ON THE DESIGN OF A SEVEN-STAGE INNOVATION LIFE CYCLE

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Abstract: This paper introduces a new industrial innovation life cycle for organizations to understand the changes of their operational environment and adjust their strategic settings. The construction of the new innovation life cycle is based on two building blocks: (1) "innovation trinity", which means that a common denominator of innovation is constituted by product, process, and business innovation, and (2) "binding forces", which means that different types of innovation and various activities related to innovation are tied by three sets of forces: learning mechanisms, perceived consequences and achieving requirements. By linking the innovation trinity and innovation binding forces, a new innovation tripartite life cycle (ITLC) is developed. Under the ITLC, basic statues of innovation, the linkages between those statues and a repeatable timeline among those statues are clearly labeled. By using the ITLC, organizations can have a better dynamic benchmark for continuously renewing themselves.

INTRODUCTION

While researches are expanding the spectrum of innovation by identifying more types of innovation (Henderson and Clark 1990, Kim and Mauborgne 1997, Christensen 1997, Von Hippel 1999, Chesbrough and Rosenbloom 2002, Cusumano and Gawer 2002, Xu et al. 2007, Birkinshaw, Hamel and Mol 2008), concepts on innovation life cycle, particularly industrial innovation life cycle, have been stagnated for decades. Our understanding towards innovation life cycle is mainly confined to a framework called "A-U model" developed by Abenarthy and Utterback in the 1970s. The A-U model selects product innovation and process innovation as the basic building blocks, and uses dominant design as a watershed to mark the shift of innovation stages. Over the last three decades, the model becomes one of benchmarks for dealing with innovation and related issues (DeBresson and Lampel 1985). However, the further applications of the A-U model are discounted in the current world due to several shortcomings, such as exclusion, oversimplification and insufficient sorting function (DeBresson and Lampel 1985, Teece 1986, Keating 2004).

Given the limitations of the A-U model and the importance of innovation dynamics, this research aims to introduce a new innovation life cycle for (1) accommodating more types of innovation, and (2) labeling clearly the linkages between innovation types and innovation stages. So that, a more detailed dynamic benchmark can be obtained.

To carry out this research, a sequential method is employed for developing an innovation tripartite life cycle (ITLC). First of all, a new gateway for entering the innovation domain is chosen. It is an innovation tripartite—product, process and business innovation. Product innovation focuses on creating functionalities; process innovation focuses on improving delivery of the functionalities; and business innovation focuses on changing relationships associated with the creation and delivery of the functionalities. Secondly, each possible combination of the innovation tripartite is examined. It finds out that seven basic innovation statues represent the majority of previously identified innovations. Thirdly, three sets of factors, which focus on enabling, motivating and governing innovative activities, are synthesized to innovation binding forces. Finally, the seven statues are converted to a chronically linked seven-stage innovation chain based on examining innovation binding forces and tracing the respective curves of the innovation tripartite.

Based on the development of the ITLC, this paper is organized as follows. After this introduction literature review section examines previous studies on innovation dynamics, with a particular reference to the A-U model and its limitations. Then three sections are dedicated to the new model construction by addressing three questions: why the innovation tripartite is a wide accessible gateway for the innovation domain? What are common forces which tie innovative activities together? How seven basic innovation statuses are converted into a seven-stage innovation life cycle? The final section discusses the limitations of the ITLC model and the avenues for future development.

LITERATURE REVIEW: INNOVATION DYNAMICS

Studies on the dynamics of innovation demonstrate different views on the fluctuations of innovation along the time arrow. In Schumpeter's initial framework, innovation dynamics is mainly reflected in innovation's economic and social impacts, i.e. the "creative destruction gale", or economic "long waves" (Schumpeter 1934, 1939), and an invention—innovation—diffusion cascading can be identified (Verloop 2004). The "creative destruction gale" goes through three stages: the initial innovation is amplified through profit generating; imitation triggers off the cumulative "virtuous" processes and forms to a substantial innovation stream; penetration of innovation then leads to new patterns of specialization both by firm and industry. Two themes exist in Schumpeter's reasoning. One is fluctuated supply of technical creativity concreted in inventions. The other is entrepreneurs' continuous pursuit of profitability based on externally supplied inventions. The interaction of those two threads forms the ups and downs of innovation along the timeline.

Departing from Schumpeter's tradition, modern studies on innovation dynamics treat innovation as an endogenous process (Lan 1996). Collectively, they form a full spectrum ranging from new idea creation to new idea realization. Separately, they focus on different stages of the overall process. Figure 1 illustrates the location of several major studies on innovation dynamics sorted by an occurring sequence of innovation activities.

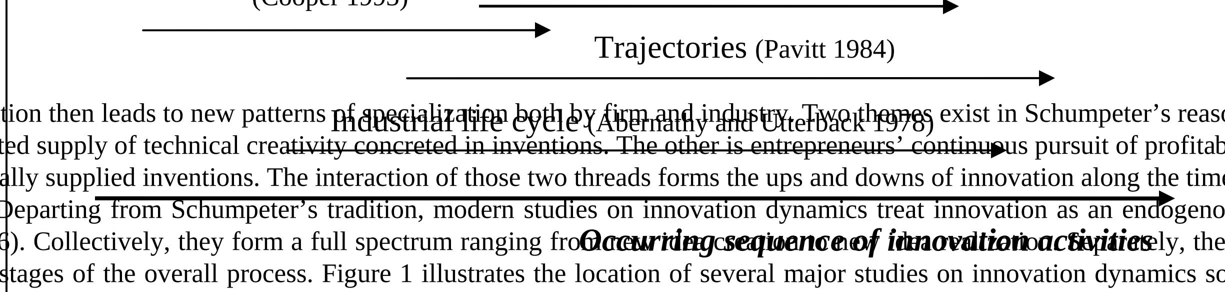

Figure 1. Selected Research on Innovation Dynamics

Studies on innovation funnel or new product development concentrate on the very early stages of innovation development. They reveal a phenomenon of distilling—a success innovation consuming hundreds or thousands of creative ideas (Stevens and Burley 1997), and evolving in a complex interactive process (Cooper 1993, Verloop 2004, Fleming 2007). A common theme in this school is a stage-gate process, which means that the success of an innovation needs to go through several phases from idea generation to product or service roll-out and exploitation, with certain phases being extremely dangerous or crucial for surviving (Morrison 2003). Differences among different studies are mainly shown in the numbers of suggested stages and associated gates, ranging from three (Verloop 2004) to six stages (Cooper 1993). Differences are also shown in the purposes for setting up the gates. Some are based on specific objectives that have to be delivered at the end of each stage (Cooper 1993). While others are based on functional and managerial requirements derived from the characteristics of each stage (Verloop 2004). Criticisms of the stage-gate process focus on its linear nature (Gaynor 2002).

Product family or product generation study mainly concerns the up-middle stream of the innovation process and reveals the co-existence of linear replacement and nonlinear branching of products. Product family study treats the development of product as the synergy of two forces (Meyer and Utterback 1993). One is family core, which includes common product platform, common user needs, common distribution channels, and common manufacturing process. The other is product applications. While the underlining technology is applied to the same market, replacement of one generation of product by the next generation happens. While the underlining technology is applied to a new market, a branching of the product family happens. The branching is based on the formation of a new product platform, which produces products with completely new secondary dimension from the original product. The branching process is regarded as random and unpredictable (Sood and Tellis 2005).

