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Total Innovation Management: a novel paradigm of innovation management in the 21st century

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Abstract Based on an ecosystem view of innovation management and in-depth case studies of firms in China and abroad, a novel paradigm of innovation management—Total Innovation Management (TIM)—is put forward in this paper. This new paradigm draws on three distinct areas of recent research, namely the innovation theory of the firm, the resource-based view (RBV), and the complexity theory. It introduces the theoretical framework of TIM, and presents a tri-dimensional innovation strategy model, which includes all elements of innovation, all innovators, and innovation in all times and spaces, and aims at value added and created.

Keywords Total Innovation Management · Strategy innovation · Paradigm change

JEL Classifications O31 · O32

1 Introduction

In the past three decades, quite a few firms such as GE, HP, and 3M in America, and Haier, Zhongxin Communications, and Baosteel Group in China, have undergone rapid growth with remarkable innovations. In China, Haier stands out as an excellent example. Over the past 17 years, Haier has witnessed an annual sales increase of 78% and has made significant achievements in innovation. It now produces a wide range of household electrical appliances in 86 categories and 13,000 specifications. Haier's now also export products to 160 countries.

Why do these firms have a long history of adapting and thriving through successive rainstorms of creative destruction in a turbulent and changing world?

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How has Haier managed to achieve such a rapid growth in only 18 years? What are the major factors behind the growth? Most firms have tried to enhance their competitiveness, but only a few have managed to make significant strides in reinventing and revitalizing themselves. Under what conditions, then, is reinventing and revitalizing possible? Based on the success of some Chinese firms, and on the innovation management experience of well-known companies in the world like GE, HP, and 3M, this paper is aimed at answering these questions and drawing some general conclusions about the conditions under which successful innovation management can take place. The following observations further underscore the motivations for this study.

Since the 1990s, firms have had to confront highly complex and turbulent environments. Management of technology and innovation presents ongoing challenges to firms, due to the increasing cost and complexity of products and services against a background of global competition, IT-based innovation networks, accelerating industrial change, and of a shortening technology life cycle (TLC). Innovation is widely regarded as central to an organization's strategy for long-term growth and survival in such an environment (Tucker, 2002). Firms innovate in a number of ways. These include innovations in business models, products, services, processes, and channels for maintaining or capturing markets, and reducing costs or prices through greater efficiencies. According to the OECD's (1996) Report on *Technology, Productivity and Job Creation*, a considerable body of research shows that technological and organizational changes are highly interconnected. Indeed, technological change both calls for and results from organizational change. This relationship is clearly demonstrated by the results obtained in a Danish survey of organizational and technical innovation in 1,900 Danish private firms: 68% of the firms that had undertaken major organizational changes from 1993 to 1995 had also introduced new products or services. The corresponding figure for firms that had not undertaken major organizational changes was only 34%. In fact, some leading firms that had undertaken major organizational changes reported that organizational innovation took place in order to strengthen the ability of the firm to continuously develop new products or services and renew the firm's knowledge base. HP is a good example of gaining long-term fast growth through implementation of total innovation management (see Menke, Xu, & Gu, forthcoming for more details).

China has been one of the fastest growing users of the Internet in the world. Now, more than ever, Chinese firms are competing in an environment of sophisticated customer needs and fast product life cycles. In the networking environment, the increasing intensity of market competition and increasing customer demands (for individualization, time to market and uniqueness) present a new challenge to Chinese enterprises. To win in this turbulent market, they can not simply depend only on high production efficiency, adequate quality, and flexibility, but must satisfy customer's demands for individualization faster than their competitors. Leading firms clearly recognize these challenges and understand that comprehensive and synergistic innovations encompassing multiple organizational units and components are required to succeed. This broad conceptualization of innovation is what we develop in this paper as the Total Innovation Management (TIM) model. It is indeed exciting to observe that leading firms in China, realizing the importance of synergy among the elements of innovation and the great contribution of total innovation to achieving growth, have put total innovation management into practice through full use of information technology. In China, Haier is a good example of total innovation

management practice gradually building up global competitive advantage (Xu, Zhu, Zheng, & Wang, forthcoming provides more details).

We put forward a new paradigm—the TIM, based on the system thinking of traditional innovation management and in-depth case studies of leading edge firms both at home and abroad. This new paradigm combines the insights and coherence of the traditional innovation management view with the more relevant portfolio innovation management view, and mainly draws on three distinct areas of recent research: the innovation theory of the firm, the resource-based view (RBV) of firm, and the complexity theory. The paper is structured as follows: Sect. 2 reviews the literature of innovation management, Sect. 3 analyzes the theoretical foundations of TIM, and Sect. 4 develops a theoretical framework for TIM. Discussions, conclusions and future research directions are presented in the last section.

