, p.231-233).

To describe the potential uniqueness of technological knowledge in the development of Competitive advantage and firm value, the general dimensions of knowledge must be considered.

1.1. Dimensions of Knowledge

There are different types of knowledge. The primary distinction among them is **tacit** knowledge and **explicit** knowledge. Recognized widely by organizational scholars, Polanyi (1958, 1967) originally advanced this important distinction of knowledge types. The dichotomy between tacit and explicit knowledge can be thought of as the difference between experiential (i.e. tacit) knowledge and articulated (i.e. explicit) knowledge. (Polanyi, 1958, p.120-121).

Tacit knowledge is accumulated through learning and experience;often,it is referred to as 'learning by doing'. Tacitness suggests that individuals know more than they can tell. Tacit knowledge entails commitment and involvement in specific contexts and has a 'personal' quality . As Polanyi stated, **"the aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them"** . Thus, tacit knowledge is difficult to codify, articulate and communicate. A scholarly view of this position is that tacit knowledge may best be defined as "**knowledge that is not yet explained"**. Terms such as ;

- **"Know-How"**
- **"Subjective Knowledge",**
- **"Personal Knowledge"**,
- **"Procedural Knowledge"** have been used to describe the tacit dimension of knowledge.

In contrast to tacit knowledge, explicit knowledge can be formalized, codified and communicated. In fact, explicit knowledge is revealed by its communication while tacit knowledge is revealed through its application. Concepts related to explicit knowledge include:

- **"Know-What"**
- **"Objective Knowledge"**
- **"Predispositional Knowledge"**
- **"Declarative Knowledge"**

The dimensions of knowledge that have described facilitate understanding of the unique and critical relationship between a particular type of knowledge — technological knowledge — and the firm's ability to create value as it competes in the uncertain, dynamic and volatile competitive landscape. (Ireland ve Hitt, 2000, p.233-234).

1.2. Technological Knowledge

As a systematic body of knowledge, technological knowledge;

- Individual Explicit (individual skills pertaining to a particular technology that can be codified),

- Individual Tacit (individual skills pertaining to a particular technology that is personal),

- **Collective Explicit** (standard operating procedures),

- Collective Tacit (an organization's routines and culture regarding technology).

Each of these technological knowledge dimensions can be the source of competitive advantage and value creation. However, the dimensions that include a tacit component demonstrate the greatest potential for creating competitive advantages and firm value. From a resource-based perspective, tacit technological knowledge can lead to sustained competitive advantage. Technological knowledge that is difficult to articulate, codify and explain is also difficult to imitate. Such tacit technological knowledge is idiosyncratic and firm specific in that other firms may find it difficult to understand and use. Furthermore, technological knowledge that is not only tacit but resides in the collective organization can increase the difficulty of imitation by competitors. For example, the success of Southwest Airlines has been attributed partially to its unique culture. This culture represents the knowledge that is embedded in the social practice of the organization and resides in the tacit experiences and enactment of the collective.

Spender (1996) argues that, collective knowledge is the most secure and strategically significant kind of organizational knowledge. Thus, collective tacit technological knowledge is an important source of competitive advantage and value creation. As stated previously, knowledge is a critical outcome of individual and collective of organizational learning. (Spender, 1996, p.45-62).

CHAPTER 2

ORGANIZATIONAL LEARNING CONCEPT

Two outcomes result from the innovation process: the innovation and learning. The success of an innovation is commercial.From this perspective, acquiring technological knowledge (learning) is valuable because it leads to further innovation. Scholars have examined a number of questions regarding innovation, in contrast, the learning and process issues related to innovation have received scant scholarly attention. Given the relationships between learning and knowledge and competitive success for firms, studying an array of research questions associated with technological learning and the management of knowledge that results from it is important. (Ireland and Hitt, 2000, p.235-236).

2.1. Organizational Learning Literature

Organisational learning has many levels (Glynn,1996).Clearly,the people who are busy on learning analysis and solve the problem when they meet lack of knowledge.Organisational learning is essentially not both micro and macro but it contains complex interaction between all organisation and business units.

According to Kim, in both group and organisation level of "learning is a period which creating knowledge, organisational distribution, communication between organisation's members and entegreted management and strategcy of organisation". (Kim, 1997, p.53-60).

There are important results of leraning about organisation. Senge express that learning has essential importance on competitive and morever organisational learning means testing experiencess in organisational learning all the time and transfering this experince to more suitable knowledge which accepted and suited the main aim of organisation. (Kazanjian, Drazin, Glynn, 2000, p.273-274).

In general theory of organisation, researches about organisational learning which done before focuse on description of periods in organisational periods. (Senge, 1993, p.121-125).

Learning as an organizational activity is perceived as "an integration of idividual efforts and group interactions." Thus, organizational learning becomes a process embedded in relationships among individuals; some authors argue that organizational culture is "the outcome of shared learning experiences." Some authors use descriptive accounts of "learning " to identify paths to the improvement of organizational performance under the presumption that firms which are better at "organizational learning" will perform better than others in the market. (Carayannis, Alexander, 2002, p.626).

Miller's (1996) definition of organizational learning, highlights the simultaneously important roles of knowledge and individuals. He suggests that "organizational learning is the acquisition of new knowledge by actors who are able and willing to apply that knowledge in making decisions or influencing others in the organization" . Thus, learning entails acquisition of knowledge and in addition, use of that knowledge in some way. These characteristics suggest two types of organizational learning, acquisitive and experimental. (Miller, 1996, p.484-505).

Acquisitive learning; takes place as the firm acquires and internalizes knowledge external to its boundaries.

Experimental learning; occurs largely inside the firm and generates new knowledge that is distinctive to the organization . On a relative basis, individuals and groups play a more active role in experimental learning than acquisitive learning. Through active experimentation and processes supporting it, individuals and groups "learn" how to use organizational learning to create competitive advantages and value.

Other learning typologies exist. One typology includes

- Lower-level learning (single-loop learningorbusiness-levellearning),
- Higher-level learning (double-loop learning or strategic learning),
- Meta learning (incorporating a dynamic character).

Lower-level learning involves developing rudimentary links between behavior and outcomes through association building. It focuses on the immediate effect of the learning on some organizational task. Lower-level learning is temporary and affects only a part of the organization. Kuwada's (1998) notion of business learning in which organizations obtain business-level knowledge is similar to lower-level or single-loop learning.

Higher-level learning involves the use of heuristics. As such, higher-level learning or double-loop learning takes place in complex and ambiguous situations. Kuwada’s (1998) notion of strategic learning in which basic assumptions concerning corporate-level knowledge (knowledge that is applied to the design of strategic behaviors) change and the organization obtains a new frame of reference is similar to higher-level learning. in general, lower-level learning is short-term orientated while higher-level learning is focused on the long-term. Although both learning types contribute to organizational success, higher-level learning is relatively more important when the firm seeks to create competitive advantage and value. As such, organizations must recognize and understand the set of factors that lead to higher-level learning. (Kuwada, 1998, p.719-736).

Lei et al. (1996) argue that learning helps build a firm’s dynamic core competences. They suggest that firms can achieve higher-order learning based on three critical factors. (Lei, Hitt, Bettis, 1996, p.549-569).

- The first relates to information transfer and retrieval that forms the foundation for a firm’s universal and tacit knowledge base.
- The second concerns experimentation that allows firms to engage in continuous improvement and redefinition of heuristics.
- Finally, firms need to cultivate dynamic routines in order to develop firm-specific skills and capabilities.

In turn, these aspects of the learning process should be integrated systematically to achieve meta learning.

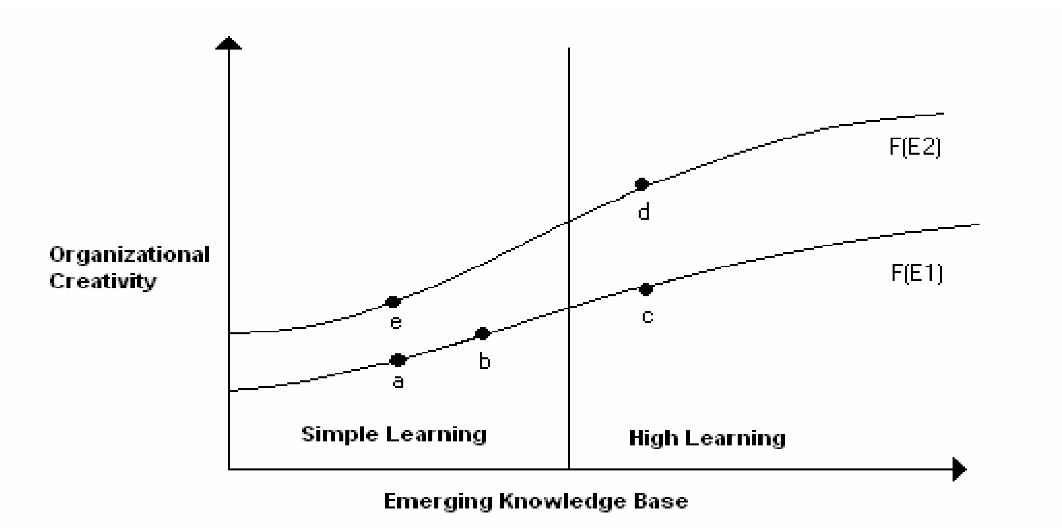
Meta learning capability is especially critical for the firm seeking to define a new competitive space in uncertain, dynamic and volatile environments. A new competitive space typically is a product of proactive and innovative behavior. Three elements are required for an organization to engage in successful meta learning:

1. The firm must obtain explicit as well as tacit technological knowledge from internal as well as external sources.

2. The firm must engage in experimentation that results in continuous improvements. For organizations to survive and prosper, they must maintain a balance between exploration and exploitation. That is, organizations must innovate and reap the benefits of that innovation.

3. Firms must build routines to effectively integrate technological knowledge throughout the organization. This integration occurs primarily through sharing across individuals and groups. (Ireland and Hitt, 2000, p.236-237).

Fig. 1. From Simple Learning to High Learning (KOH,2000.,p.94)



In Fig.1, there is a close relationship between learning, knowledge and organisational creating. In this figure, simple learning is in the left, complex learning in the right on the X axis. Learning has positive balance with organizational learning. Transition from simple learning to complex learning causes quick rise in organizational creativity. Firstly, in advanced learning, it will continue to develop organizational creating. In other words, it is possible to increase organizational creativity creative along F(E1) curve. It is necessary to increase on F(E2) curve which is a new creaitive learning of firm to further development. Firms with advanced level of learning have more capabiliy than those with learning.Thus spring in the F curve is wider in advanced learning than simple learning. The distance between c and d is on this point also wider than F(E2) curve and differences between. (KOH, 2000., p.94).

Dynamic routines are necessary for creative technological learning. Here, the role of an organization's strategic leaders is critical. As Ireland and Hitt suggest, strategic leaders must cultivate the necessary intellectual capital and create an environment in which innovation and knowledge are developed and exploited through continuous learning. Thus, the role of setting technology direction must come from the strategic apex of the organization.