Research on innovation diffusion focuses on the downstream of innovation development. Two types of diffusion can be identified. One is product embedded diffusion exemplified in the product acceptance curve (Rogers 1962), which specifies five accepting stages with five types of adopters—innovators, early adopters, early majority, late majority and laggards—and a particular bottleneck or "chasm" exists between the early adopters and early majority (Moore 2004). The other is non-product embedded diffusion demonstrated in various forms of technology transfer, such as from research institutes to enterprises (Mansfield 1971, Rosenberg and Nelson 1994) and from enterprises to enterprises (Quinn 1969, Lan 1996). Differing from linear product-embedded diffusion, non-product-embedded diffusion tends to show a network nature with multi-diffusion channels at information age (Chesbrough 2003).

Innovation trajectory studies reveal the industrial diversity of the innovation dynamics due to operational differences (Dosi 1982). Several innovation trajectories are clarified including science based, supplier dominated, specialized suppliers intensive, scale intensive and information intensive innovation trajectories (Pavitt 1984, 1990). The differences between the trajectories are exemplified in different combinations of product, process, and service innovation. (Powell and Moris 2004).

As a description and application of the S-curve of the growth trajectory, a life cycle model offers an explanation around the dynamics of firms and industries (Kuznets 1930, Vernon 1966). In 1970s, Abernathy and Utterback introduced the most articulate version of an innovation life cycle. The A-U model suggested that an aggregated innovation will go through three stages in its life time: the introduction or fluid phase, the growth or transitional phase, and the mature or specific phase. The hallmarks of the changes are dominant design and associated standardization, which not only emphasize the roles of process and incremental innovations, but also point out the linkage between dominant design and the shift of innovation priority. Over the last three decades several aspects of the model have been modified. First, it was expanded from three to four stages by adding a decline or discontinuities phase (Abernathy and Clark 1985), which will sweep away much of a firm's existing investment in technical skills and knowledge, design, production technique, plant and equipment (Utterback 1994). Secondly, more business considerations regarding model applications were channeled in and the similarities and differences of the applications between assembled-product and nonassembled-product industries were highlighted (Utterback 1994). Thirdly, stage transformation was supplemented by a "segmented" model, consisting of three production modes: "batch", "line" and "custom", because different production models are believed to show different rates of product and process innovation over time (DeBresson and Lampel 1985).

As the popularity of the A-U model grows, more concerns about the model and its applications have been aired. Critics are in several aspects including exclusion, simplification and insufficient sorting function. Exclusion means that business innovation is excluded from the foundation of the A-U model. A wide range of business initiatives neither has a position in the life cycle, nor can show their footprints systematically in the model (DeBresson and Lampel 1985, Teece 1986, Keating 2004). More recent research demonstrates that business innovations play an important role at either the industrial level, or the enterprise level (Kim and Mauborgne 1997, Christense 1997, Von Hippel 1999, Rosenblum, Tomlinson and Scott 2003, Sawhney, Wolcott and Arroniz 2006, Markides 2006); and managing non-technical innovation is becoming one of the most important tasks for top managers (Brown 2003, Verloop 2004, McGregor and Barrett 2006). Since technology innovation itself does not have a value without commercialization arrangement in a knowledge-based economy (Chesbrough 2003), an innovation life cycle without business innovation as an integrated component has difficulty revealing the true dynamics of an innovation process.

Oversimplification means that the A-U model fails to reveal the complexity of an industry evolution, particularly after a dominant design (Mazzucato and Semmler 2000). According to the A-U model, innovation will fade out or be concentrated mainly in process improvement when a dominant design is established. The landscape of competition since then is difficult to change. However, in the reality this explanation does not work very well. Firstly, the model focuses on the traditional assembly-line view of U.S. industry (Vonortas 1997) and is difficult to apply to service industries which are the main stake of the current economy (Thomke 2003). Even within manufacturing industries, the model does not suit industries with small niche markets (Teece 1986). Secondly, innovation does not stop after having a dominant design. Inside the industry, standardization and diversification coexist even with a dominant design (DeBresson and Lampel 1985). Outside the industry, a trajectory of innovations could be coupled with original technology (Pavitt, Robson and Townsend 1989, Jovanovic and MacDonald 1994). Longitudinal studies on automobiles, tires, televisions and penicillin industries demonstrate that shakeouts are not triggered by dominant designs (Klepper and Simons 1996), and complex interactions continue between technical and non-technical innovation, individual firm initiatives, and industrial aggregative efforts along the time line (Teece 1986, Verloop 2004). One theoretical reason of the simplification may be attributed to a single-peak life curve assumption for each innovation component (Abernathy and Utterback 1978). This assumption may be applicable to an isolated simple technical innovation, or homogenous manufacturing goods production (Teece 1986), but it is difficult to apply to aggregated innovation in an industry context (DeBresson and Lampel 1985, Mazzucato and Semmler 2000). Many industry analyses prove that substituted technology has been an integral part of an industry’s evolution (Porter 1985, 2008). When innovations interact with other innovations deprived from the original functionality creation at different stages, the pattern of innovation evolution is differentiated and complex (Pavitt, Robson and Townsend 1989, Sood and Tellis 2005). At the same time, a long term incremental innovation could activate radical innovation (Anderson and Tushman 1990) resulting in a dematurity process (Abernathy and Clark 1985). Besides that modular production over time could also cause innovation rate increases due to architectural innovation (Henderson and Clark 1990). Taking into account of the complexity mentioned above, the single-peak life curve for each innovation component can no longer holds true.

Insufficient sorting function means that different types of innovations cannot be converted into a comparatively clear time sequence. Although the A-U model points out that product innovation comes prior to process innovation, and radical innovation gradually shifts to incremental innovation, it has difficulty in sorting many new types of innovation in the time dimension (Lan et al 2007). More studies have revealed that a type of innovation is not only context specified (Gaynor 2002), but also time specified (Henderson and Clark 1990, Christensen 1997, Cusumano and Gawer 2002). Without effective conversion of an innovation spectrum to a time sequence, the dynamics of innovation are hard to understand and handled, with strategic choices given to managers being too limited (DeBresson and Lampel 1985).

Differing from the above streams, discontinuity and disruption studies focus on certain turning points in the innovation process. For example, disruption I, or new consumption disruptive innovation, usually occurs in introducing a new technology, which serves an unmet market segment (Christensen and Raynor 2003). Disruption II, or low cost consumption disruptive innovation, often happens after a period of incremental innovation (Tushman and Anderson 1986), especially when technology overshooting happens within an established industry. In this case, disruption II innovation usually aims at a larger customer base by starting from a previously belittled market segment (Christensen 1997). Discontinuity and disruption studies also offer a wide range of explanations regarding the reasons for fluctuations. In a broad sense, it acknowledges the role that knowledge advancement plays in activating the ferment stage of innovation from the incremental innovation stage (Anderson and Tushman 1990), and the characteristics of technology in reinforcing alternative development (Rosenberg 1982). In a specific sense, it links architectural innovation to restructuring barriers (Henderson and Clark 1990). Judging at the micro level, it is the mismatch between knowledge advancement and the DNA of firms, i.e. the resources-processes-value chain (Christensen 1997) that triggers competence-destruction and prevents established firms from recognizing and responding to disruptive technology (Christensen 1997, Anderson and Tushman 1991).