2 Literature review

Schumpeter (Schumpeter, 1934) first put forward the concept of ''innovation.'' He defined ''innovation'' as the new combination of factors of production made by the entrepreneur and thought innovation was the critical driving force of economic growth. Schumpeter's concept of innovation involved production innovation, process innovation, market innovation, use of new raw materials and getting materials in new ways, and organizational innovation. Schumpeter paved the way for innovation theory research. Following him, many scholars shifted the focus of innovation research from economic growth at the macro level to enterprises innovation management at the micro level to illuminate the ''black box'' of innovation within firms. Reviewing the main research on innovation management helps identify five phases, as outlined in the following sections.

2.1 First-phase: research on individual innovation (1940s–1950s)

It was in the 1940s that systematic research on innovation of enterprises at the micro level began to take place. Influenced by Schumpeter's theory of innovation, research during the 1940s and 1950s was based on the theory of the ''entrepreneur as the driving force of innovation'' and mainly studied the material innovation process, the success factors affecting innovation, and the driving forces of innovation (Freeman, 1988; Myer & Marquis, 1969; Rothwell, 1992). In this beginning phase of innovation, the basic problems of innovation were still unsettled and research focused on the separate components. The outstanding characteristic of this phase of innovation theory research was the research philosophy of individual innovation management.

2.2 Second-phase: research on organizational promotion (1960s–1970s)

As the theoretical research on innovation advanced, academic studies touched more and more on specialized fields of innovation. Building on the theoretical outcomes of the first phase, the second phase of innovation research mainly studied the sources of innovation within organizations and focused on how to attain the objective of innovation and promote innovation in organizations through effective management of R&D activities. In fact, research during the second phase mainly studied R&D department and its activities. The main contributions in this research phase were

those of Abernathy and Utterback (1975). Their ''U–A'' pattern divided the evolutionary pattern of product innovation, process innovation and industrial organization into three phases: fluid phase, transitional phase and specific phase, and linked these to the product life cycle.

2.3 Third-phase: research on outsider involvement (1970s)

Research in the third phase focused on the important role of users on innovation and the innovation process. The main question is how companies can employ effectively users as a key source of innovation. The main advocate of this thought was Eric von Hippel, who put forward the concept of ''User as Innovator'' and then ''Lead User'' (von Hippel, 1988). Today, more attention is paid to the idea of users as innovation sources. For example, Stephen M. Shapiro (Shapiro, 2001) thought that firms should invite users into the process of R&D in a co-innovation partnership. He advanced the method of ''lead user,'' and developed the methods of finding innovation sources in ''betrayed users'' and ''potential users.''

The essence of the second and third research phases is the sources of innovation. The second research phase emphasized internal promotion of innovation and the third research phase emphasized interactive promotion of internal (R&D) and external sources (users). The perspective of these two phases on driving forces is mechanistic and linear, and is based on the philosophy of Newton's classical mechanics.

2.4 Fourth-phase: research on portfolio, integrated and systematic innovation (1980s–1990s)

The first three research phases of innovation theory focused not on the interactive mechanisms and relationships among the components of innovation, but on individual innovation processes, activities and components, which are the individual components in the five innovation forms cited by Schumpeter (1934). Beginning in the 1980s, when organizations had to set more ambitious goals for innovation effectiveness in order to adapt to changing situations, the limitations of the traditional theory of patterns of innovation became more apparent. Based on the system theory, some scholars (particularly some Asian scholars) shifted the research focus from individual components in the innovation system to the interactive relationships of these components, thereby arriving at portfolio innovation theory.

The research and practice of portfolio innovation theory went through four ever-deepening phases: products portfolio innovation, technology portfolio innovation (Xu, Chen, & Guo, 1997), portfolios of various innovations (Kim, 1996; Wu, 1995), and portfolio innovation based on core competences (Xu, Chen, & Guo, 1998). Portfolio innovation theory is currently the predominant innovation management pattern and involves at least five portfolio forms: coordination between product innovation and process innovation, coordination between radical innovation and incremental innovation, coordination between implicit innovation benefits and explicit innovation benefits, coordination between technology innovation and organizational culture innovation, and coordination between independent internal innovation and cooperative external innovation (Xu et al., 1997; Xu, Guo, Pei, & Shen, 1997; Xu & Chen, 2001). Likewise, Hardy and Dougherty (1997), through empirical case studies, revealed that an enterprise's sustained product innovation competence is affected by organizational process and architecture.

During the fourth research phase of innovation study, driven by portfolio innovation theory at the end of the 20th century, innovation theory further evolved into integrated innovation theory and systematic innovation theory (Iansiti, 1998; Jiang & Chen, 2000; Tidd, Bessant, & Pavitt, 2001). Integrated innovation stresses the creative integration of existing innovative elements, which demonstrates, to a certain degree, a systematic way of thinking. Many scholars have researched the concept of enterprise innovation systems (Chen, 1999; Padmore, Schuetze, & Gibson, 1998). Janszen (2000) sees enterprise innovation as a complex self-adaptive system. Tucker (2002) proposed five principles of innovative management. They include the principle that innovation should be comprehensive, involving R&D department and other departments; the principle that innovation should seek new opportunities organizationally, systematically and continually; and the principle that innovation must involve every member of the organization. All of these principles embody a systematic and comprehensive way of thinking.