BASF, a giant chemical/pharmaceutical firm in Germany, fosters technological learning.This firm has encountered many strategic discontinuities throughout its 130-year history and has primarily overcome these challenges through multi-tiered, adaptive and dynamic technological learning. The resulting technological knowledge is both tacit and collective. As such, other firms find it difficult to understand and imitate, allowing BASF to exploit a competitive advantage and to create value as a result of doing so.

However, when the firm uses technological learning as the source of competitive advantage, it cannot assume that its core competencies will remain valuable. Sudden and unpredictable changes in technological environments (e.g. Schumpeterian revolutions and technological discontinuities) can alter the value of a firm's existing technological knowledge or render it obsolete. Therefore, firms must maintain a balance between cultivating core competencies as a part of their knowledge-creating system while ensuring that the competencies do not become core rigidities.

Organizational learning must be used to create dynamic core competencies. Dynamic core competencies may be grounded in either acquisitive or experimental organizational learning. (Ireland and Hitt, 2000, p.237-238).

Some authors point out that learning can decrease organizational performance. Huber (1991) notes, "Entities can incorrectly learn, and they can correctly learn that which is incorrect". Ineffective or inappropriate learning processes can erode firm competitive advantage if they reinforce incorrect linkages between managerial activities and firm performance. Even effective learning processes can be undermined by changes in market and environmental conditions which render them irrelevant, or worse, damaging to firm performance. Thus, learning activities can change from core competencies to core rigidities. It is also possible that competence-destroying technological learning can limit firm performance in the short run, but lead to superior performance in the long term when market conditions adapt to new technologies. (Huber, 1991, p.88-115).

2.2. Strategic Learning Literature and Advantages Based on Learning

The field of strategic management is dedicated to the explanation of differences in firm performance, and further to the understanding of how to replicate conditions which lead to improvements in performance. As noted above, a significant subset of current work in this field is focused on developing a “dynamic theory of strategy” . Teece et al. expand on the resource-based view of the firm, with an analysis of strategic resources, capabilities, and competencies to explore the possibility of a theory of “dynamic capabilities”.

Adopting a learning-based view of competitive advantage changes the basis for identifying how various activities by firms are linked to improved performance. Under the older conceptions of strategy as the domain of top management, performance improvement was attributed to the assumed “superior knowledge” of executives compared to employees, and the ability of those executives to create rules and structures for executing plans based on that knowledge. While top management still has an important role in learning-based strategic management, the top-down approach to strategy is no longer valid:

…top management would do better to provide a context in which employees at every level become independent agents, take responsibility, experiment and make mistakes and learn as they strive for continuous improvement in every aspect of the firm’s total transformation process.

In order for learning processes to qualify as a source of competitive advantage, they must possess the attributes of non-substitutability, imperfect imitability, rarity, and value. In the terminology of the resource-based view of the firm, learning which improves performance will tend to display:

- heterogeneity (processes are not identical across all firms),

- **durability** (learning processes must endure over time),

- **causal ambiguity** (the basis and development of learning processes are not immediately apparent),

- **imperfect mobility** (learning processes are difficult to transfer across organizational boundaries),

- **non-replicability** (learning processes cannot be easily imitated), and

- **appropriability** (firms are able to profit from learning).

For the concept of organizational learning to be useful to strategic management, it must be unbundled to identify different dimensions of organizational learning, so that these can then be used to evaluate and even predict firm performance. For researchers to isolate how learning affects performance, learning activities must also have these attributes:

- distinguishability (good learning can be seen as distinct from bad learning),

- pervasiveness (the learning style is present throughout the organization, thus representing organizational learning rather than individual or group learning),

- communicability (new employees can learn the new style of learning through explicit teaching, tacit socialization, or other processes),

flexibility (the learning style can be changed to meet new needs and new conditions) (Carayannis, Alexander, 2002.,p.627-628).

CHAPTER 3

TECHNOLOGICAL LEARNING CONCEPT

Technological learning is a part of organisational learning. Technological learning can be described as technological development and process that firms covered and clear sources stock, creating undeveloped abilities, to renew and improve. This learning combines both managerial and technic learning processes. Managing technological abilities create increasing economic profits. As can be understood from cone in Table.3, the most value get from strategic managing of technological learning.

Dodgson (1991) defines technological learning as "the ways firms build and supplement their knowledge-bases about technologies, products and processes, and develop and improve the use of the broad skills of their workforces". (Dodgson, 1991, p.140-148).

Firms operating in technological fields often operate in complex, dynamic and risky competitive conditions. Mohrman and Von Glinow (1990) stated that, the technological environment could simultaneously:

Create new opportunities for entry,

Bankrupt existing companies, and

Render obsolete entire product lines and manufacturing and design processes overnight. As such, technological learning is important to build technological knowledge, particularly in a dynamic, discontinuous and complex competitive landscape. Recent evidence showing that technological learning contributes to the success of new ventures competing in global markets highlights the importance of this particular type of learning. Thus, technological learning, especially when applied through meta learning processes, helps the firm to develop its technological knowledge stock and use that stock to create value. (Mohrman, Von Glinow, 1990, p.261-280).

Because of the dynamic competitive landscape, advantage accrues to firms that are particularly adept at technological learning. Contextual factors that are either internal (e.g. firm size, structure, managerial ability) or external (e.g. industry) to the organization may enhance or impede the firm's ability to engage in effective technological learning processes. Technological learning facilitates the firm's efforts to:

- take appropriate levels of risks,
- proact
- innovate
- develop, maintain and use dynamic core competencies,
- build sustained competitive advantages, and
- create value. (Ireland and Hitt, 2000, p.233).

Technological learning can be mentioned as a practise which makes organizational learning more private and focused. New knowledge, in other words technic knowledge shapes not only product design but also organization basic routines and practises. (Kazanjian, Drazin, Glynn, 2000, p.273-274).

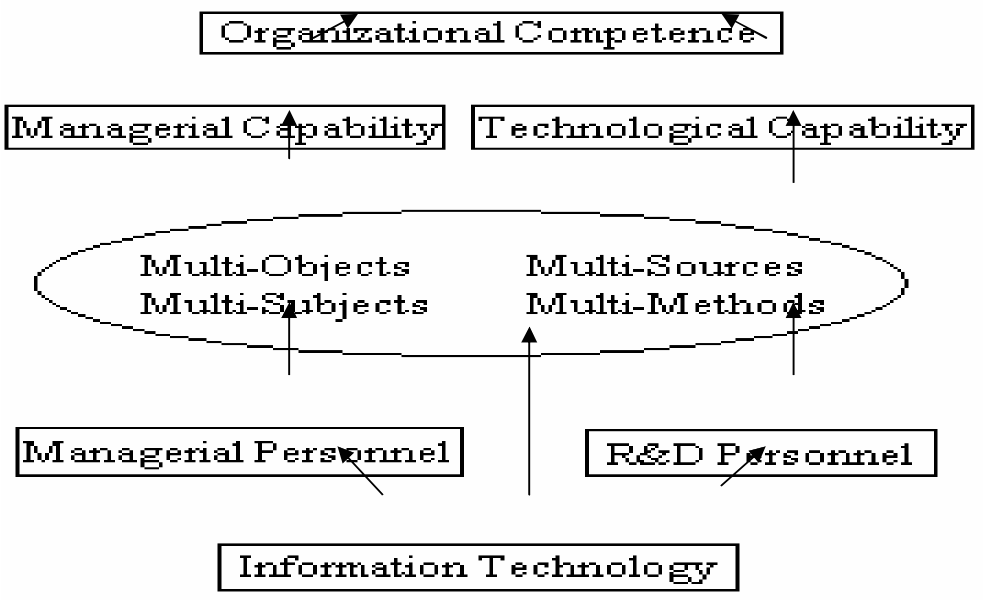
If we consider from different point of view, the world has changed dramatically with the development of information technology and the increasing importance of knowledge. Consequently, technological learning also needs to be revamped. The concept of technological learning in developing countries, which inherently focuses on technologies and learning, needs to be redefined in today's hypercompetitive environment. (D'Aveni, 1994, p.98-103).

Technological learning is no longer about learning technologies solely. Instead, it should involve learning both technologies and nano-technologies, such as effective management techniques. More often than not, the latter is more important than technology itself. Further, technological learning should involve multiple sources, multiple subjects, and multiple methods. As such, a more integrative model of technological learning may be more appropriate for the needs of today's developing countries.

Many scholars suggest that firms must adopt integrated learning to survive and grow in today's turbulent environment. Lei et al. (1996) introduce the term "meta-learning" which consists of information transfer and retrieval, experiment, and dynamic routines. They claim that meta-learning is necessary to develop and sustain effective dynamic core competence. Firms need to enhance the breath, depth, and speed of technological learning in order to effectively manage technological knowledge.

Integrated technological learning requires firms to conduct acquisition, assimilation, and improvement simultaneously. The overemphasis on the role of stages of acquisition and assimilation in traditional model prevent firms in developing countries from strategic learning. This can account for the well-known problem of "trap of technology import" in developing countries, that is, firms keep importing technologies from developed countries, but never build up their own technological capabilities. (J. Chen, W.G. Qu, 2002, p.2).

Fig. 2. The Framework of New Technological Learning (J. Chen, W.G. Qu, 2002., p.4)



3.1. Objects of Technological Learning

The first critical question for effective technological learning is "what do firms need to learn". Technological learning inherently involves learning technologies. However, simply focusing on technologies alone is no longer enough. With the increased importance that today's companies place on knowledge, people are becoming one of the most valuable resource for firms. Deriving value from this resource is not a question about technologies, but rather about non-technologies, such as effective management. Consequently, technological learning is not solely about learning technologies any more. Rather, it is best construed as learning in technology-driven firms. Therefore, learning must include technologies and nano-technologies.

Another issue that firms need to consider is that there are different types of technologies. The traditional staged model suggests that firms should learn matured technologies in their early stages. However, this may not be true for firms that already have certain technological capabilities in their early stages. Those firms can learn some matured technologies to build their capabilities in production, but it may be more important for them to learn emerging technologies because the emerging technologies have more strategic importance. Moreover, with different types of technologies, the corresponding non-technologies should also be different. For instance, the management required for imitation should be different from that for innovation. (J. Chen, W.G. Qu,2002, p.2).

3.2. Sources of Technological Learning

The second question for technological learning is 'which sources do firms learn from'. The staged model overstates the importance of learning from developed countries and neglects other, at least equally valuable, sources of learning. The reason for this overstatement may be that the gap in technological capabilities between developing countries and developed countries was very large during the 60s and 70s. Only learning from developed countries is already a very tough job for firms in developing countries. They may not have remained capable to learn from other sources.

However, relying on developed countries as only source of learning may lead firms in developing countries to shadow their counterparts in developed countries forever. There are equally, even more, valuable sources from which firms can learn. This is especially true for firms that already have capabilities to learn from more sources. von Hippel (1988) argues that users and providers are the main sources of innovation. (Von Hippel, 1988, p.177-178).