Recognition of the importance of innovation has led to an increase in innovation studies from multiple disciplines. However, there remains a scarcity of models that bridge increasing innovation types and complex innovation dynamics. Without a proper channel for integrating various innovations, it is difficult to view innovation as a system instead of the sum of its components (von Bertalanffy 1975) in the time dimension.

INNOVATION TRIPARTITE AND THEIR TEMPORAL FLUCTUATIONS

A feature of previous innovation studies is to use a dichotomy as a gateway for entering innovation domain. It means that innovation was always been treated as a combination of two things. In a narrow sense, the dichotomy is shown as a division of product and process innovation within the boundaries of technical innovation. In a broad sense, the dichotomy is shown as technical vs. non-technical innovation. Various dichotomies can be spotted in existing literature such as radical versus incremental innovation (Schumpeter 1939), product versus process innovation (Abernathy & Utterback 1978), competence-enhancing versus competence-destroying innovation (Anderson and Tushman 1990), technology versus administration innovation (Daft 1978, Damanpour 1991), technology versus market innovation (Markides 1997, Leonard-Barton 1998), disruptive versus sustainable innovation (Christenson 1997), demand innovation versus product innovation (Slywotzky and Wise 2003), and closed versus open innovation (Chesbrough 2003). These dichotomous divisions are undoubtedly helpful in advancing our understanding of the complexity of innovation. However, they also present a challenge to connecting various dichotomies, since complex phenomena or systems have to be explained by not only components, but the entire set of relationships between the components (von Bertalanffy 1975). To deal with this problem, some researchers began using other gateways to approach innovation. For example, Henderson and Clark (1990) defined innovation in four quadrants: incremental innovation, modular innovation, changed innovation and radical innovation. Gaynor (2002) suggested another classification of innovation comprising three components: incremental, new-to-the-market, and breakthrough innovation.

By combining the narrow sense dichotomy and the broad sense dichotomy, an innovation tripartite, consisting of product, process, and business innovation, can be identified. The three components of the tripartite are distinguished from each other. However, their interweaving is apparently.

Product innovation focuses on creating functionalities, utilities, or usefulness. New functionalities can be embedded in tangible goods, intangible services, or the combination of both (Shepherd and Ahmed 2000). Having a new product or service creates an outlet to display the creation of new concepts (Meyer and Utterback 1993, Porter 1985). At the same time, the product or service determines the goal of a firm and helps to define its relationship to the outside world (DeBresson and Lampel 1985). The creation of functionality results from knowledge advancement, and causes upward shift of a demand curve (Athey and Schmutzler 1995). In product innovation, research, development, and engineer activities are more prominent and distinct (Freeman 1982), and it is often in the form of proprietary (Ettlie 2000), and can be achieved through several routes (Goldenberg, Mazursky, Horowitz and Levav 2003). A few issues that directly affect product innovation are technological feasibility, customer demands, market availability, product timing, etc (Linnarson, 2005). Measured by introducing or improving functionalities, product innovation can have several ups and downs throughout its life cycle. As shown by the solid line in Figure 2, the first peak may be related to the introduction of new functionalities embedded within a new product or a service a single-peak life curve for each innovation component (Rosenberg 1982, Gaynor 2002). The second peak may correspond to diversification of functionality, which raises the overall product innovation rate again. A number of reasons are attributed to the rise. On the one hand, product innovation could branch a product family when it focuses on developing new secondary dimension from the original product or service (Sood and Tellis 2005). On the other hand, the architectural knowledge could ferment the migration of functionality among different products and systems when the formation and delivery of the functionality become modular (Henderson and Clark 1990). The third peak may be related to the replacement of the functionalities and their embedded products or services. In this stage, the original innovation trajectory is going downward. At the same time, surviving pressure motivates more product regeneration efforts, which could lead to a new innovation trajectory with an upward move of product innovation.

Process innovation focuses on improving the efficiency through changing the formation and delivery of functionalities in question (Abernathy and Utterback 1978, Athey and Schmutzler 1995). In manufacturing arenas, internal oriented technical changes and the rational of organization are set as the default for process innovation (Spear and Bowen 1999). In the service arena, both internal and external delivery improvements are set as the default for process innovation (O'Sullivan and Dooley 2009). Process innovation demonstrates greater variety in openness. On the one hand, it may be more transparent to others, since some of process innovation can be purchased from the outside sources (Ettlie 2000), which are also available to competitors (Freeman 1982). On the other hand, it may be more obscure since whole process can be developed by the innovator internally with little disclosure to the outside world (Prahalad and Hamel 1990). Also, process innovations are common in mature industries (Loudon 2001) and are expected to bring substantial financial gains to innovators (Abernathy 1978, Gaynor 2002). Using the same starting point to trace the process innovation life curve, more than one innovation peak can be identified as shown in the unevenly dashed line in Figure 2. The first peak may come after new product or service introduction and lasts quite a long period; process innovation emphasizes refining production or delivery activities, providing special equipment or facilities, and standardizing or automating operating systems (Abernathy and Utterback 1978). The other peaks, however, could differ from the first one in two aspects. First, product and process innovation are linked much closer than in the first peak. This can be seen from the smaller time gap between product and process innovation (Utterback 1994). Secondly, process innovation gradually shifts its focus from simply delivering functionality to altering or creating new functionality through decoding of practices (Spear and Bowen 1999). Taking this feature into account, it is easy to understand why there is no clear linkage between shakeouts and innovation shifts from product to process within the late stages of industrial development (Klepper and Simons 1996).