By breaking away from the previous linear thinking pattern and pointing out the significant effects of the matching and interaction between each subsystem and component in the performance of innovation systems, the system-theory-based innovation theories that were developed in the fourth phase focused on the organizations and institutions (understood in a comprehensive sense) involved in the generation of technology innovation (Coriat & Weinstein, 2002).

2.5 Fifth-phase: research on TIM (21st century)

In the 21st century, innovation theories are developing toward a higher level and many scholars are conducting innovation theory research based on the ecosystem theory. The focus of the next research phase is the TIM, defined as innovation by anyone at any time in all processes, among different functions and around the world. Researchers increasingly emphasize the idea of inspiring each employee's creativity and making everyone an innovator (Shapiro, 2001; Wheatley, 2001; Tucker, 2002). Bean and Radford (2001) pointed out that innovation should be considered a business and that innovation should take place in every aspect. Due to fierce competition and more rigorous requirements of customers, Shapiro (2001) indicated that enterprises should try to realize 24/7 innovation in order to respond in a timely fashion to the needs of customers. Some scholars think that the emergence of new organization forms such as outsourcing and strategic alliance have advanced the globalization of R&D, manufacture, and marketing (Chen, 2002). At the conference of ISMOT & ICMIT of Hangzhou in 2002, Xu and colleagues (Xu, Yu, Zheng, & Zhou, 2002) first put forth the systematic management theory of TIM. The fifth phase of innovation research aims at developing the TIM model to guide total innovation management in enterprises. The development course of innovation theory can be briefly summarized as shown in Table 1.

3 The theoretical foundation of TIM

In this paper, TIM is defined as the reinvention and management of an innovation value network that dynamically integrates the conception, strategy, technology (including IT base), structure and business process, culture, and people at all levels

Table 1 Development course of innovation theory

Phase	Main contentions	Main contributors	Theory foundation
First phase (1940s–1950s)	Individual innovation Innovation process Success factor	Myer and Marquis; Rothwell[a]; Freeman[a]	Driving force
Second phase (1960s–earlier 1970s)	Organizational promotion R&D Management Internal sources	Roberts; Utterback	Newton classical mechanism
Third phase (1970s)	Outsiders involved User as innovator	von Hippel	Newton classical mechanism
Fourth phase (1980s–1990s)	Portfolio innovation Integrated innovation Systematic innovation	Menke; Xu; Guo; Chen; Wu; Kim	System theory
Fifth phase (21st century)	TIM	Xu (2001, 2002); Shapiro (2001); Bean and Radford (2002); Tucker (2002)	Ecosystem

Notes: [a] Research in first phase is further done by Roy Rothwell and Chris Freeman in 1970s

of an organization. TIM aims to enhance the innovation competence of the company, create value for stakeholders, and sustain competitive advantage.

The framework of total innovation management mainly draws on innovation theory, as described in detail in Sect. 2, as well as on two distinct areas of recent research: core competence theory and complexity theory.

3.1 Core competence theory

The resource-based view of the firm (Barney, 1991; Peteraf, 1993; Prahalad & Hamel, 1990; Teece, Pisano, & Shuen, 1997; Wernerfelt, 1984) indicates that a firm is a bundle of assets and capabilities. Firms gain competitive advantage by accumulating strategic assets and capabilities. Therefore, innovation management efforts should be focused on nurturing and enhancing these capabilities.

The core competence-based view argues that the core competencies of corporations (especially coordination and integration capabilities linking multiple organizational areas) are the collective learning in the organization and the source of sustainable competitive advantage. Therefore, the practice of innovation management should be integrated with cultivating and heightening core competencies (Barton, 1992; Hamel & Heene, 1994; Heene & Sanchez, 1997; Patel & Pavitt, 1997; Prahalad & Hamel, 1990; Sanchez & Heene, 1997).

The dynamic capabilities (Teece & Pisano, 1994) view indicates that competitive advantage comes through leveraging the managerial and organizational processes of a firm, and is shaped by the strategic positioning of its assets and available paths. Eisenhardt and Martin (2000) argued that dynamic capabilities can be used to not only enhance existing resource configurations in the pursuit of long-term competitive advantage, but very frequently also used to build new resource configurations in the pursuit of temporary advantages. In dynamic markets, where the competitive landscape is shifting, the dynamic capabilities by which managers ''integrate, build, and reconfigure internal and external competencies to address rapidly changing environments'' (Teece et al., 1997) become

the source of sustainable competitive advantage (Eisenhardt & Martin, 2000; Luo, 2000; Markides, 1999; Teece & Pisano, 1994; Teece et al., 1997).