Zhang (1998) argues that the inner sources of learning include R&D, marketing, and manufacturing departments, and employees with special techniques, and that the outer sources include government, users, consultants, providers, competitors, universities, and research institutes. (Zhang, 1998, p.27-31).

Kim (1997) regards universities, research institutes, other firms, other support systems as domestic sources, and equipment embodied, human embodied, printed information, foreign suppliers, and foreign buyers as international sources of technological learning in newly industrializing countries. (J. Chen, W.G. Qu, 2002, p.3).

3.3. Subjects of Technological Learning

The third question for technological learning is 'who should learn'. Generally, it is believed that only individuals can learn. All learning takes place inside individual human minds. Although the actors of learning are individuals, organizations can also learn, or more precisely they can evolve. The reason that we consider organizational learning as a process of evolution is that the learning is not controlled by people. When people in organizations learn and apply the knowledge they have learned, the organizations per se also learn in ways that people cannot always understand and control. And yet, the learning and knowledge application of individuals in organizations can promote organizational learning.

The roles that managerial personnel and R&D personnel play in learning are different. The R&D personnel learn technological knowledge and build up the technological capabilities of organizations, such as patents and technological documents. The managerial personnel learn knowledge on management and build up managerial capabilities, such as institutions and routines. Technological and managerial capabilities are consistent with the concepts of "human capital" and "structural capital" respectively in technology-driven firms. The increase of both technological capabilities and managerial capabilities subsequently improves the whole organization's competence. (J. Chen, W.G. Qu, 2002, p.3).

3.4. Methods of Technological Learning

The fourth question for technological learning is 'how to learn'. The answer depends on what firms want to learn and who learns. For instance, Hansen (1999) argue that there are different methods to manage different types of knowledge. For technological knowledge, learning by doing, learning by using, and learning by R&D may be appropriate for acquirement, assimilation, and improvement of technologies, respectively. For managerial knowledge, benchmarking or "best practice" are good tools. (Hansen, 1999, p.106-116).

Huber (1991) suggests that organizational experiments are effective ways for firms to survive and grow in today's fast changing and unpredictable environments. He argues that organizational experiments and self-appraisals are generally directed toward enhancing adaptation, while maintaining organizational experiments is generally directed toward enhancing adaptability. This idea is similar to strategic and meta-strategic learning. (Huber,1991, p.88-115).

For individuals, learning by doing may be the best way to learn tacit knowledge. Therefore, training programs and apprenticeships are effective ways to enhance both tacit knowledge and explicit knowledge of newcomers. Sharing knowledge in a "field" or "self-organizing team" is also very helpful for individuals to improve their tacit and explicit knowledge.

Grant (1996) treats the firm as an institution for knowledge application. Thus, the main tasks of organization learning are to understand the coordination mechanisms and processes through which firms access and utilize the knowledge possessed by their members, and to adapt these mechanisms and processes for more effective and efficient knowledge application. (Grant, 1996, p.109-127).

3.5. Media of Technological Learning

The last question for technological learning is "how can firms learn more efficiently?". We suggest using information technology as a facilitator for technological learning. With the increasing power of information technology, it is easier today for firms to get information and implement their knowledge management. Emerging information technologies dramatically improve firms' capabilities in technological learning. For instance, with access to the Internet, firms in developing countries now can retrieve more information about the technologies they are interested in and can make a more informed decision about the introduction of technologies. At the same time, intranets can provide an inner platform for knowledge sharing among organizational members.

Interactive information technologies, such as Bulletin Board System (BBS) and Email, enable or facilitate certain kinds of learning that must happen in an interactive way. For example, the BBS can be used to build up a virtual "field" to facilitate the knowledge sharing of employees and to contribute to organizational learning. BBS and Email also are very efficient ways to contact customers and suppliers who are considered to be important sources of innovation. Other valuable information technologies for learning include Decision Support System/Artificial Intelligence/Data Mining for decision-making, CAD/CAM/CIMS for R&D and manufacturing, MRP II/ERP for operation, Web/Software Agency/Database/Data warehouse for marketing, and Groupware for teamwork.

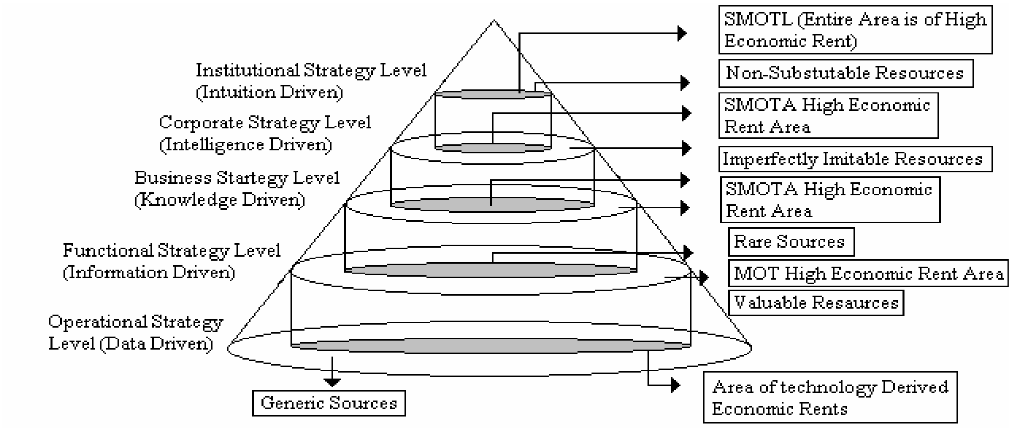
3.6. Managing Technology and Competitive Advantage in Technological Learning

There are some theories explore technology management practices as a source of competitive advantage. These practices often compose a "hidden advantage" of firms, as they are often deeply embedded in the tacit organizational routines of the firm and hence reflect causal ambiguity. The strategic management of technology makes those practices explicit and governs the process of improving their contribution to firm performance. This has been defined as "an information-seeking and information-processing activity" that tries to "build advantage on the basis of technology" , or "bring the potential opportunities that technology creates to bear on the formulation of corporate strategy".

The particular dynamics of competition in industries with rapid technological change has led some authors to point out the need for a "theory of the technology-based firm", based on but distinct from a more general theory of the firm. In these industries, the technological competence of the firm is a fundamental source of competitive advantage, contributing to other core competencies and firm-specific resources. In this environment, strategy becomes "a series of quests for the next technological winner". The role of unlearning is particularly important, ashyper-competitive environments tend to turn core competencies into "core rigidities" over time. The result is what D'Aveni (1994) describes as the strategic maneuvering of firms among continuous technological discontinuities:

Hyper-competitive firms attempt to avoid or break out of perfect competition (where no one has an advantage by speeding up the ladder faster than the other players or restarting the cycle by building new knowledge bases that allow new products and business methods to be used .

Fig.3. Illustration of Concentric Levels of Technological Learning (Carayannis, Alexander, 2002.,p.627)



STRATEGIC "CURRENCY" GENRE LEGEND:

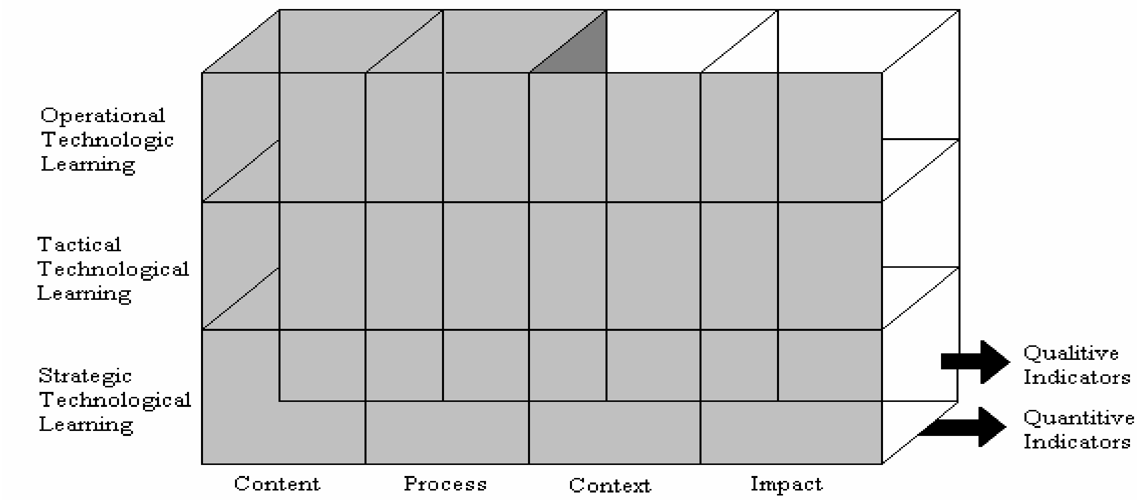
MOT : Management of Technology

SMOT : Strategic Management of Technology

SMOTA : Strategic Management of Technology Assets

SMOTL : Strategic Management of Technological Learning

Fig. 4. An Architecture of Concepts in Technological Learning (Carayannis, Alexander,2002.,p.627)



Technological learning is one avenue by which firms can adjust to both incremental and discontinuous technological change. One field of theory in technology management argues that the processes of managing incremental improvements in technology differ substantially from those appropriate for managing "disruptive" technologies. Linking this theory to research on learning could show that this difference is due to the difference in processes of learning appropriate for incremental and discontinuous technological change. (Carayannis, Alexander, 2002.,p.628).

3.7. Technological Learning as a Source of Competitive Advantage

Technological learning processes are organizational transformation processes whereby individuals, groups, and/or the organization as a whole internalize (with both extrinsic and intrinsic motivation) technical and administrative experience to improve their decision making and the management of uncertainty and complexity. In this view, technological learning enables an organization to pursue a greater range of technology-based strategies and activities. The effective management of technological learning would therefore contribute to competitive advantage by expanding the horizon of possibilities for technology-based strategic action, and improving the ability of management to select the strategy most appropriate for the firm's competitive environment.

Firm competitive advantage in this environment is based not simply on whether a firm is able to learn, but how effectively it can recognize and exploit learning opportunities created by aligning its internal capabilities with the external technology-intensive environment. Synthesizing the strategic management of technology and the management of technological learning results in the concept of the strategic management of technological learning (SMOTL).

In SMOTL, the term "strategic" refers to the ability to develop competitive advantage through the management of technological learning, not the development of some explicit plan. This can occur consciously or unconsciously, where this competence is the result of explicit design and/or the unintended consequence of embedded organizational routines. (Carayannis, Alexander, 2002, p.629).