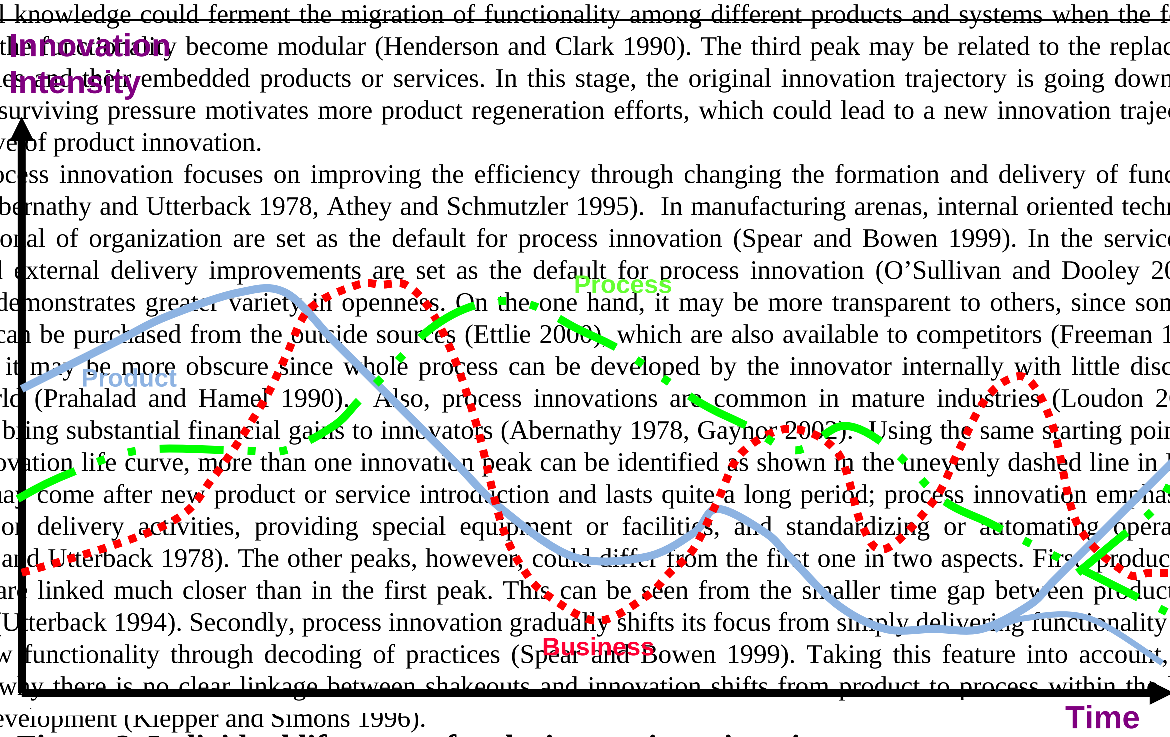

Figure 2. Individual life curves for the innovation tripartite

Business innovation focuses on creating value through formulating or changing relationships based on the features and delivery of certain functionality in question. However, business innovation is not a mono-innovation, but a collection of many subinnovations. Defined by a subtracting method, business innovation is the residual of product and process innovation. Defined by an adding method, business innovation is the sum of strategic innovation (Markides 1997, 2006), market innovation (Kim and Mauborgne 1997, Leonard-Barton 1998), and organizational and administration innovation (Daft 1978, Teece 1986, Damanpour 1991, Birkinshaw, Hamel and Mol 2008). The success of business innovation creates or improves links inside and/or outside an organization which enables it to sell desired results rather than just products (Wynne 2006). Research reveals that about twenty percent of high performance companies attribute their success to business innovation rather than technological breakthroughs and process innovation (Goldenberg, Mazursky, Horowitz and Levav 2003). Furthermore, business innovation displays deeper social roots and can be conducted by anyone in a society with entrepreneurial spirit (Schumpeter 1939). As shown in the dotted line in Figure 2 business innovation has a unique life curve, which shows three, more or less, even peaks correspond to the birth pulse, mid-life pulse, and death pulse of an industry. The birth pulse results from capturing technological opportunities created by new product innovation. In this stage, entrepreneurship or entrepreneur spirit drives the burgeoning of business innovation as described by Schumpeter (1939). The targets of business creation include forming a new value chain, figuring out a profitable or practical business model, and designing an operational configuration. The mid-life pulse is related to the emergence of technological disruption, and organizational bureaucracy. In this stage, business innovation usually focuses on reassessment of the competitive landscape, and the renewal of an enterprise's resource-process-value chain (Christensen 1997) for improving performance after a plateau of no improvement (Sood and Tellis 2005). The death pulse corresponds to the stagnation and decline of industry and the deterioration of an enterprise's profitability (Deschamps 2005). In this stage, business creativity could be demonstrated in exiting the current field by "soft landing" to another indirectly related field, or capturing strategic positions in directly related descendant fields, or wining battles regardless of the war. The life curve of business innovation may vary dramatically from one industry to another, and the heights of the three peaks are not necessarily equal nor do they follow a fixed order. Since business innovative activities are more evenly distributed alone the timeline than product and process innovation, it should play a larger role in explaining the evolution of an industry (Verloop 2004).

It is apparent that the co-existence of product, process and business innovation forms a broader common denominator of innovation, which can be used for checking the various links among innovative activities, such as how one type of innovation can trigger (Drucker 1985, Christensen and Raynor 2003), reinforce (Burns and Stalker 1961, DeBresson and Lampel 1985), or constrain (Abernathy 1978, Henderson and Clark 1990) another type of innovation in a given context.

INNOVATION BINDING FORCES

The functionality and fluctuation analysis for each component of the innovation tripartite reveal that the tripartite is tied closely and holistically. However, what factors tie the three parts together? How have those factors functioned jointly? Scattered studies related to those questions can be spotted in various literatures. But a concise and systematical explanation is still lacking. By scrutinizing the previous studies, I identify three sets of factors which can be seen playing crucial and interweaving roles in gluing all innovative activities: learning mechanisms, perceived consequences and achieving requirements.

Learning is a process of obtaining knowledge and is the precondition for innovation (Sagar and Zwaan 2006). Different learning mechanisms enable and nurse different capabilities (Nonaka 1991). At the same time, those learning mechanisms show specific context and timing for employment. Arrow (1962) demonstrates that "learning by doing" is most obvious at an early stage, with idea growth repealing the law of diminished returns (Lucas 1987). Rosenberg (1982) suggests that "learning by using" happens at the later stage of innovation development. A spectrum exists between them includes learning by sharing, learning by searching, learning by training, learning by hiring and learning by reverse engineering (Lan 1996). Since all innovative activities are all based on learning mechanism, the spectrum of learning mechanisms not only ties various innovation activities together by its enabling function, but also sorts those activities according to the employment context of each learning mechanism.

Perceived consequences are judgments on phenomena. They provide an expected output based on a given state or a situation. Those interpretations could be drawn from various sources: direct experiences, indirect experiences, knowledge obtained through learning, or simply an imagination. In many situations real consequence of an innovation does not necessarily coincide with the expected output due to various reasons and factors. But people do believe that novelty in functionality, efficiency and arrangement generates results within certain ranges or zones (Schumpeter 1939, Gaynor 2002, Verloop 2004). It is the perceived positive consequences of innovation that keep innovative efforts matching forward (Sawhney, Wolcott and Arroniz 2006, Kanter 2006, Kao 2007). Although there are countless innovative efforts, the perceived consequences are comparatively simple: falling in a gain-loss spectrum. Limited scenarios associated to this spectrum are the combinations of system change and trend change (Schumpeter 1939, Anderson and Tushman 1990, Christensen 1997, Cusumano and Gawer 2002, and Sawhney, Wolcott and Arroniz 2006). Since most innovative activities are guided by pre-set expectations, every innovation activity is subject to the judging on what it can bring about over time, and different innovation efforts can be arranged by different degrees and fashions of their actions.

Achieving requirements are reflection of internal logics of innovation development, which are shown as prioritized coordination of activities for realizing a perceived consequence (Scott and Bruce 1994). Previous studies on innovation have paid attention to some internal logics of innovation development, whether it is on linear or partial parallel stage-gate sequence (Cooper 1993, Gaynor 2002, Morrison 2003, Verloop 2004), or certain organizational structure formation and function (Christensen 1997, Hansen and Birkinshaw 2007), or particular implementing methods (Quinn, Baruch and Zien 1996, Goldenberg, Mazursky, Horowitz and Levav 2003, Gottfredson and Aspinall 2005, Fleming 2007), or engaging different stakeholders (Von Hippel 1999, Quinn 2000, Chesbrough 2003). Although diversified, those efforts focus on revealing required conditions or linkages for reaching a goal. If perceived consequences are more related to "knowing the course", archiving requirements are more related to "realizing the course" by completing the key job. It has been widely discussed that innovation involves many factors, and only certain tasks are crucial at certain stages (Drucker 1985, Gaynor 2002, Verloop 2004, Sawhney, Wolcott and Arroniz 2006). It is those key links that tie diversified innovative activities, and distinguish the patterns in realizing those links.