The resource-based view focuses on the control and exploitation of resources. The core competence-based view concentrates on competence as the source of sustainable competitive advantage. The dynamic capabilities view focuses on positions, processes and paths to ''integrate, build, and reconfigure internal and external competencies to address rapidly changing environments'' (Teece et al., 1997). Therefore, innovation management should follow the appropriate pattern, path, mechanism and measurement to rapidly integrate, build, and reconfigure internal and external competencies.

3.2 Complexity theory

In certain conditions, a managerial system will exhibit an increasing effect of systematic entropy value—that is, will manifest an evolution of the managerial system from order to disorder. In other conditions, the managerial system, as an open system not in equilibrium, will form a systematic dissipative structure—that is, will manifest an evolution of the managerial system from disorder to order. Nelson and Winter (1982) claimed that the mechanism of innovation process is an evolutionary system, called innovation evolutionism, based on the theory of biological evolution and Schumpeter's innovation perspective.

A firm's innovation management is not a one-time event, but rather a high-risk, interactive, distributed non-linear sequence—an extremely complex system requiring real-time, dynamic coordination and integration of strategy, technology (including IT base), structure, business process, culture, and people, all of which are continually changing and often geographically dispersed. Van de Ven, Polley, Garud, and Venkataraman (1999) indicated that the innovation journey is neither sequential and orderly nor random; instead, it is a nonlinear dynamic cycle of divergent and convergent activities that repeat over time and across levels, if enabling and constraining conditions are present. They further emphasized that people cannot control the innovation process, but can learn to maneuver it by developing ambidextrous management skills. According to these authors, enabling and constraining factors set the innovation scope (Van de Ven et al., 1999). Therefore, in terms of complexity theory, innovation management is also focused on decreasing the effect of systematic entropy value and enhancing the effectiveness and efficiency of managerial systems.

4 The theoretical framework of TIM

In this part, a theoretical framework of TIM is proposed. The focus of this part is ''3-全''[1] innovation or tri-comprehensiveness or tri-totality in innovation. The first ''totality'' includes innovation in all technological and non-technological elements (strategy, culture, organization, institution, and market). The second ''totality'' relates to innovation by all individuals involved. The third ''totality'' is innovation at all time and in all spaces. This TIM framework emphasizing tri-comprehensiveness or tri-totality is based on theoretical frameworks we reviewed earlier,

[1] ''全'' is the Chinese word, pronounced ''quan'', for ''all'' or ''total'' or ''comprehensive.''

and the empirical observations of leading edge firm practices. TIM is an emerging paradigm that incorporates important contributions from earlier research while emphasizing the importance of ecosystem thinking. Figure 1 depicts the TIM model.

From an ecosystem perspective, TIM not only emphasizes the synergistic linkage among all inherent elements, but also emphasizes that all employees are innovators and that innovation is realized in the totality of time/space of an enterprise and beyond. TIM may be defined as an ecological system (see Fig. 2) directed by strategy innovation. Its function is to accumulate and enhance core competency to win sustainable competitive advantage.

4.1 The major components of the TIM framework

This section introduces the key components of TIM and their respective roles. We emphasize that TIM relates to innovation in all organizational sectors, all employees and covers all time and space dimensions. Each element plays a key role in the practice of TIM and is an integral part of the TIM framework (see Fig. 3).

The all-elements innovation, as Fig. 4 shows, can be described as creating synergy between the technological (mainly product, process, and portfolio) and non-technological (mainly market, organization, and institution) areas in an organization through effective tools and facilitating mechanisms that encourage and regulate innovation by every employee.

Haken (1984), the founder of Synergetics, points out that synergy mainly relates the associated operations of many sub-systems (generally the same or different species) to give birth to an orderly structure and systemic function at a macroscopic level. In the framework of TIM, there exist close relationships of synergistic innovation among different elements in the firm's innovation system. The synergistic relationship between technological innovation and non-technological innovation can be defined with technology as the key element (technological innovation always requires the relative adjustment of marketing, institution, and organization) and the non-technological as subsidiary elements (non-technological innovation re-deploys and better integrates a firm's resources, including human resources, to facilitate technological innovation that satisfies customer needs). We go over these key elements further below.