CHAPTER 4

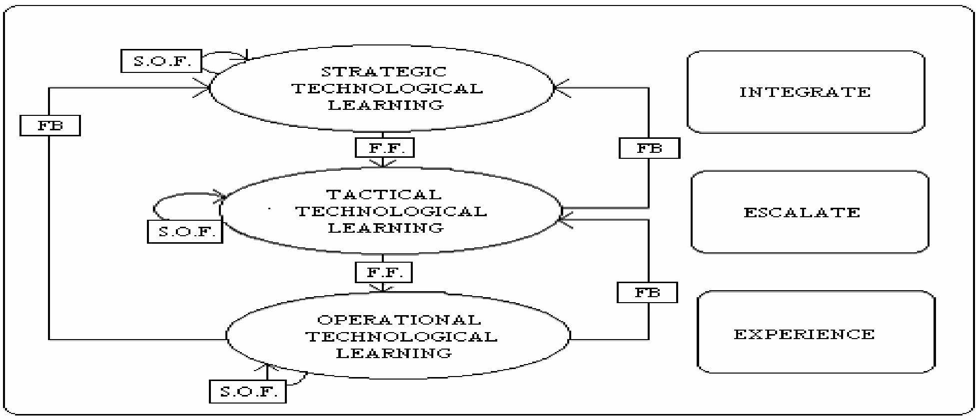
TOWARDS A MULTI-DIMENSIONAL THEORY OF TECHNOLOGICAL LEARNING

4.1. Classification Of Technological Learning

The above discussion leads to an architecture of learning activities, where learning takes place at three interrelated conceptual levels:

- Operational learning or learning and unlearning from experience
- Tactical learning or learning how-to-learn and unlearn from experience,
- Strategic learning or learning to learn-how-to-learn and unlearn from experience. (Carayannis, Alexander, 2002, p.629).

Fig. 5. A Triple-layered Architecture of Technological Learning: strategic, tactical, operational (Carayannis, Alexander, 2002., p.629).



S.O.F.= self-organizing feedback,

FB= feedback loop,

FF= feedforward loop

4.1.1. Operational Technological Learning

On the operational learning level, we have accumulated experience and learning by doing: we learn new things. This is the short-to medium-term perspective on learning, focusing on new or improved capabilities built through the content learned by an organization. This learning contributes to the management of core organizational capabilities , resource allocation, and competitive strategy.

4.1.2. Tactical Technological Learning

On the tactical learning level, we have learning of new tactics about applying the accumulating experience and the learning process (redefinition of the fundamental rules and contingencies of our short term operating universe): we build new contingency models of decision making by changing the rules for making decisions and/or adding new ones . This is the medium- to long-term perspective on learning, resulting in a process of re-inventing and re-engineering the corporation.

4.1.3. Strategic Technological Learning

On the strategic learning level, we have development and learning internalization and institutionalization of new views of our operating universe. Thus, we redefine our fundamentals our rules and contingencies for our decision making, or we redefine the fundamentals of our operating universe. . This is the very long term perspective on learning, that focuses on re-shaping our reinventing and re-engineering organizational tools.The strategic learning level involves the expansion and reformulation of concepts about the limits and potential of the firm's strategic environment. The strategic learning level involves the expansion and reformulation of concepts about the limits and potential of the firm's strategic environment.

Strategic learning serves to "leap-frog" to a new competitive realm and "to increase the slope of the learning curve. The result is what other authors refer to as "changing the rules of the game" or creating new "ecologies of business" .The firm pioneers a new conceptualization of its business, itsmarket, and/or its overall competitive environment.

The effect on firm performance of activities at each level of technological learning (operational, tactical, and strategic) initially appear difficult to discern, but are brought into sharp relief by considering the performance effects of the absence of each type of learning:

- Firms which are unable to learn (absence of operational learning) are quickly eliminated from competition, as they are unable to develop new capabilities to match changes in their environment and to maintain performance parity with other firms.

- Firms which are unable to learn how to learn (absence of tactical learning) are able to compete in the short term, but in the medium term are unable to adopt new learning strategies which could enable them to make discontinuous leaps in performance (analogous to changes in quanta). Thus, such firms are unable to maintain the same rate of performance improvement as firms which engage in tactical learning.

- Firms which are unable to learn to learn-how-to-learn absence of strategic learning are able to compete in the medium term, but in the long term are eliminated because they cannot maintain a consistent rate of improvement in learning processes..., and therefore can-what problems are perceived, how these problems are interpreted, and what learning ultimately results” not control the timing and scale of quantum leaps in performance.

Firms exhibiting tactical and/or strategic technological learning but not operational technological learning may be vulnerable in the short run, but have a long-term advantage if they manage to survive. Conversely, those focused on lower-order learning activities versus lower-order activities may excel in the short term but see their advantage erode over time. The various configurations of learning may be a factor in the formation of learning alliances; i.e. firms may form alliances if they have complementary strengths in different levels of technological learning. The three levels of learning activities are linked through a series of feedback and feed-forward loops so that cumulative learning at lower levels may lead to improved learning at higher levels, while learning at higher levels can reconfigure learning processes occurring at lower levels.

The reflexive analysis of strategic technological learning styles enables a firm to identify and leverage instances of strategic pivot points, when a particular strategic approach to learning becomes inappropriate and must be changed. In other words, meta-strategic technological learning is seen in changes in the cognitive maps utilized by top management to analyze the competitive environment and to generate new strategies. (Carayannis, Alexander, 2002, p.629-630).

4.2. A General Framework of Technological Learning

Differentiating among the learning styles of various firms requires further decomposition of technological learning within each of the three levels. In our model, we identify and study four general aspects of technological learning present at each level. Each of these aspects itself has several dimensions, enabling a greater degree of specification in describing the particular approach to technological learning adopted by a firm. The four aspects are:

- Content (what is being learned, whether it is a skill, a theory, or a new way of thinking),

- Process (the conceptual level of learning, whether it is simply learning new content, learning to learn, or learning to learn-how-to-learn), context (the environmental conditions of the learning activity under study), and impact (the change resulting from learning on the firm).

- Context (the environmental conditions of the learning activity under study), and

- Impact (the change resulting from learning on the firm)

Table 1 shows the range of dimensions found within each aspect.

4.2.1. Content

The content of the learning describes the nature of the corporate capability which is improved or added through organizational learning. One breakdown of learning content distinguishes among learning facts, learning rules, and learning meta-rules. Facts are codified and tacit understandings about the nature of the physical world and its contents. Rules are procedures, practices, and routines which dictate or guide the activities of members in an organization. Meta-rules are the culture, shared social experiences, and world-views which shape the organization's perception of reality and the resulting rules that it develops. Table 2 illustrates various forms of learning content at the individual and organizational levels.

4.2.2. Process

The process of learning concerns whether the learning is limited to the improvement of existing capabilities or the creation of new capabilities, or if learning encompasses new ways to learn and the development of a new capacity

4.2.3. Context

The context of learning refers to the level and scope within which a learning activity is analyzed and measured. Context consists of many different variables, each measured along a continuum, which together is analogous to the "magnification" of the lens used to view learning. For example, learning can be analyzed at several different organizational levels (individual, team, plant, division, company-wide, or even industry-wide); Context also characterizes the nature of the knowledge gained through learning and its effects.

4.2.4. Impact

To these three dimensions we add a fourth aspect of learning, namely impact (the nature of the resulting change due to learning). This impact operates on three levels as well:

- Instrumental impact, corresponding to operational learning, which produces incremental change in firm processes, outputs, operations and performance;

- Innovative impact, corresponding to tactical learning, which produces radical change in firm processes, outputs, operations and performance; and

- Creative impact, corresponding to strategic learning, which produces architectural change in firm processes, outputs, operations and performance

Together, these four aspects of learning can be used to specify the essential features of a specific instance of learning, project the nature of its likely outcomes, and compare it to other observed instances of learning. While the categories used are not entirely mutually exclusive, the framework is useful in the development of a typology which can link specific types of learning to specific outcomes. Furthermore, the scale and scope of the outcomes depends on the extent to which each aspect is emphasized in the technological learning activities of the firm. For example, Table 2 shows how reengineering. Emphasizing the context and impact dimensions enables more strategic technological learning. (Carayannis, Alexander, 2002, p.631-632).

4.3. Outline of a Working Model of Technological Learning

As the exact nature of technological learning at the operational, tactical and strategic levels is difficult to discern, we develop our learning profiles using very general concepts. In essence, technological learning is a "black box" in the view of traditional research methods, so we explore technological learning by dividing that "black box" into specific domains to create multi-dimensional surface models. At the general level, the model assumes the following:

- Certain activities within an organization constitute the inputs to technological learning, in that they facilitate or contribute to the development of new knowledge, capabilities and strategic possibilities based on technological competences within the firm.

- These inputs function (at the operational, tactical, and/or strategic) levels of technological learning.

- These learning inputs can be correlated to some extent with indicators of firm performance, such as market share, market capitalization, productivity, and efficiency.

Table 1. Framework for the Assessment of Learning (Carayannis, Alexander, 2002, p.631).

Aspect	Description	Dimensions
Learning content	Nature of the capability added or improved through learning	- Facts (operational) - Rules, theories, models (tactical) - Meta-rules (strategic)
Learning process	Nature and effectiveness of the mechanism of Learning	- Learning (learning new capabilities or improving existing capabilities) Learning to learn (Learning how to improve firm performance through learning) - Learning to learn-how to learn (learning how to redesign organizationalparadigms to generate improved learning)
Learning context	Environmental conditions affecting and affected	- focus(administrative versus technical) - by learning content and process - Scope (individual, group, firm,industry) - Nature, including: - Timeframe (short, medium or long term) - Structure (formal to informal) - Tangibility (explicit to tacit) - Magnitude (radical to incremental) - Relation (competitive to cooperative) - Function (sociocultural change, socioeconomic change, etc.)
Learning impact	Nature and function of the change which results from learning in the technological operations and activities of the firm	- Instrumental change (operational) - Innovative change (tactical) - Creative change (strategic

Table 2. Typologies of technologic learning content:strategic, tactical, and operational (Carayannis, Alexander, 2002, p.632).

	Individual	Group
Typology of operational technological learning		
Tacit	Know-how, expertise	Group texture, work practise
Explicit	Rules of thumb, procedures	Drills, stories
Typology of tactical technological learning		
Tacit	Common sense, good judgment	Work practise, core competencies
Explicit	Design rules, procedures	Best practices, work processes
Typology of strategic technological learning		
Tacit	Wisdom, intuition	organizational intelligence
Explicit	Design meta-rules	Business process re-engineering

- The relationship between inputs and outputs of technological learning is mediated through the four aspects of technological learning described above:content, process, context and impact. Firms of different learning styles will display different strengths of relationships, in that particular aspects of technological learning will be stronger influences on these relationships than other aspects.

The ability of each technological learning input to affect outcomes will vary based on the fit between that input and the learning style of the firm. This model is outlined in Fig. 6. Based on this model, we identify particular constructs which represent the inputs, outputs, and aspects of technological learning within firms. (Carayannis, Alexander, 2002, p.633).

4.4. Operational Constructs for Technological Learning

Existing literature linking the development of firm-specific technological competence and performance has identified an array of indicators which we can use to denote the presence or absence of technological learning. These potential indicators include:

- spending on research and development activities relative to firm size,
- growth or decline in R&D,
- rates of new product development and introductions,
- changes in efficiency and productivity from new process technologies,
- development of competences in new fields of technology
- involvement in strategic technological alliances

- rates of patent applications and awards

- technological licensing activity

- managerial attitudes and opinions on the significance of technology to firm strategy.