A NEW INNOVATION TRIPARTITE LIFE CYCLE

Breaking away from the traditional innovation dichotomy and the long term assumption of single-peak life curve for each innovation community, a more realistic industrial innovation life cycle can be constructed by combining the innovation tripartite and innovation binding forces.

By adopting the innovation tripartite it implies that that innovation should have seven basic statuses and an innovation life cycle should have at least seven stages. Since three types of innovation in the innovation tripartite are not equally represented in every situation, or at every stage of innovation development. Due to the differences of product functionality, process complexity, stakeholder characteristics, and value net configurations, the impacts of one type of innovation may be more important, active, or dynamic than others (Anderson and Tushman 1990, Fleming 2007). Considering all possibilities of the co-existence of the three types of innovation and their varied activeness in different situations, seven meaningful combinations of the three components, i.e. seven basic innovation statuses" are identified as shown in Table 1. One striking feature is that the seven statuses correspond well to previously identified major innovations. Taking into account of the correspondence of spatial/pattern and temporal, at least seven stages should be identified in an innovation life cycle.

By using the three set of innovation binding forces, a seven-stage innovation chain is obtained from converting seven basic innovation statuses, because the transition of innovation from one status to another is corresponding to continuous changes of innovation foundation, initiation motives and action tendency. This seven-stage innovation chain is the new innovation tripartite life cycle (ITLC) at the context of an industrial evolution. An ideal ITLC usually starts with radical innovation, going through dual-core, crossing, incremental, restructuring, engaging, and ends at dichotomy innovation as shown in Figure 3. Each stage of the seven-stage sequence possesses not only unique innovation contents, but also distinctive internal connecting mechanisms and external interfacing patterns.

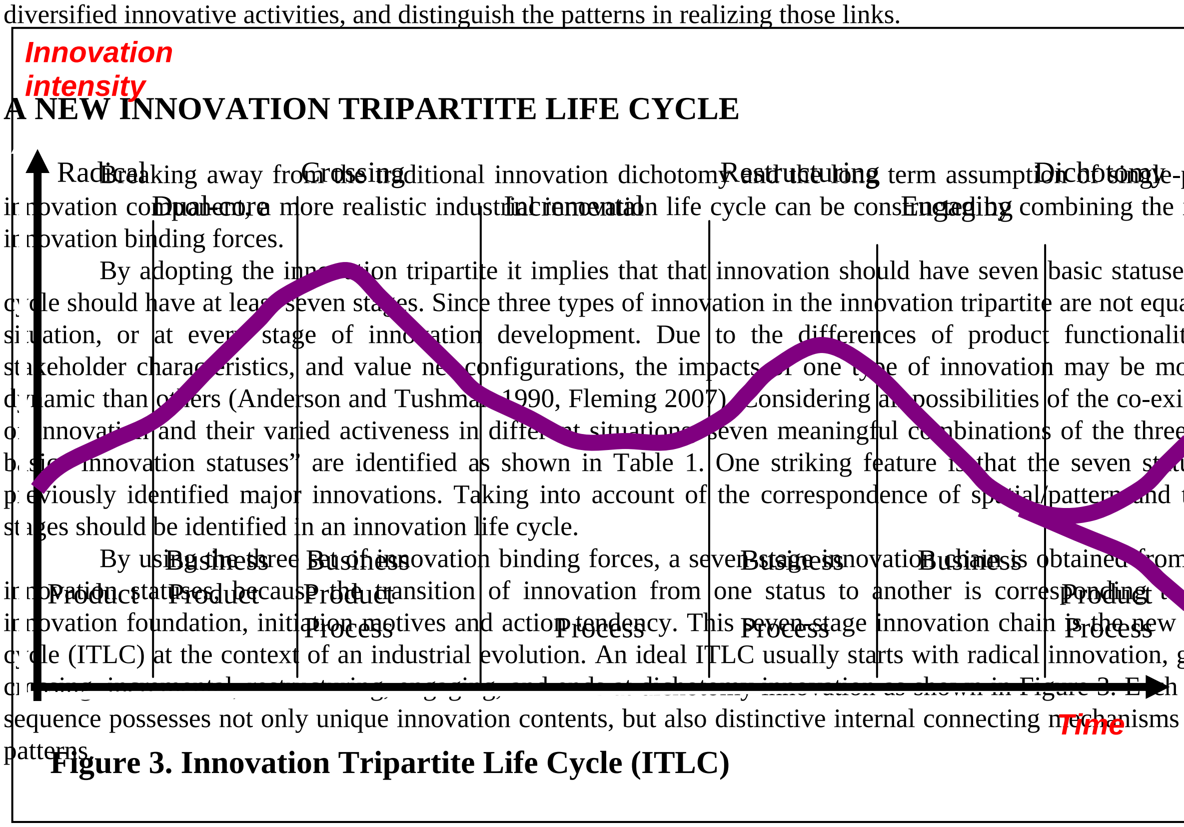

Figure 3. Innovation Tripartite Life Cycle (ITLC)

As the starting phase of an innovation life cycle, radical innovation involves creating new functionalities which results from new methods and materials that are novel to the innovators and others (Schumpeter 1939), and results in new products or services. The novel methods and materials are derived from either an entirely different knowledge base or from a combination of parts of an established knowledge base with a new stream of knowledge (Freeman 1982). Because the creation of new functionality needs time and commitment (Verloop 2004), and requires repeated accumulation of necessary knowledge (Arrow 1962), only limited organizations have the opportunities to commercialize it in an uncertain environment. When innovators pursue a radical innovation they expect to enter a new domain by having block burst products or service (Rosenblum, Tomlinson and Scott 2003). To move forward, they have to align the new functionality with possible consumption (Christensen and Raynor 2003), since only new consumption can prove the usefulness of a new functionality.

After a new functionality is embedded into a product or service, innovation moves into the second stage—dual-core innovation. In this stage, establishing a consumer beachhead is the goal. Pioneers could gain the first mover advantages by entering the domain earlier. Stimulated by the pioneers, more ventures will be formed based on the spread of know-how. Winners in this stage are innovators who successfully combine product innovation and business innovation instead of being technology champion alone (Teece 1986). Unless someone knows the most valuable uses of a technology and the best markets to target, the technology superiority is difficult to realize (Chesbrough 2003). Successful innovators, on the one hand, create a new business model to posit the new functionality to the unfamiliar environment with a very different value proposition (Christensen 1997). On the other hand, they develop the new functionality to fit the new channel linked to the market (Gaynor 2002, Verloop 2004). When innovators pursue a dual-core innovation, they expect to find a new trend or path for dealing with the "regime of appropriability" and speed of exploiting the new domain (Teece 1986). To move forward, they have to align the possible consumption with increasing competition in this area, since competition will change the value of consumption from both consumer and provider sides (Rogers 1962, DeBresson and Lampel 1985).