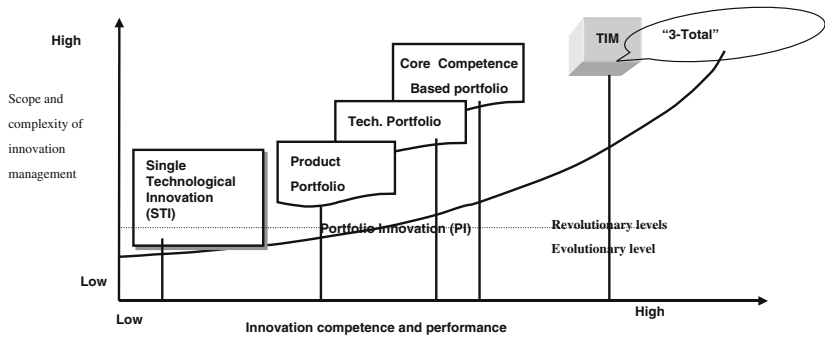

Fig. 1 The three levels of innovation management

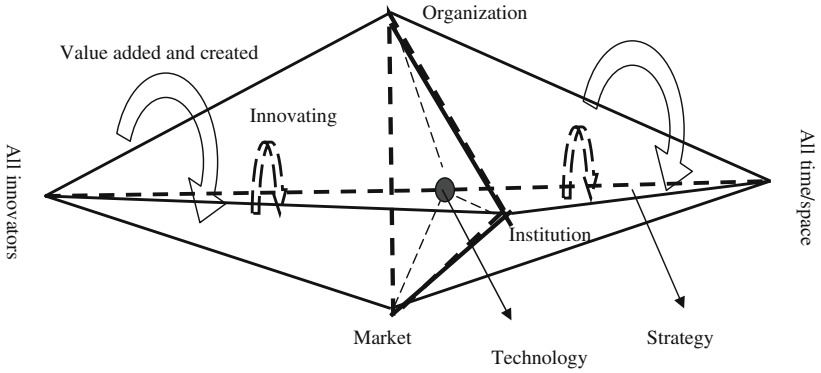

Fig. 2 The framework of TIM

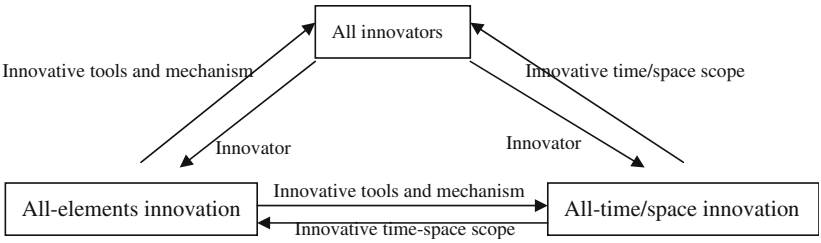

Fig. 3 Constituents of the framework of TIM

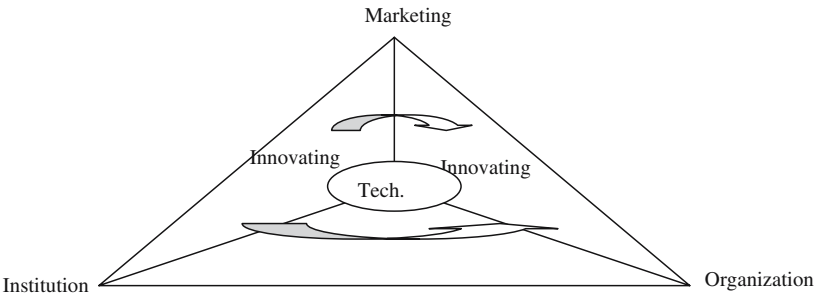

Fig. 4 All-elements innovation of TIM

First, *technological innovation will be the key innovation element*. Technological innovation is the key source for enterprises to gain core competence and, accordingly, to obtain sustainable competitive advantage. This is especially true for Chinese firms that are still in the developmental stage where the technological level lags significantly behind Western companies. These firms must put more emphasis on technological innovation to keep up with transnational companies that possess advanced technologies. Of course, many leading firms in the world now put more emphasis on non-technological innovation. Wolfe (1994) reported that, in the 5 years preceding that study, approximately 350 dissertations and 1,300 journal articles were written on the topic of organizational innovation. All

of the non-technological innovations in these firms are mainly used to promote the generation of technological innovation (new products or services) to exploit new markets more quickly for greater revenues. Technological innovation always calls for organizational and institutional innovations (Colombo & Delmastro, 2002). For example, the rule of ''15% free time for workers'' at 3M is intended to produce more new technology. So is the new working team for the development of Inkjet at HP. So TIM must regard technological innovation as the key and foundation, particularly for Chinese firms. (Obviously, for service enterprises, service innovation is the key).

4.1.1 Marketing innovation will become the foundation

Marketing innovation means the innovation in marketing channels, tactics and operating methods. Only when new technology has been commercialized successfully, can it create or add new value. To accomplish new product commercialization more effectively and quickly, marketing innovation is needed as a foundation for technology innovation. It provides needed information and builds up new product sale channels and methods.

4.1.2 Organizational innovation will provide the structural context

When an enterprise grows to a certain scale, a traditional pyramidal structure would easily cause overstaffing, low efficiency, and slow response speed. Such changes in structure will ultimately have a negative impact on the innovative performance and competitiveness of the enterprise. Innovative enterprises require a flatter and more network oriented structure. Organizational structure must be adjusted in a timely manner to accommodate the need for innovation.