We have selected certain indicators for use in this study which represent a balance among various types of indicators along the following axes:

- quantitative and qualitative indicators

- indicators of technical and administrative learning,

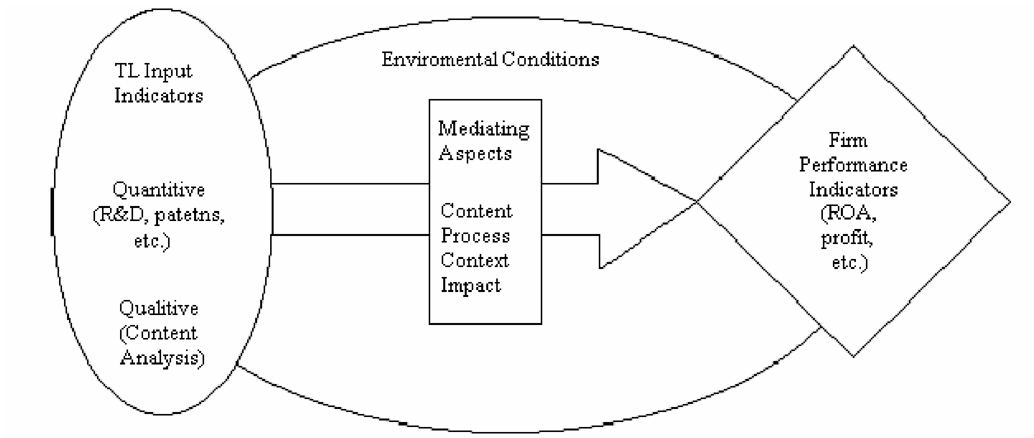
-indicators of operational and tactical/strategic technological learning (Carayannis, Alexander, 2002, p.633).

4.4.1. Quantitative Versus Qualitative Indicators

One important distinction is the difference in the nature and application of quantitative and qualitative indicators of technological learning. Both have particular advantages which suit the investigation of different but important issues in technological learning. Quantitative indicators, such as R&D investment and patenting rates, are useful as standardized and readily-comparable metrics for the presence and scale of technological learning activities. These attributes also limit the application of quantitative indicators. Much of technological learning involves tacit processes which are not captured by quantitative data.

Qualitative research indicators, on the other hand, focus primarily on issues of process and motivation. They are intended to highlight the small but significant differences in detail between activities at different firms, drawing out factors which may be tacit and difficult to observe directly. Case study methodology is especially helpful in deriving qualitative indicators for particular firms. However, case studies are often criticized for their limited capability to generalize findings across firms. Therefore, we adopt a hybrid approach to generating and measuring qualitative indicators, with a form of content analysis described below. (Carayannis, Alexander, 2002, p.634).

Fig. 6. Basic Working Model Linking Technological Learning and Performance (Carayannis, Alexander, 2002., p.633)



4.4.2. Differentiating Technical from Administrative Learning

For the purposes of this study, technological learning is further broken down into two primary domains: technical learning, or learning about the development and exploitation of technologies; and administrative learning, or learning about new approaches to organizational and technological management. Technical learning contributes to firm performance by

(a) enhancing the depth of knowledge in a firm's core technologies and increasing the ways in which the firm can leverage or exploit those technologies in the marketplace,

(b) expanding the range of technologies in the firm's portfolio, and thus increase the number of permutations possible through integrating various technologies into new capabilities and products.

Administrative learning changes the way that a firm manages its technical activities, particularly in research and development, and affects firm performance by enabling a firm to implement, integrate and commercialize technologies more efficiently and effectively. Examples of administrative learning include implementing concurrent engineering, instituting a total quality management system, or decentralizing research activities. These indicatorsare categorized shown in Table 3, as either technical learning (learning the content of the technology itself — its potentials, limitations, and application) or administrative learning (learning the content of managing the technology — how to develop, commercialize and exploit the technology for greater strategic impact). (Carayannis, Alexander, 2002, p.634).

4.4.3. Differentiating Operational from Tactical and Strategic Technological Learning

Although our architecture of learning activities above describes three levels of learning, previous case study research reveals that the fundamental nature of strategic learning makes it very difficult to discern using research methods other than in-depth ethnographic observation. Therefore, for the purposes of our analysis focus on the differences between operational technological learning and higher technological learning. (see Table 4).

Technological Learning is observed through the activities which explore and expand existing fields of technological competence within the firm. These activities focus on learning and understanding the facts about new technologies and their application to corporate operations. Technological Learning concentrates on creating new options for the utilization of technologies which are new to ther firm.

Technological Learning is concerned with the incremental accumulation of technological knowledge for strategic purposes, higher technologic learning involves the development of new approaches, routines, and environments which stimulate technological learning in new ways. The emphasis of such activities is not simply on acquiring and applying new technologies. Instead, Technological Learning activities focus on changing the modes of technological learning, to make such learning more effective, efficient, productive and dynamic. In other words, higher technological learning focuses on creating new options for the generation of technologies which are new to the firm

The distinction between Technological Learnning and higher technological learning can be characterized using the traditional contrast between "stock" and "flow", where Technological Learning is analogous to "flow", indicating a particular volume of learning activities, and higher technologic learning is analogous to “stock”, or the creation of new capabilities to learn which are then exploited at a later time. Higher technological learning activities are somewhat difficult to observe from an external position. Bacause most firms keep information about the strategic impact of their technical activities fairly proprietary. This operative contrast between Technological Learning and higher technological learning provides a comprehensive framework for designing a more focused research approach to investigate the link between technological learning and firm market performance. (Carayannis, Alexander, 2002, p.634-635).

Table 3. Indicators of technological learning (Carayannis, Alexander, 2002, p.635).

Indicator type	Indicator domains	examples
Technical learning indicators	Indicators of R&D productivity	- R&D intensity or R&D spending/assets - number of new patents per R&D spending - number of new products per R&D spending
	Indicators of absorptive capacity	- R&D spending per employee - Ratio of R&D personnel to total employees - Licencing agreements signed - Formation of strategic alliances
Administrative learning	Indicators of new approaches to innovation	- Introduction of new methods of managing innovation, such as alliances - Announcement of new R&D facilities and organization, e.g.movement of R&D closer to business units - Adoption of radical new forms of organizing innovation, such as concurrent engineering, global R&D
	Human capital development	- new training programs and initiatives, such as partnerships with universities - changes in compensation practices, especially for technical/research personnel

Table 4

Contrast between Techonologic Learning and Higher order Techonologic Learning Activities (Carayannis, Alexander, 2002, p.635).

Technical learning		Higher order technical learning	
Technical learning	Administrative learning	Technical learning	Administrative learning
Change in the rate and volume of innovation	Change in the organization of innovation activities	change in the productivity and effectiveness of innovation	introduction of new approaches to the management and organization of innovation

CHAPTER 5

TECNOLOGICAL LEARNING IN PRACTICE

5.1. The ZDZK Case

Many studies have focused on the processes of successful technological learning in the industrialization of developing countries. It is believed that, in general, newly industrialized countries initially learn technologies from developed countries, and then build their own technological capabilities step by step. The stages of technological learning are necessary for developing countries that want to build up their own technological capabilities.

Korea is an excellent example of successful technological learning. In fact, no nation has tried harder and come so far as quickly. This country has gone from handicrafts to heavy industry and from poverty to prosperity, and has been transformed from a subsistent agrarian economy into a newly industrialized one during the past four decades.

Some scholars in Korea argue that the technological trajectory in developing countries is comprised of acquisition, assimilation, and improvement (from imitation to innovation), which is in the reverse order of that in developed countries.

China considers Korea as a paragon in technological learning. Therefore, many scholars in China believe that Korea's model of technological learning is also applicable to China. Arguably, however, no one solution can effectively deal with all problems. (J. Chen, W.G. Qu, 2002, p.1).

Technological learning in some firms in China does not follow the traditional staged model. These firms have opted for a more integrated technological learning that involves acquirement, assimilation, and improvement simultaneously. There are three common characteristics among these firms. First, technological learning in these firms is often fast and successful. Second, most of them are high-technology-based. Third, these firms generally keep close relationship with universities or research institutes and have their own technological capabilities in certain fields at the initiation stage.

The ZDZK Automation Ltd Co. is a good example of new technological learning. It has many typical properties that can be explained by the staged model. (J. Chen, W.G. Qu,2002, p.4).

ZDZK Co. was launched in March, 1993. Its founders and initial technologies came from the China State Engineering Research Center of Industrial Automation (CSERCIA) and the China State Key Lab of Industrial Control Technology (CSKLICT). Its main products were distributed control systems (DCS), which were widely used in the engineering projects of the chemical, oil refining, metallurgical, electric power, medical, and biochemical industries. The company had 175 employees in 1998, including 3 professors, 15 senior, 92 junior, and 30 assistant engineers. There were 16 doctoral degree and 25 master degree holders at ZDZK. The average age of the employees was 27.5.

Before ZDZK began producing DCS, China had relied on the DCS of foreign companies for its engineering projects. Although some projects funded by the Chinese government had tried to develop their own DCS, these projects eventually failed because the researchers could not address the key problems associated with developing DCS. As the first success in China, ZDZK developed a series of DCS with its own brand of SUPCON, basing their design on technologies from the Industrial Control Institute of Zhejiang University, the CSERCIA and the CSKLICT. By using both emerging and matured technologies, ZDZK introduced its own advanced DCS in 1993. Since then, the company has secured a considerable share of China DCS market. ZDZK has become a modern high-tech company with its own R&D, manufacturing, marketing and engineering departments. (J. Chen,W.G. Qu, 2002, p.4-5).

The Technological Learning at ZDZK

As mentioned before, the technological learning at ZDZK does not follow the traditional staged model. Based on information technology, this new technological learning has multiple objects, sources, subjects, and methods.

ZDZK succeeded in learning technologies and nano-technologies simultaneously. As a tech-based company, ZDZK learned technologies from many sources when the company developed its first DCS called JX-100. They developed the software for the upper part by imitating the control interface and operational methods of "qXL" DCS, which came from Japan. They also imitated the structure of control station and the "ONSPEC" software, which came from the USA, to develop the lower part. As ZDZK had strong links with the CSERCIA and the CSKLICT, they capitalized on this association and made use of the technologies that these research institutes were developing. At the same time, ZDZK learned nano-technologies actively. One manager said that because they lacked experience in management, they often appropriated effective managerial methods from other firms and imitated them when needed. Moreover, to improve the quality of its products, ZDZK began to implement the ISO9001.

Unlike some firms that always learned matured technologies, ZDZK made a balance in learning matured and emerging technologies. The company had utilized many matured technologies from foreign firms during the development of DCS. In 1996, ZDZK imported the software called "Hiecon" from Adersa Co. in France. They transplanted "Hiecon" into the systemic supervision software of the "JX-300X" DCS and developed an improved control software—AdvanTrol–Hiecon. The company assimilated the technology of "Smart 1151" transport, which is produced by Rosemount Co., and developed an intelligent transport called "SMART1151" in 1997. With the completion of its manufacturing factory, ZDZK adopted a lot of advanced equipment to improve its production.