The establishment of a consumer beachhead stimulates more players in the domain and leads innovation into a cross-over pattern. In this crossing innovation stage new functionality spreads quickly. Invention and innovation related to the usage of the new functionality are pervasive. Merging and acquisition are widely used to access special know-how or to enter the market via a fast track. While the boundary of the industry domain is enlarging, a new business platform is emerging too, which changes many aspects of operations in a short period (Lan 2006). Innovation winners in this stage are not necessarily the pioneers. Any participant who contributes to designing a widely acceptable product or service, sets a sound infrastructure, or organize an effective interface can win out. In this way, advantages of early followers can be secured, because knowledge base for innovation is much larger than before (Chesbrough 2003). When innovators act in the crossing innovation stage, they expect to become a key builder or part of a key team of builders which build the new operation platform within the new domain (Shapiro and Varian 1999, Sawhney 2001, Cusumano and Gawer 2002). To move forward, they have to align the competition they felt in many dimensions with a popular form of product or service (Abernathy and Utterback 1978), and a new form of organization which is adaptable to a rapidly changing environment (Tushman and O'Reilly 1996).

After dominant design is established on a new operation platform, innovation moves to an incremental improvement stage. In this stage, innovation is defined comparatively clear, and it builds mainly on the established knowledge base. The priorities of innovation are introducing relatively minor but persistent changes to the existing products or services, exploiting the potential of the established design, and processing methods, and or used materials (Freeman 1982). During this process, standardization and automation of product or service is achieved through vertical invention, which not only raises the threshold for new-comers, but also reinforces the dominance of established firms (Nelson and Winter 1982). The incremental innovation stage is regarded as a golden age for both innovation winners and users of new functionality, because the gains in productivity are substantial (Abernathy 1978, Henderson and Clark 1990). It is also a period where sustaining innovation "over shoots" itself and becomes a "tyranny of success" (Christensen 1997). When innovators compete in the incremental innovation stage, they expect to become a new rhythm setter within the new operation platform for finding an optimal routine. To go through this stage, innovators have to align their previous adoptable organizations with a better structure which facilitates the optimization of operations, i.e. to optimize their resources-processes-value chain (Christensen 1997).

Restructuring innovation comes after incremental innovation, which represents the second peak in the ITLC. Several reasons are attributed to the rising of the innovation curve. First, modulated production or delivery of the new functionality is possible due to a comparative long term vertical and horizontal invention surrounding the new functionality in the previous stage (DeBresson and Lampel 1985, Henderson and Clark 1990, Verloop 2004) or an innovation "long tail"—a jump of innovation over a period of steady moving (Fleming 2007). Secondly, the enhancement of dominant design over a period of time could marginalize certain segments of consumers (Cusumano and Gawer 2002) through technological overshooting (Christensen 1997), which leaves room for low-cost disruptive innovation (Christensen and Raynor 2003). Thirdly, the interaction of architectural and disruptive innovations is often embedded in or results in enterprises' mid life crisis, which requires more business innovation to recover (Sull and Houlder 2006). The three forces bring about many structural changes and propel the innovation life cycle to its mid peak. The restructuring innovation opens doors for late entrants, because they can use their know-how to respond to customer demands, to improve modules or components, and to use system integration as a winning ticket. When innovators contend in this stage, most of them do not aim at totally changing the functionality of a product or a service. They expect to change the delivery and or certain features of the product or service, as Cannon did in entering the photocopy machine market (Christensen 1997) and Underwood did in introducing a new typewriter (Utterback 1994). To succeed in restructuring innovation, innovators have to align their optimizing structures with a broad base of resources including both internal and external ones, which makes restructuring efforts absorb more complementary innovations.

While the restructuring innovation curve falls, the innovation life cycle moves into a stage of engaging more stakeholders. In this stage, stagnant or declining demands for the products or services can be observed from decreasing of operation margins, particularly decreasing returns on modifying the product or service. Facing the surviving challenges, innovators expect that new business deals could help them to reverse the trend within their domain. Various business innovations, therefore, are aiming for adjusting or optimizing linkages set up before. To gain high efficiency, innovators broaden their learning channels and conduct a wide range of activities with leveraging purpose, which could include partnering with customers and engaging them as innovators (Von Hippel 1999, Thomke and von Hippel 2002), having more M&A and getting more stimulation (Roberts and Liu 2001), changing personnel frequently with some outsiders on board (Sutton 2002), or soliciting other supports and their knowledge from suppliers, universities, national labs, consortia, consultants, and others (Chesbrough 2003).

Dichotomy innovation signals the end of an industrial innovation life cycle. In this stage, overall market for products or services may be shrinking, and operation margins may be diminished due to overall environment change. Technology for generating original functionalities may be in perfect shape, but the original functionalities are no longer desirable. Under this situation, an innovation dichotomy happens. On one hand, many players exit the industry with most selecting a fast-track. On the other hand, some players tend to embrace a new product or service, which has either a similar functionality with a different enabling system, such as the electronic typewriter replacing the hand typewriter (Utterback 1994), or a new functionality such as Xerox photocopy machine. Most innovators who hang on in the industry have the faith in science advancement or nature of cyclic development. They expect to go through the tunnel of small outlets and bet that either something will grow big, or that the environment will favor similar functionalities again in the future. As a feature of innovation at this stage, R&D ratios and innovation orientation show substantial changes. R&D ratios may be either higher, due to other expenditure cuts, or lower, due to the phasing out of innovation. Innovation orientation shows an internal shift. More innovation efforts are concentrating on comparatively closed experiments or highly selected technology transfer. To do so, industry-wide innovation on both product and process may be raised again. However, product and process innovation will be less interdependent (DeBresson and Lampel 1985), because the linkage between them becomes vague, and either can be a spring board for entering a new domain. In this situation, innovators may even pursue a set of potentially conflicting paths at the same time (Sawhney and Prandelli 2000). However, to go through this stage, players have to align their deteriorating efficiency with new functionality creation, since only new functionality can justify the hanging on in declining operations.

DISCUSSION AND CONCLUSION

This research is an effort to develop a complete industrial innovation life cycle with a broad coverage. While this research sheds lights on the dynamics of innovation, it also shows limitations in the scope of research, using methods and obtained results, which provide extra avenues for expanding this study. First, this research is built squarely on a business setting with little consideration for activities outside this boundary. If the model is applied outside business arena, modification is required. One suggestion is to replace business innovation with value innovation, because in a non-business setting value creation will tie closely to the changing of relationships associated with key functionality formation and delivery. Secondly, this research is a qualitative analysis without quantitative analysis on how the seven stages of the ITLC could be distributed along the time arrow, or the constitution of the innovation tripartite at each stage. Although it is impractical for expecting a unified formula, it may be helpful if more empirical studies could be conducted. Thirdly, this research identifies a dichotomy at the last stage of an ITLC: dying of an industry and the birth of a new industry. In reality, this stage may last a long time (Fleming 2007) with many things happening between the two extremes. It may be over simplified by labeling it as a dichotomy. One preliminary hypothesis for further exploration in this stage is that the dichotomy stage may consist of more than one small-scale cycle of experimenting-restructuring-engaging-experimenting innovations. New experiments on product or process could induce the small cycle by having new functionality and improved delivery in secondary dimensions (Sood and Tellis 2005).

Tempo dimension is definitely important to innovation. The clearer an innovation rhythm, the better the overall understanding of innovation; and the more effective innovation issues could be handled. The value of the ITLC lies in facilitating this process.

REFERENCES

Abernathy, W. J. and K. B. Clark 1985. Innovation: Mapping the winds of creative destruction, ***Research Policy***. 14: 3-22.

Abernathy, W. J. 1978. ***Productivity Dilemma: Roadblock to innovation in the automobile industry***, Baltimore and London: Johns Hopkins University Press.

Abernathy, W. J. and Utterback, J. M. 1978. Patterns of Industrial Innovation, ***Technology Review***, 80(7): 40-47.