4.1.3 Institutional innovation will provide the stimulation

Institutional innovation can be defined externally as innovation in the rules and regulations governing an enterprise's routine management, performance evaluation, staff reward and punishment, salary system, training and promotion. Innovations in these areas should occur in a timely manner, according to internal and external changes of environment, in order to meet the requirements of total innovation. Cultural innovation is a pre-condition of institutional innovation.

As culture is the intrinsic factor of institution, its innovation is an evolving process of idea sharing among all employees within technological innovation, directed at greater innovation value. Innovation in thought is the prerequisite for carrying out any innovation. If ideas can't change according to changed situations, there will not be an outstanding innovative spirit. Strong innovative culture is the key factor that influences effective and continuous innovation in enterprises, witness for example the influence of innovation culture at 3M.

Employees are the executors of the total innovation management. We therefore now focus on all employees as innovators. Everyone possesses the capability to deal with complexity and interconnection. Creativity and commitment are the greatest resources for innovation. According to Porter's (1980) value chain analysis, every value creating activity embodies special technologies. Therefore, technological improvements will influence all value creating activities and ultimately firm

competitive advantage. More importantly since all these value creating activities are carried out by employees, effective human resources practices become key for firm survival and success. Studies in the survival rate of IPO firms provide confirming evidence (Pfeffer, 1999).

The TIM paradigm advocates commitments and participations in innovation by all employees to produce its competitive advantage impact (Shapiro, 2001; Wheatley, 2001). We believe that innovation is no longer the function of R&D personnel alone, but the expected behavior and practice of all employees. All personnel, from sales, manufacturing, and R&D to customer service, administration, and the financial department are outstanding innovation sources (Wheatley, 2001). Furthermore, within the TIM framework, we believe that innovation is not a simple call from the top for every employee to get involved in the process of innovation, but should be a process that involves five types of transformation: (1) from specialist innovation to collective innovation (let everyone be an innovator); (2) from ''force me to innovate'' to ''I want to innovate'' (let everyone take part in innovation actively and proactively); (3) from isolated innovations to harmonious innovations (integrating everyone's innovative action into the organization); (4) from focusing on development of the organization to co-development of organization and individual (to drive firm's growth and satisfy staff needs at the same time); and (5) from single function innovations to multi-function innovation (to maximize the impact of innovation). Studies after studies have demonstrated that if employees are encouraged to take part in and learn the entire process of one job, they will show greater innovative performance (Hammer & Champy, 1993; Johannessen, Olsen, & Olaisen, 1999). In order to drive the five transformations to realize the all innovator goal, thought and values must change, and organization and institution must be redesigned to create an innovative atmosphere in the firm. As Bill Hewlett (one of the co-founders of HP), said, ''Men and women want to do a good job, a creative job, and if they are provided the proper environment, they will do.'' GE may provide another example. Since the 1980s, GE has advanced a comprehensive ''work-out'' system aimed at making every GE employee an innovator. Based on the ''work-out'' implementation, GE evolves towards TIM by facilitating continuous organizational culture change, bureaucracy busting, and innovation empowerment.

Moving beyond innovation across all organizational elements and every employee as an innovator, we now focus on innovation activities taking place at all time and in all locations, or all time/space innovation, as the activity pattern of innovation. Innovation in an organization should take place all times, all places, all things and all chains involved in innovation. According to the TIM framework, innovation penetrates into all time/space of a firm: through synergistic innovation of technological and non-technological elements, effective mechanisms, methods, and tools can be created to move everyone to innovate in every time, at every place, on everything and every chain, so as to improve innovation performance as much as possible in a sustainable way. All-time/space innovation enlarges the scope to require and encourage all elements and all people to be involved in the continuous process of innovation. For example, HP has always encouraged achievement and contribution by everyone and tries to provide the tools and training to make it work (Packard, Kirby, & Lewis, 1995). Innovation by everyone leads to innovation in all business functions, in all aspects of the supply chain, and in all aspects of product life cycle management. It is even increasingly global among HP organizations and also (by collaborative development) customers, partners and suppliers. As a result, HP has

an increasingly improvisational approach to new product generation, with 25 patent applications daily (Menke et al., forthcoming). To describe in detail, the ''4-W'' (when, where, what, whole) model is used for analysis of the all-time/space aspect of TIM (see Fig. 5).

Businesses today face increasing competition and customer demands for prompt responses. This type of competitive environment calls for innovations to be carried out at all times. Thus, we emphasize that innovation occur at any time. This answers the ''when'' question. Enterprises must make every effort to realize 24/7 innovation (innovation throughout 7 days of every week, 24 h of every day) (Shapiro, 2001). Innovative enterprises should encourage immediate innovation in the moment akin to writers' or musicians' improvisations.