At the same time, ZDZK learned many emerging technologies from China's research institutes. For example, during the development of "JX100" DCS, the company utilized the technologies of redundancy and groupware from the Industrial Control Institute of Zhejiang University (J. Chen, W.G. Qu, 2002, p.5).

Table 5.

The First Degree of New Technological Learning

Index	Measurements
Inside of Firms	
1. Capabilities of personnel	Education, work experiences, etc
2. Structure of R&D	Extent of appropriate pyramidal personnel structure
3. Accumulation of R&D documents	Amount of R&D document per documents year
4. Usage of R&D documents	Ratio of R&D documents used to total documents
5. R&D tools	Extent of advance in R&D tools
6. Knowledge sharing in R& D	Extent of formal and informal knowledge sharing Department
7. Knowledge sharing among departments	Extent of formal and informal knowledge sharing among R&D, production, and marketing departments
8.Top management support learning	CEO's attitude and effect to support technologicallearning
9. Incentive systems	Extent to which incentive systems are suitable for technological learning
10. Training programs	Training plans or informal training
11. Knowledge management	Extent of formal knowledge management
12. IT usage in KM	Extent of IT penetration in knowledge management
Outside of Firms	
13. Cooperation with leading firms	Extent of joint venture, technological cooperation and exchange with domestic and international leading firms
14. Cooperation with universities and R&D institutes	Extent of cooperation with universities and research institutes
15. Cooperation with users	Extent of cooperation with users
16. Cooperation with suppliers	Extent of cooperation with suppliers
17. Benchmarking	Extent of using benchmarking or best practice
18. Human resource	Extent of consistence between human resource planning and learning strategy
19. Usage of IT in cooperation	Extent of IT penetration in outside cooperation
20. Technology monitoring	Extent of formal technology monitoring

ZDZK had many sources for technological learning, including the foreign leading firms, universities, research institutes, users, and suppliers. Although foreign leading firms and universities were its main sources of learning, ZDZK did not want to miss the chance to learn from other sources. As the company belonged to Zhejiang University, it could easily learn technologies from this university. ZDZK often combined emerging technologies from the university and matured technologies from foreign firms to develop new products. ZDZK also emphasized its openness to the innovative ideas from actual users. For example, during the development of its series of DCS, suggestions from users played an important role. Some managers believed that it was this attention to the demand of users that drove the improvement of products. Also the company kept a close relationship with providers. (J. Chen, W.G. Qu, 2002, p.5-6).

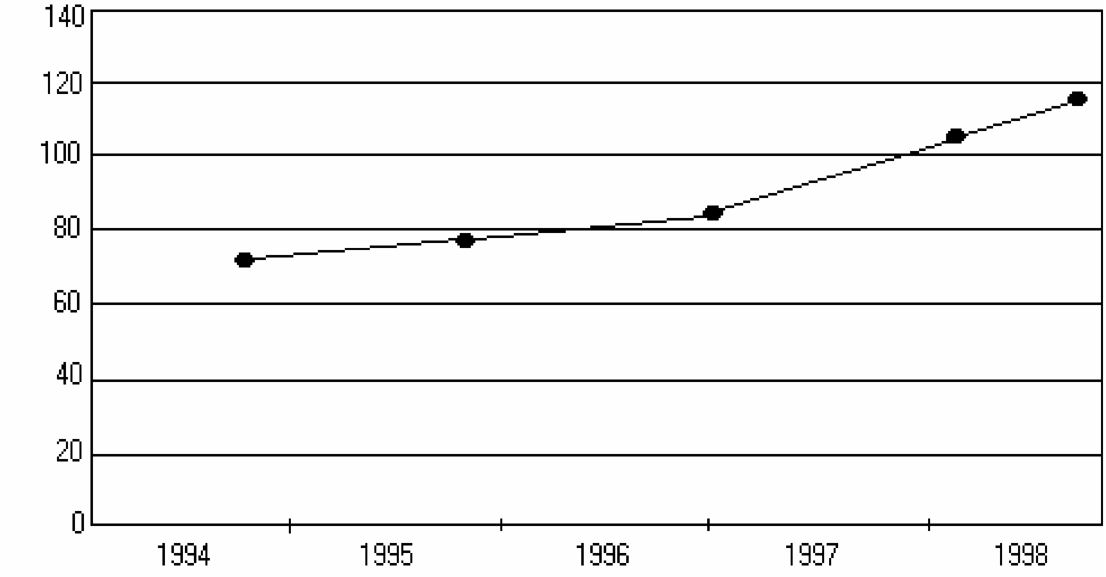
Individual learning and organizational learning were penetrated in ZDZK. When new employees were hired, they would be given a regular training to familiarize themselves with the company. The training program improved newcomers' explicit knowledge about the company. During the first year, ZDZK would not let new employees do a job independently. Rather, it teamed them up with veteran personnel. This practice was very effective for learning tacit knowledge. After this apprenticeship of one year, newcomers generally became skilled. Furthermore, jobs were generally done by teams.With teamwork, individuals could easily learn additional tacit and explicit knowledge. ZDZK even appointed special managers to integrate the knowledge generated by various departments and individuals. In most departments, there were managers who were responsible for collecting valuable knowledge. In this way, the explicit knowledge of the organization could be accumulated. By increasing organization's explicit knowledge, the individual explicit knowledge would increase gradually also because the individual could learn more explicit knowledge from the knowledge base of the company. Because of the lack in managerial experience, ZDZK often searched outside for best practice. With learning by organizational experiment, ZDZK had made important strides in developing effective management capabilities.

During technological learning, ZDZK availed itself of information technology to accelerate learning. The company had many computers for R&D. The penetration of computers could facilitate IT-based knowledge management. Since 1996, the company had built LANs in its three branches and had begun to accumulate knowledge with the support of its computer networks. The LANs facilitated the communication and knowledge sharing among the employees. The BBS and Email had become the primary means of online communication. Because of the inter-dependence of work in different teams, employees made extensive use of these technologies to support their frequent communications. Database technologies made the storage and retrieval of knowledge more efficient. However, the official communication among the branches was still through traditional channels, such as mail. Using a preliminary scale, ZDZK's capabilities in technological learning from 1994 to 1998 are measured. (Table. 7). The scores are based on interviews and documents and evaluated by three experts in the field of technology learning.

Correspondingly, the sales of ZDZK from 1994 to 1998 are shown in Table 8. Within six years, ZDZK has made an obvious progress in both technological capabilities and market share. Seemingly, new technological learning at ZDZK had played a significant role in its successful growth. (J. Chen,W.G. Qu, 2002, p.6).

Fig. 7. Capability of ZDZK in New Technological Learning (J. Chen, W.G. Qu, 2002.,p.6).

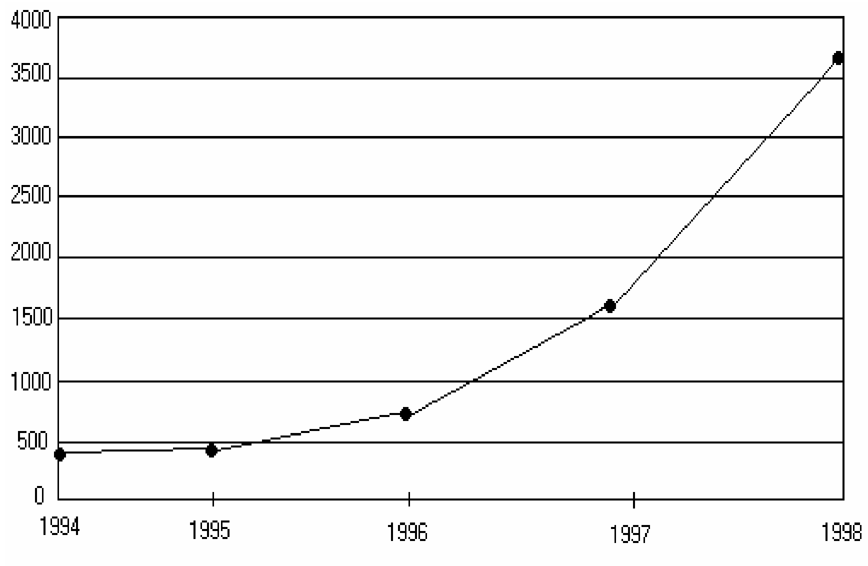
Education Period



Years

Fig. 8. Sales of ZDZK from 1994 to 1998 (J. Chen, W.G. Qu, 2002.,p.6**)**

Sales



Years

In this study, it is argued that the traditional staged model of technological learning pays too much attention to technologies and the necessity of the phases. Although it may have applied to developing countries in the 60s and 70s, such as Korea, the analysis suggests that it may no longer meet the needs of firms in developing countries nowadays. It is proposed that a new form of technological learning, which integrates different stages of the traditional model, is emerging in developing countries, such as China. This new form of learning may be more feasible because the current situation of countries such as China is different from that in other developing countries decades ago. For firms that already possess a certain technological capability, they can and should circumvent the lower stages of the traditional model. With the globalization, firms in developing countries must realize the danger of focusing on lower-level technological learning. A more integrated technological learning approach is probably necessary for the survival of firms in developing countries.

The new technological learning involves not only operational and tactical learning, but strategic learning as well. It emphasizes the long-term goal of firms. Therefore, the new technological learning involves both technologies and non-technologies, both matured and emerging technologies. It requires firms to learn from multiple sources: universities, research institutes, customers, suppliers, employees, and international and domestic leading firms. Although learning is an individual activity, organizations also learn or evolve precisely when individuals learn and apply their knowledge in organizations. Thus, individual learning can improve organizational learning. While learning by doing, learning by using, and learning by R&D can enhance technological capabilities, organizational experiment may be a good way to enhance managerial capabilities. While training and self-organizing teams are suitable for improving individual knowledge, the adaptation of coordination mechanisms and processes of knowledge application is a manageable way to increase the complicated capabilities of organizations. Also, information technology plays an important role in new technological learning. (J. Chen, W.G. Qu, 2002, p.6).

5.2. Carayannis and Alexander's Survey

Carayannis and Jeff Alexander conducted a multi-industry, longitudinal, empirical study to investigate the relationship between technological learning activities and firm market performance. Based on the previous analysis of learning activities and their relationship to competitive advantage, they adressed the following research questions:

1. In what instances and through which aspects do learning activities contribute to or detract from firm market performance?

2. What is the scale of the impact of technological learning activities on firm market performance, and how does that impact vary under different firm, industry and market conditions?

3. What is the time lag between learning activities and their impact on firm market performance?

4. How does the scope of learning activities affect the resulting impact on firm market performance?

5. How does the level of investment in learning activities affect the impact of those activities on firm market performance?

These research questions were further narrowed into hypotheses appropriate for empirical testing through the study of actual firm technological learning activities:

H1:The scale of technological learning activities is correlated with firm market performance (test of relationship).

H2: The level and direction of correlation between technological learning activities and market performance vary with the time horizon implicit in calculating the level of firm market performance (test of time effects).

H3 :Investment in technological learning activities is positively correlated with the level of firm market performance (test of sensitivity).