Anderson, P. and Tushman, M. L. 1990. Technological Discontinuities and Dominant Design: A cyclical model of technological change. ***Administrative Science Quarterly.*** 35(4): 604-633.

Anthony, S.D., Eyring, M. and Gibson, L. 2006. Mapping your innovation strategy. ***Harvard Business Review***, 84(5): 104-113.

Arrow, K. 1962. The Economic Implications of Learning by Doing, ***Review of Economic Studies***, 29(6): 155-173.

Athey, S. and Schmutzler, A. 1995. Product and Process Flexibility in an Innovative Environment. ***RAND Journal of Economics***. 26: 557-574.

Birkinshaw, L., Hamel, G. and Mol, M. J. 2008. Managing Innovation, ***Academic of Management Review,*** 33(4): 825-845.

Brown, J. S. 2002. Research that Reinvents the Corporation, ***Harvard Business Review***, 80(8): 105-114.

Brown, J. S. 2003. Foreword: Innovating Innovation, for Chesbrough, H. W ***Open Innovation: The New Imperative for Creating and Profiting from Technology.*** Boston: Harvard Business School Press, pp. ix-xii.

Burns, T. and Stalker, G.M. 1961. ***The Management of Innovation.*** London: Tavistock Publication Ltd.

Chesbrough, H. W. 2003. ***Open Innovation: The New Imperative for Creating and Profiting from Technology.*** Boston: Harvard Business School Press.

Chesbrough, H. W. and Rosenbloom, R. 2002. The role of the business model in capturing value from innovation. ***Industrial and Corporate Change***. 11(3):529-556.

Christensen, C. 1997. ***The Innovator's Dilemma***. Boston: Harvard Business School Press.

Christensen, C. and Raynor, M. E. 2003. ***The Innovator's Solution***. Boston: Harvard Business School Press.

Christensen, C. M., Kaufman, S. P. and Shih, W. C. 2008. Innovation Killers:How financial tools destroy your capacity to do new things. ***Harvard Business Review,*** 86(1): 98-105.

Cooper, R. G. 1993. ***Winning at new products: Accelerating the process from idea to launch.*** Reading, Mass: Addison Wesley.

Cusumano, M. A. and Gawer, A. 2002. The elements of platform leadership. ***MIT Sloan Management Review,*** 43(3): 51-58.

Daft, R. L. 1978. A Dual-core model of organizational innovation. ***Academy of Management Journal***. 21(2):193-210.

Damanpour, F. 1991. Organizational Innovation: a meta-analysis of effects of determinants and moderators. ***Academy of Management Journal.*** 34(3): 555-590.

DeBresson, C. and Lampel, J. 1985. Beyond the Life Cycle: Organizational and Technological Design. I. An Alternative perspective. ***Journal of Product Innovation Management.*** No. 3. pp.170-187.

Jean-Philippe, D. 2005. Different leadership skills for different innovation strategies. ***Strategy & Leadership***. 33(5): 31-38.

Dosi, G. 1982. Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. ***Research Policy***. 11: 147-162.

Drucker, P. F. 1985. The discipline of innovation. ***Harvard Business Review***, 63(3): 67-72.

Ettlie, J. E. 2000. ***Managing Technological Innovation***, New York: John Wiley & Son Inc.

Fleming, L. 2007. Breakthroughs and the "long tail" of innovation. ***MIT Sloan Management Review,*** 48(3): 69-74.

Freeman, C. 1982. ***The Economics of Industrial Innovation***, 2nd edition, London: Frances Printer.

Gaynor, G. H. 2002. ***Innovation by Design.*** New York: AMACOM

Geiger, D. 2004. It's Time to Start Innovating, ***Design News,*** 60(13): 20

Gottardi, G. 2000. Presentation: How should technology be managed in the post-Fordist era? ***International Journal of Technology Management.*** 20(1/2): 1-19.

Goldenberg; J., Mazursky, D., Horowitz, R. and Levav, A. 2003. Finding Your Innovation Sweet Spot. ***Harvard Business Review,*** 81(3): 120-129.

Gottfredson, M. and Aspinall, K. 2005. Innovation vs Complexity. ***Harvard Business Review***, 83(11): 62-71.

Hansen, M. T. and Birkinshaw, J. 2007. The Innovation Value Chain. ***Harvard Business Review***, 85(6): 121-130.

Hargadon, A. and Sutton, R. I. 2000. Building an Innovation Factory, ***Harvard Business Review***. 78(3): 157-166.

Henderson, R.M. and K. Clark, 1990. Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, ***Administrative Science Quarterly***, Vol. 35. pp. 9-30.

Jovanovic, B. and MacDonald, G. M. 1994. The life cycle of a competitive industry. ***Journal of Political Economy.*** 102(June): 322-347.

Kanter, R. M. 2006. Innovation: The classic traps. ***Harvard Business Review***. 84(11): 73-83.

Kao, J. 2007. ***Innovation Nation: How America is losing its innovation edge, why it matters, and what we can do to get it back.*** New York: Free Press.

Kaplan, R. S. and Norton, D. P. 1996. Strategic learning & the balanced scorecard. ***Strategy & Leadership***, Sep/Oct 19-24.

Kaplan, R. S. and Norton, D. P. 2006. Response to S. Voelped et al. ***Journal of Intellectual Capital,*** 7(3):421-428.

Keating, S. 2004. Managing Data Life-Cycle from Creation to Deletion, ***Drug Discovery and Development***, 7(6): 52-54.

Kim, C. W. and Mauborgne, R. 1997. Value innovation: The Strategic logic of high growth. ***Harvard Business Review.*** 75(1): 103-112.

Kim, C. W. and Mauborgne, R. 2000. Knowing a Winning Business Idea When You See One. ***Harvard Business Review***. 78(5): 129-138.

Klepper, S. and Simons, K. L. 1996. Innovation and Industry Shakeouts. ***Business and Economic History.*** 25(1):81-89.

Kogut, B. and A. Turcanu 1999. ***Global Software Development and the Emergence of E-innovation,*** Carnegie Bosche Institute, http://cbi.gsia.cmu.edu/newweb/1999Sfconference/Kogut/Kogut.html

Kuznets, S. S. 1930. ***Secular Movements in Production and Prices.*** Boston: Houghton Mifflin Co.

Lan, P. 1996. ***Technology transfer to China through Foreign Direct Investment.*** Aldershot, England: Avebury.

Lan, P. 2006. A New Vision of Innovation Management: Towards an Integrated Paradigm, ***International Journal of Technology Marketing***. 1(4): 355-374.

Lan, P., Hutcheson, G., Markov, Y. and Runyan, N. 2007. An Examination on the Integration of Technological and Business Innovation: Cases of Yahoo! and Google. ***International Journal of Technology Marketing.*** 2(4):295-315.

Leonard-Barton, D. 1998. ***Wellsprings of Knowledge***. Boston: Harvard Business School Press.

Linnarson, H. 2005. Patterns of Alignment in Alliance Structure and Innovation, ***Technology Analysis & Strategic Management***, 17(2): 161-181.

Liu, C. 2005. An Emperical study of the construction of a model for measuring organizational innovation in Taiwanese High-Tech enterprises***. International Journal of Innovation Management.*** 9(2): 241-257.