When it comes to the ''what'' question, we advocate that innovations occur throughout all processes. Traditional organizational processes are based on functions and specializations, which often lead to separation of processes from each other. As a result, no one is responsible for the overall process, and no one is really responsible to customers. This approach makes it difficult to adapt to the customer-centered new economy. With the increasingly individualized demand of customers, innovation should no longer be regarded as only the function of the R&D process, but of all processes. Only by embodying innovation in each process can enterprises better meet the real demands of customer.

Furthermore, the innovation ought to take place across the global. So we identify ''where'' with a global innovation emphasis. With the rapid development of economic globalization, e-commerce, and the networked economy, the boundary of an enterprise becomes difficult to identify. With the rise of new organizational forms, such as outsourcing, strategic alliance, and virtual organization, the boundary of an enterprise transcends the restrictions of the geographical region, industry and even country. This has promoted the globalization of key value creating activities such as R&D, manufacture, and marketing. Many transnational enterprises (Microsoft and Nokia, for instance) have set up R&D centers or bases throughout the world to carry on innovation, in order to combine global scientific and technological resources. Nokia has 55 R&D organizations located in 14 countries, totaling more than 19,000 R&D personnel. Some leading Chinese firms like Haier Group, Legend Group, and Baosteel

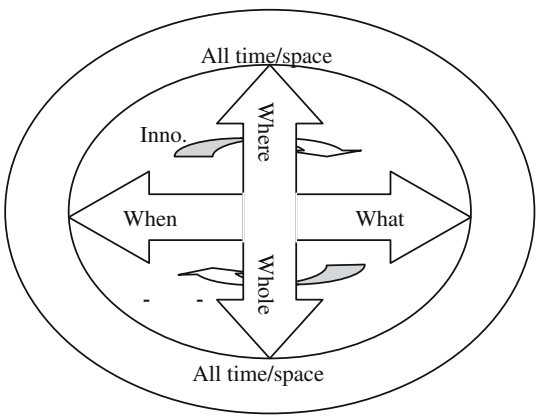

Fig. 5 All-time/space innovation of TIM

Group are paying more attention to innovation under a vision of globalization. For example, Haier has realized the globalization of all innovation processes, with 15 R&D centers, 6 design branches, and 10 S&T information stations located throughout Europe, North America and the Asia-Pacific region.

Finally it is important to focus on the wholeness in innovation or innovation throughout the whole value chain. With the evolution of innovation management theory and practice, and the change in market environment, has come the realization that, no matter how the information network in an enterprise develops, it is unable to obtain all of the users' information and consequently is unable to fully meet users' individualized demands. For this reason, innovation must transcend the borders of enterprises, integrating users into the innovation system of enterprises and making them the most important innovation source, in order to really meet users' demands (Shapiro, 2001; von Hippel, 1988). Similarly, all resources throughout the value chain, such as suppliers, dealers and stockholders, should also be integrated into idea creation, R&D, and product design. Practices worldwide have proved that, by integrating the science and technology (S&T) resources of the entire value chain as innovators, innovation performance can be improved greatly, and innovation cost can be reduced, because of sharing with the whole value chain at the same time.

4.2 The linkage between TIM and strategy innovation

In a complex and dynamic market, only continuous innovation can drive a firm's sustainable growth and profits. But in the process of innovation, firms often drive themselves into ''the war of innovative attrition'' (Braun, 1997), and lead to the so called innovator's dilemma (Christensen, 1997). Much research and practice has proven that, to overcome this dilemma, innovation must be brought into the framework of the firm's strategy and serve the process of business strategy changes (Janszen, 2000; Rothwell, 1992, 1994; Roussel, Saad, & Erickson, 1991; Xu, 2000).

The implementation of TIM undergoes three transformations. They include from single innovation to total innovation, from separate innovation to integrated innovation, and from a focus on only the internal resources of firm to an emphasis on the integration of internal and eternal resources. Thus innovation will not only be the responsibility of some people or functions, but an integrated strategic process for adding and creating value. TIM should be integrated with the corporate innovation strategy, such as R&D (Roussel et al., 1991). Organizational and institutional innovation (Janszen, 2000) should support strategy implementation. According to institutional economics, there are two preconditions for the establishment of an institutional innovation: one is that the innovation alters latent profits and the other is that the cost of innovation must be less than the profits added (Davis & North, 1970). TIM calls for all functions and all employees to be involved in total innovation—the resources put into innovation will be much greater and the cost of TIM implementation will increase accordingly. Therefore, if TIM is not linked with innovation strategy so that it creates more value in the market than it costs, TIM will not receive supported and subsequently will not be carried out.