In the study done by Carayannis and Alexander, technological learning activities of 24 firms across six industries were analyzed. These six industries fell into two general technological "clusters".

- Cluster 1 consists of firms in pharmaceutical, chemical, and biotechnology industries.

- Cluster 2 is composed of firms in the semiconductor, computer, and computer peripherals and networking industries.

The firms in the sample were selected in two ways:

- For more established industries such as chemical and semiconductor, the leading firms as identified by the 1999 Fortune 500 listing of the largest US firms in each industry by sales were chosen.

- For more entrepreneurial industries, such as biotechnology; firms identified as industry leaders by securities analyst reports were selected. In this survey, market performance and indicators of technological learning for these 24 firms were studied for a time period of approximately 12 years, from 1986 to 1997.

As outlined in the model in fig. 6, Carayannis and Alexander measured the relationship between specific indicators of inputs to technological learning and outputs representing market performance. After that they investigated how that relationship had been affected by the mediating aspects such as content and context.

The data set for inputs to technological learning drew on two types of indicators described above: quantitative and qualitative indicators. For quantitative indicators of technological learning activities, this study utilized two generally-accepted measures of the scale of technological capability in R&D, namely research and development spending and patenting rates. The patenting rate was generated by counting the number of new patents awarded each year to each firm by the US Patent and Trademark Office (PTO), using the PTO's own database of awards. To normalize these statistics to firm size, R&D spending and new patent awards as a ratio of total firm assets for each year measured, producing two quantitative indicators: R&D spending (RDS) and patent productivity (PAT).

Table 6. The Sample Used For Learning Activities Indicators

R&D Indicators	Research
	Development
	Patent
	Technology
Cooperative R&D Indicators	Integrate
	Joint-Venture
	Licencing
Technology Management Indicators	Asquisition
	Innovation
	Quality

To determine the strength of the relationship between each of the learning indicators in this study and performance, a series of multivariate linear regressions were conducted as:

1. A regression of RDS against ROA.
2. A regression of PAT against ROA.
3. A regression of LRN against ROA.
4. A regression of RDS and PAT against ROA.
5. A regression of RDS, PAT and LRN against ROA.

In each case, a dummy variable to identify the membership of each firm in each of the six industries can be found. Also, as the theoretical framework included the implicit assumption that any change in performance would follow changes in learning activities by some period of time, they conducted the regressions by inserting a time lag between the observed learning indicators and the observed firm performance. Table 7 summarizes the results for regression 5 for lag periods of 1, 2, 3 and 4 years.

Based on these results, it is possible to say that there is no strong evidence of a linear relationship between firm performance and any of the learning indicators (with the possible exception of spending AGH at a lag of 4 years). It is also interesting to note that the coefficients generated by these regressions would indicate that both patenting and the qualitative learning index are negatively related to performance.

Table 7

Results of Full Regressions

Time Lag	Adjusted R^2	Variables Used	Beta	Sig. *T*
1 Year	0.192	RDS	0,048	0,565
		PAT	-0,102	0,156
		LRN	-0,013	0,849
2 Years	0.189	RDS	0,095	0,284
		PAT	-0,098	0,196
		LRN	-0,017	0,821
3 Years	0.218	RDS	0,133	0,158
		PAT	-0,105	0,19
		LRN	-0,065	0,401
4 Years	0.199	RDS	0,268	0,009
		PAT	-0,117	0,171
		LRN	-0,058	0,484

More extensive examination of the date generated the following insights which guided further analytical investigations:

1. Attempting to fit a curve to the scatter plots for each of the learning indicators and performance showed that the relationship between these

variables is not linear. In most cases, the best-fitting curve between each indicator and performance at various time lags was a cubic equation.

The curve fit analysis showed an interesting pattern. For LRN and RDS, performance initially improves as the value of each indicator increases, and performance later declines. Performance once again improves as the indicator values reach their maximum.

For PAT, the inverse pattern is observed, with performance declining initially as patenting increases. Performance later improves, and then declines again (see Figs. 5(a)–(d) for a representation of this).

2. The original analysis was based on an extrinsic grouping of companies, trying to control for the influence of the firms' industry membership on the relationship between learning and performance. More useful results were gained by using an intrinsic grouping approach, i.e. clustering the firms based on their performance and then testing for the relationship between learning and performance.

To develop this intrinsic grouping, firstly the firms were ranked based on a combination of two criteria: the level of returns on assets, and the stability of returns on assets.

Following the methodology established in Carayannis and Maldifassi (1991), the average and standard deviation of ROA for each firm over the 12year period of the study were calculated. This provided a means to rank the firms based first on how well they minimize the variability in their performance, and second on the absolute scale of performance. Stability of performance is particularly important to research on learning, as learning should enable firms to adjust more rapidly to changes in their environment and maintain consistent performance over time.

Then the median average and median standard deviation of ROA for all firms were calculated in the study over the period. These statistics were used for grouping the firms into four cohorts or "quadrants" based on their relative performance scores (Table 8). This ranking reflects a higher value assigned to firms with consistent performance records versus those with a high level of performance.

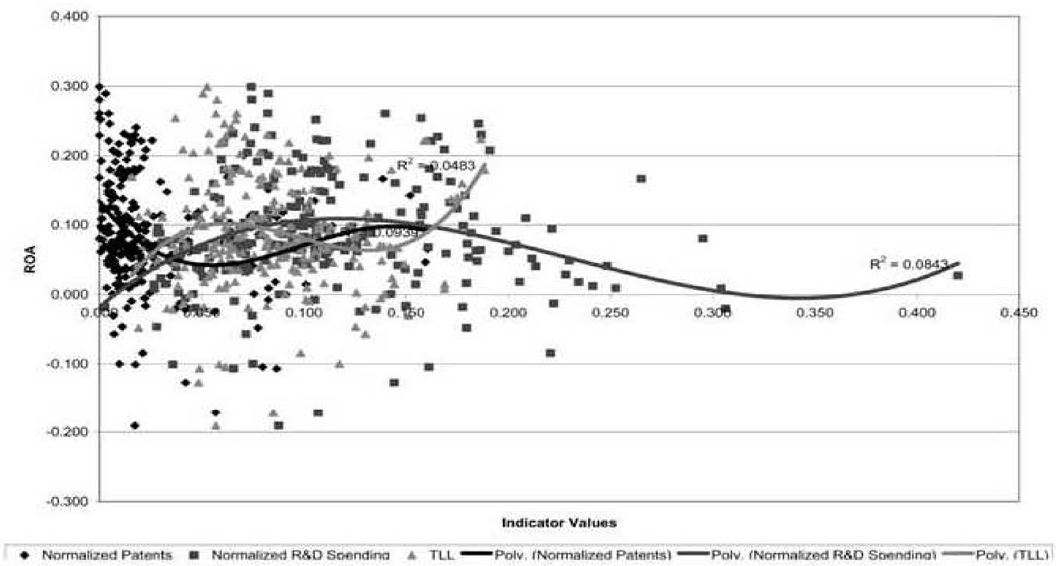
Table 8. Ranking Scheme for Firm Performance

Standard Deviation of ROA	Average ROA	Rank
Below Median	Above Median	1
Below Median	Below Median	2
Above Median	Above Median	3
Above Median	Below Median	4

Using this ranking, a series of partial correlations were performed to determine if any relationship existed between the learning indicators and performance. The results of this analysis were more promising than the linear regressions described above. In several cases, the learning indicators showed a significant degree of correlation with performance at various time lags (see Table 8). As this table shows, the PAT indicator is significantly correlated with ROA in the negative direction at a 3-year lag, with a 95% level of significance. RDS is significantly correlated with ROA in the positive direction at a 4-year lag, with a 99% level of significance. LRN is significantly correlated with ROA in all lag periods.

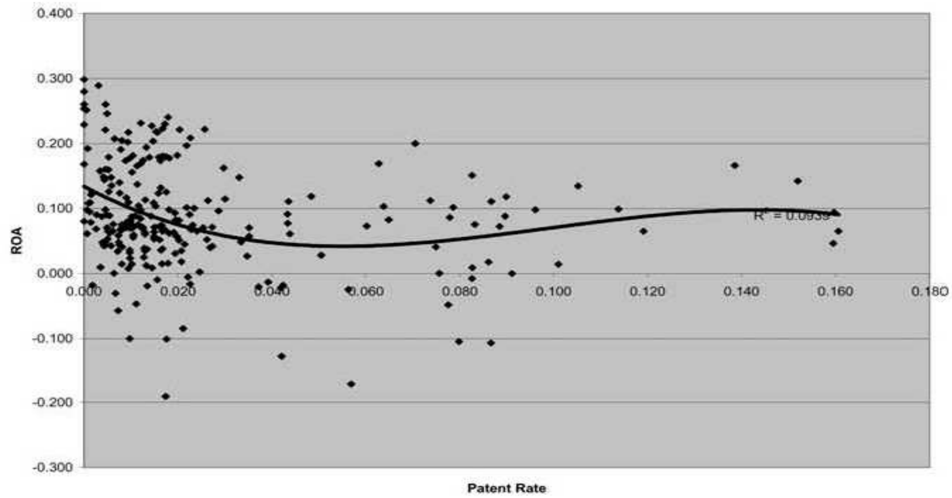
Fig. 9.

(a)