The linkage of TIM to strategy innovation is illustrated in Fig. 6. Due to the increasingly turbulent and uncertain environment that enterprises face, strategy should remain relatively stable but avoid rigidity. As the internal and external environments change, the enterprise's strategy should be adjusted in a timely manner and kept in a dynamic balance. Through TIM implementation, dynamic

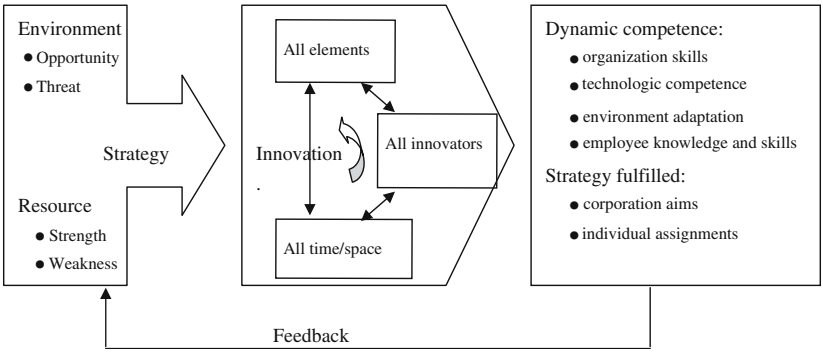

Fig. 6 The linkage of TIM to strategy innovation

competences, including organizational skills, technologic competence, environment adaptation, and all employees' knowledge and skills, will be improved and better feedback will promote strategy innovation.

As illustrated in Fig. 6, the linkage between TIM and strategy innovation starts with the corporate strategy. Affirming the interaction between innovation and strategy, TIM pervades the enterprise, not only satisfying the need for implementation of corporation strategy, but also fostering and accumulating dynamic competence to facilitate strategic plans. We discuss the linkage along three totalities identified in TIM, namely all elements, all employees and all time and space innovation.

Strategy encompasses corporate aims as well as resources deployed, and focuses on technological and product development (Roussel et al., 1991; Rothwell, 1992, 1994; Xu, 2000). Organizational structure, process, and corporate institutions also should be matched to the strategy (Janszen, 2000; Teece et al., 1997; Xu, 2000). The all-element innovation of TIM aims to leverage organizational skills and technological competence by optimizing the resource allocation and tapping new market opportunities effectively.

In the framework of TIM, a firm's innovation is no longer driven by individual actions from the top down but by collective actions in downward and upward patterns, to advance corporation strategy quickly and effectively. The linkage of all innovators to innovation strategy can be described as people-oriented—new corporate strategy should be linked to the work of every employee. The organization's resources and responsibility for satisfying consumer's demands should be distributed across every work team and person, allowing everyone to become a self-managed innovator. This would create an innovative environment that energizes everyone to focus on the implementation of new corporate strategy.

5 Discussions, conclusion and future research directions

5.1 Summary and contributions

The core issues in the field of innovation management are innovation itself and the synergy between the technological and non-technological elements (strategy, culture, organization, and institution) of innovation. The traditional view of innovation management covered the synergistic patterns between product and process, but it

limited itself by focusing only on these two innovation elements. The portfolio innovation management view insists on innovation synergies among technology, organization, and culture to build up innovation competence, and has provided more extension and pertinence, but did not take the time-space dimension of innovation management into account. Therefore, based on case studies of firms at home and abroad, we introduced in this paper a new paradigm of innovation management—total innovation management (TIM).

This paper has focused mainly on two topics: the theoretical framework of TIM and the practical relevance of TIM. The theoretical framework addresses the following questions: (1) the content of TIM and (2) innovation's mechanisms and patterns of synergies between technological and non-technological elements. The synergy is addressed according to three aspects: (1) environmental promotion—the requirements of the complex and changeable Internet environment; (2) practical needs—the requirements of total innovation practice in firm; and (3) the importance of organizational culture in enabling successful total innovation management.

The main contributions of the new paradigm of TIM are as follows. The TIM offers a distinctive view on the core issues as well as new directions for the innovation management field. The paradigm of TIM stresses the synergies between the technological and non-technological elements of innovation. Furthermore, it proposes an extension to the portfolio innovation management view and offers a more dynamic, and integrative, theoretical framework for the field of innovation management. It takes the time and space dimension of innovation management into account and also holds the view that all people are innovators. The paradigm of TIM provides a basis for an upgraded, more unified, and better-attuned view of the core issues of the innovation management field.

5.2 Policy implications and future research directions

There are several important theoretical and policy implications. TIM is a journey, not a destination, towards enhanced firm competence. It isn't an annual, quick fix, slogan-based management approach, but rather a long-term, competence-based management philosophy for achieving sustainable competitive advantage involving all people at every aspect and level of organization at all time and across all space. TIM is about corporate survival and growth—therefore, top management must seek meaningful involvement for successful total innovation management. TIM furthermore is a long-term process of organizational learning. In conclusion, TIM is a very significant path to reinvent and revitalize companies competing in the 21st century.

This paper provides a preliminary introduction to the TIM model. We believe four future research directions are worthwhile. They include the strategy of TIM, and its formulation and implementation; the critical success factors related to TIM; the dynamic relationship between organizational learning and TIM; and finally the measurement of the TIM and the associated performance impact of TIM.

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