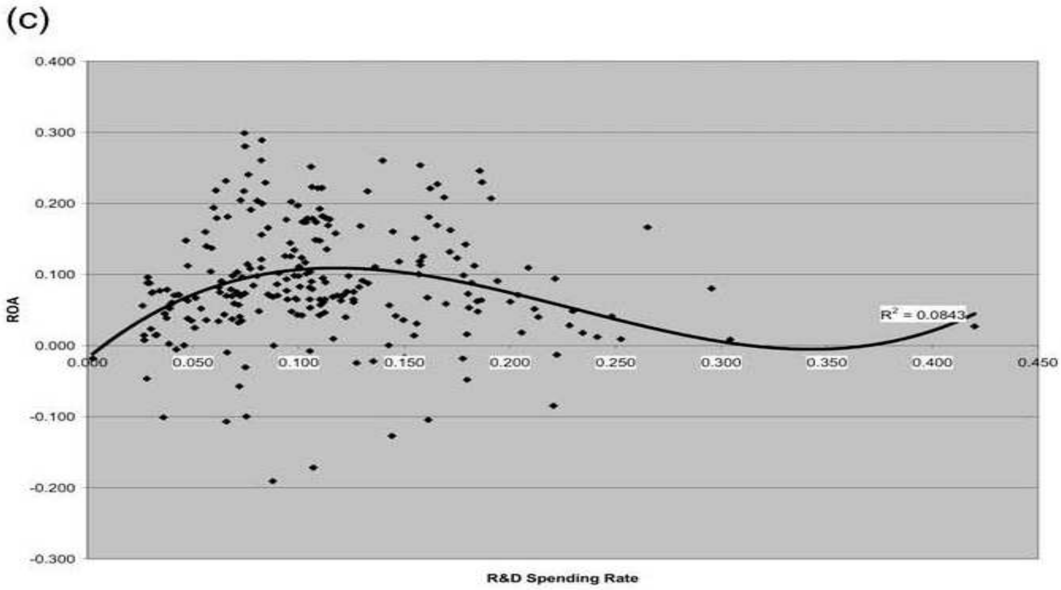


(a) Curve fit for ROA versus learning indicators at 1 year lag

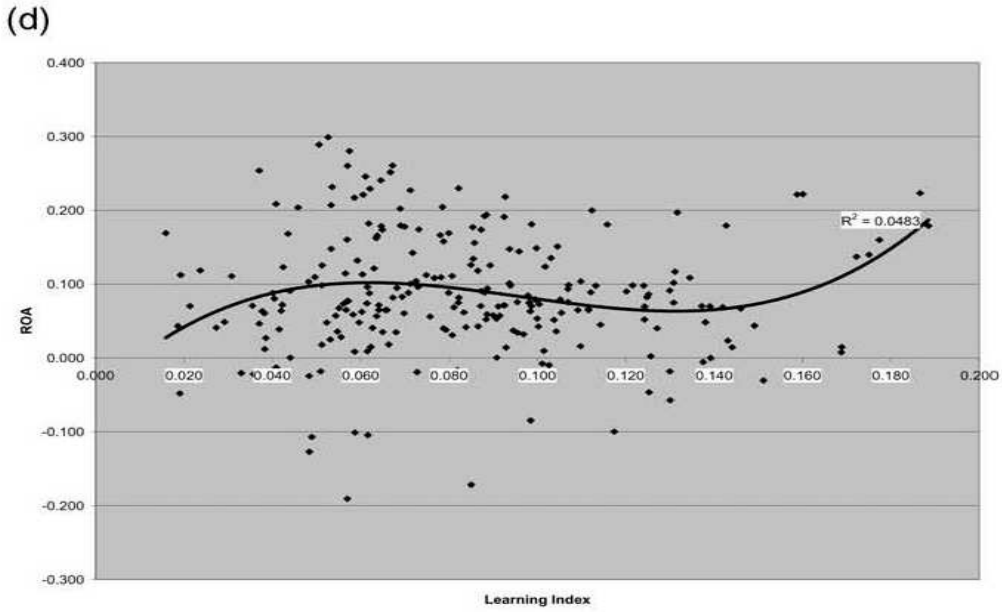
(b)



(b) Data points are njormalized patents; line denotes polynominal curve for normalized patents.



c) Data points are normalized R&D Spendings; line denotes polynominal curve for normalized R&D spending.



(d) Data points are TLL; line denotes polynominal curve for TLL

To begin investigating the relationship between higher order learning activities and performance, a similar set of correlation analyses between ROA and a new set of indicators showing the year-to-year percentage change in the indicators PAT, RDS and LRN were conducted. These new indicators were labeled as DPAT, DRDS, and DLRN, respectively. The results, which are shown in Table 10, are less conclusive. DPAT is significantly correlated in the negative direction with ROA with a 1-year lag at the 95% level. DRDS is significantly correlated in the negative direction with ROA with a 1-and 4-year lag at the 90% level. DLRN is not significantly correlated with ROA at any time lag.

Table 9

Results of First-order partial correlation

	ROA	PAT	RDS	LRN	*Lag*
ROA	1.000	-0,0885	-0,0036	-0,1609	
	0	237	237	237	1 Year
		P=0,173	*P*=0,955	*P*=0,013**	
ROA	1.000	-0,0902	0,0742	-0,1903	
	0	213	213	213	2 Years
		P=0,188	*P*=0,279	*P*=0,005***	
ROA	1.000	-0,01553	0,0737	-0,1229	
	0	189	189	189	3 Years
		P=0,032**	*P*=0,311	*P*=0,090*	
ROA	1.000	-0,0814	0,2371	-0,2934	
	0	165	165	165	4 Years
		P=0,296	*P*=0,002***	*P*=0,000***	

" Significant at *90%,95%.***99%**

Table 10
Results of Higher order partial correlations

	ROA	DPAT	DRDS	DLRN	Lag
ROA	1.000	-0,1585	-0,1116	0,0248	
	0	237	237	237	
		P=0,014**	*P*=0,085*	*P*=0,0703	1 Year
ROA	1.000	-0,0842	0,0533	0,001	
	0	213	213	213	
		P=0,219	*P*=0,437	*P*=0,989	2 Years
ROA	1.000	-0,0906	-0,0459	-0,111	
	0	189	189	189	
		P=0,212	*P*=0,528	*P*=0,879	3 Years
ROA	1.000	-0,0215	-0,1483	0,0274	
	0	165	165	165	
		P=0,783	*P*=0,056*	*P*=0,726	4 Years

"Significant at *90%,95%.***99%**

The findings of the survey may be summarized as follows:

First, as predicted by theory, there is evidence that technological learning activities are related to firm performance, although that relationship cannot be proven to be particularly strong. Still, the results support hypothesis H1. In particular, the significance of the correlation only becomes apparent when the analysis controls for the performance characteristics of the firms. This suggests that high-performing firms may be more adept at leveraging the advantages gained from technological learning and applying those advantages to influence their performance. If this is true, it appears that the strength of the relationship between technological learning and firm performance exhibits positive returns to scale; that is, firms which perform better learn better, and in turn are positioned to improve their performance even more. It is also important to include variability as a component of measuring performance, since technological learning should help a firm to maintain more consistent performance by enabling the firm to adapt more quickly to rapid changes in its market environment.

Second, there is also apparently some lag between the time that technological learning activities are conducted and their impact on market performance, based on the results that a significant level of correlation is found only if a specific time lag is inserted between the observations of technological learning and performance. This confirms hypothesis H2. Furthermore, the lag is dependent upon the type of technological learning activity, and patenting activity is correlated with performance along a time horizon which differs from that for research and development spending.

Third, there is conclusive evidence that technological learning is positively correlated with firm market performance. Thus, hypothesis H3 is not supported by the research results. In fact, the linear regressions and partial correlations suggest that the relationship is negative in many cases. However, upon closer examination, the relationship appears to be nonlinear, complicating the task of determining the direction of the relationship. In particular, the curve shapes for LRN and RDS suggest that learning activities may initially improve performance, but that there is some limit to a firm's absorptive capacity for learning.

Larger increments of technological learning begin to depress performance, until a new critical point is reached and performance again improves. This suggests the presence of an optimal learning absorption bandwidth for each firm, where learning activities should not exceed the absorptive capacity of the firm but also must be sufficient to sustain improved performance.

In a strategic sense, a firm must have a sufficiently long-term perspective on these investments in technological learning to continue these investments even if market performance is decreasing in the short term. At the same time, the firm must be flexible enough to sense when investments in technological learning may have reached a level of diminishing returns. This would provide greater insight into understanding the demands of flexibility required for the management of technological learning resources.

Our research appears to indicate that the effectiveness of technological learning activities in influencing firm market performance varies across industries. As Linton and Walsh (1999) discuss, however, different learning styles may also be needed to acquire different technological competences within the same set of firms. Therefore, variation in the relationship between technological learning activities and market performance may be related not only to industry characteristics, but to characteristics of the technologies underlying each industry as well. One stream of future research would investigate whether industry factors or technological factors have greater significance for the selection of technological learning activities by a given firm at a given point in time. (Linton ve Walsh, 1999, p.101).

One other aspect that warrants further examination is the distinction between strategic, tactical and operational technological learning, and their relative effects on market performance. Refining the indicators of technological learning activities could help to distinguish between these levels of technological learning.

Existing literature from the organizational learning, strategic management, and technology management fields suggests that the relationship between technological learning and firm market performance is substantial but very complex and contingency-dependent. A more detailed analysis of learning activities shows that technological learning has numerous aspects which are interlinked in a nonlinear manner, each of which affects the final influence of learning activities on firm market performance.

Furthermore, the relationship between learning and performance can change with the context adopted to analyze the relationship. The empirical study undertaken by Carayannis and Alexander shows that quantitative indicators of technological learning have limited ability to predict firm performance. The addition of qualitative variables adds somewhat to the strength of the relationship identified between technological learning and market performance. While full case studies would provide the greatest detail linking technological learning to firm performance, the limited generalizability of case studies makes a hybrid quantitative and qualitative approach more useful in the exploration of technological learning.

To sum up, the existing of conflicting data in the two cases discussed in this thesis indicate that more research is needed in the directions specified in this conclusion chapter.

CHAPTER 6

CONCLUSION

Economics attempts to solve problems arising from having to meet unlimited needs with limited resources. As consumers' needs increase and vary in time, while resources get scarce, competition becomes more serious and crueler. In the new uncertain, dynamic and volatile competitive landscape, science and technology learning will play a vital role in a firms' success. In such a milieu, information technology and knowledge one bound to have a dramatic impact.

Some scholars believe that competition is becoming more knowledge-based and that the sources of competitive advantage are shifting to intellectual capabilities from physical assets. Thus, being able to develop, maintain or nurture and exploit competitive advantages depends on the firm's ability to create, diffuse and utilize knowledge throughout the company.

As Polanyi stated, the aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them. Thus, tacit knowledge is difficult to codify, articulate and communicate. Importantly, the tacit dimension does not suggest that knowledge cannot be codified.

The ZDZK case has indicated that technological learning could create a competitive advantage; ZDZK became a market leader in a short time, thanks to technological learning. Other firms' experiences in Korea support the ZDZK case. For example CANDU showed similar success in the electronic sector.

On the other hand, Carayannis and Alexander's survey conflicts with the first case in certain directions. Even if the findings on the content, process, context and impact of technological learning hint at a positive impact on market performance, as substantial time lag is involved (this was not the case in ZDZK). Carayannis and Alexander's study needs to be supported by greater statistical validation and the implications of trends in decreasing market performance must be explored further with regard to initial resource investments to promote technological learning. Apparently, better ways of identifying valid qualitative data and deriving consistent indicators of learning patterns from those data must be found.

Previous research suggests that technological knowledge may be the foundation for economic growth. For example, Sanchez and Ross (1990) state that technological change involving the development of superior technologically advanced products is the main reason for the growth of output per worker in the United States and other industrialized countries. This supports arguments that technological knowledge is the principal source of long-run economic growth. Through technological learning, firms create and/or acquire technological knowledge from both internal and external sources. Furthermore, by using integrating mechanisms to manage technological knowledge and to link it with strategy, the firm can develop an ability to proactively use technological knowledge to innovate. These efforts can produce core competencies and ultimately sustained competitive advantage.

It is still early to say that there is technological learning taking place in Turkey in a general sense. Following questions help us see the big picture of the situation in Turkey. Is Turkey a technologically developing country? Do we produce or do we buy technological knowledge? How do we manage it? The proportion of Tubitak's budget allocated to R&D activities, which is approximately % 0,6 (Tubitak Official web site), shows us the lack of collaboration between universities and industry. And it is still developed countries that are producing technological knowledge. In general, newly industrialized countries initially learn technologies from developed countries, and then build their own technological capabilities step by step. The stages of technological learning are necessary for developing countries which want to build up their own technological capabilities.

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