Loudon, A. 2001. ***Webs of Innovation: the networked economy demands new ways to innovate,*** London: Pearson Education Ltd.

Lucas, R. E. 1987. On the mechanics of economic development. In Jacobs, D.P., Schwartz, N.L., Kalai, E. and Kamien, M. I. (eds.) ***Frontiers of Research in Economic Theory: The Nancy L. Schwartz Memorial Lectures, 1983-1997***, Cambridge: Cambridge University Press, pp.61-70.

McGregor, J. and Barrett, A. 2006. Dawn of the Idea Czar. ***Business Week***. April 10.

Markides, C. 1997. Strategic innovation. ***MIT Sloan Management Review***. 38(3): 9-23.

Markides, C. 2004. Rethinking Innovation. ***Leader to Leader***. 34: 35-42.

Markides, C. 2006. Disruptive Innovation: In need of a better theory. ***The Journal of Productive Innovation Management***; 23:19-25.

Mairesse, J. and Mohnen, P. 2002. Accounting for innovation and measuring innovativeness: an illustrative framework and an application. ***The American Economic Review.*** 92(2): 226-230.

Mansfield, E. 1968. ***The Economics of technological change***. New York: W.W. Norton & Company.
Mansfield, E. 1971. ***Industrial Research and Technological Innovation***. New York: Norton.

Mazzucato, M. and Semmler, W. 2000. Market share instability and stock price volatility during the industry life-cycle: the US automobile industry. In Cantner, U., Hanusch, H. and Klepper, S (eds.) ***Economic Evolution, Learning, and Complexity***. Herdelberg: Physica-Verlag,.

Meyer, M. H. and Utterback, J. M. 1993. The Product family and the dynamics of core capability. ***MIT Sloan Management Review***. 34(3): 29-47.

Moore, G. A. 2004. Crossing the Chasm—and Beyond. In Burgelman et al. eds. ***Strategic Management of Technology and Innovation***. Boston: McGraw-Hill, pp.362-368.

Morrison, A. 2003. ***Going beyond the idea—delivering successful corporate innovation***. Grist.

NAS 2004. ***Measuring R&D Expenditures in the U.S. Economy***. The National Academy of Science. Access at http://www.nap.edu/catalog/11111.html.

Nelson, R. and Winter, S. 1982. ***An Evolutionary Theory of Economic Change***. Cambridge, MA: Harvard University Press.

Nonaka, I. 1991. The knowledge-creating company, ***Harvard Business Review***, 69(6): 96-104.

O'Reilly, C. and Tushman, M. 2004. The Ambidextrous Organization, ***Harvard Business Review***, 82(4):

O'Sullivan, D. and Dooley, L. 2009. ***Applying Innovation.*** Los Angeles: SAGE Publications.

Pavitt, K. 1984. Sectoral patterns of technical change: toward a taxonomy and theory. ***Research Policy.*** Vol. 13, pp.343-373.

Pavitt, K. 1990. What We Know about the Strategic Management of Technology. ***California Management Review*** Vol. 32 Issue 3, pp.17-26.

Pavitt, K., Robson, M. and Townsend, J. 1989. Technological accumulation, diversification and organization in UK companies, 1945-1983. ***Management Science***. 35(1): 81-99.

Porter, M. E. 1985. ***Competitive Advantage: Creating and Sustaining Superior Performance.*** Free Press: New York.

Porter, M. E. 1990. ***The Competitive Advantage of Nations.*** Free Press: New York.

Porter, M. E. and Stern, S. 2001. Innovation: Location Matters. ***MIT Sloan Management Review***, 43(): .

Porter, M. E. 2001. Strategy and the Internet. ***Harvard Business Review***, 79(3): 62-79.

Porter, M. E. 2008. The five competitive forces that shape strategy. ***Harvard Business Review***, 86(1): 79-93.

Powell, J. and Moris, F. 2004. Different timelines for different technologies. ***Journal of Technology Transfer.*** Vol. 29, pp.125-152.

Prahalad, C. K. and Hamel, G. 1990. The Core Competence of the Corporation. ***Harvard Business Review,*** 68 (3): 79-91.

Quinn, J. B. 1969. Technology Transfer by Multinational Companies. ***Harvard Business Review,*** 47 (6): 147-161.

Quinn, J. B. 2000. Outsourcing innovation. ***MIT Sloan Management Review.*** 41(4):13-28.

Quinn, J. B., Baruch, J. J. and Zien, K. A.1996. Software-Based Innovation, ***McKinsey Quarterly.*** 4: 94-119.

Reid, S. E. and de Brentani, U. 2004. The Fuzzy Front End for New Product Development for Discontinuous Innovations: A Theoretical Model. ***Journal of Product Innovation Management.*** 21: 170-184.

Rizova, P. 2006. Are you networked for successful innovation? ***MIT Sloan Management Review***, 48(1): 49-55.

Roberts, E. B. and Liu, W. K. 2001. Ally or acquire? How technology leaders decide, ***MIT Sloan Management Review***, 43(1): 26-34.
Rogers, E. M. 1962. ***Diffusion of Innovations.*** New York: The Free Press.

Rosenberg, N. 1982. ***Inside the Black Box: technology and economics.*** London: Cambridge University Press.

Rosenberg, N. and R. R. Nelson 1994. American Universities and Technical Advance in Industry. ***Research Policy*** 23:323-328.

Rosenblum, D., Tomlinson, D. and Scott, L. 2003. Bottom-Feeding for Blockbuster Businesses. ***Harvard Business Review,*** 81(3): 52-59.

Rousesel, P.A., Saad, K. N. and Erickson, T. J. 1991. ***Third Generation R&D***. Boston: Harvard Business School Press.

Sagar, A. D. and Zwaan, B. 2005. Technological innovation in the energy sector: R&D, deployment, and learning-by-doing. ***Energy Policy***. 34: 2601-2608.

Sawhney, M. and Prandelli, E. 2000. Communities of Creation: Managing distributed innovation in turbulent markets, ***California Management Review***, 4(2): 24-54.

Sawhney, M. Wolcott, R. C. and Arroniz, I. 2006. The 12 Different Ways for Companies to Innovate. ***MIT Sloan Management Review***. 47(3): 75-81.

Schilling, M. A. 2008. ***Strategic Management of Technological Innovation***. Boston: McGraw-Hill.

Schumpeter, J. A. 1934. ***The Theory of Economic Development***. Boston: Harvard University Press.

Schumpeter, J. A. 1939. ***Business Cycles***. New York: McGraw-Hill Book Company Inc.

Scott, S. G. and Bruce, R. A. 1994. Determinants of innovative behavior: a path model of individual innovation in the workplace. ***Academy of Management Journal.*** 37(3): 580-607.

Shapiro, C. and Varian, H. R. 1999***. Information Rules: A strategic guide to the networked economy***. Boston: Harvard Business School Press.

Shepherd, C. and Ahmed, P. K. 2000. From product innovation to solutions innovation: a new paradigm for competitive advantage, ***European Journal of Innovation Management***, 3(2): 100-106.

Slywotzky, A. and Wise, R. (2003). Three keys to groundbreaking growth: A demand innovation strategy, nurturing practices, and a chief growth officer. ***Strategy & Leadership.*** 31(5):12-19.

Sood, A. and Tellis, G. J. 2005. Technological evolution and radical innovation***. Journal of Marketing***. 69 (July): 152-168/

Spear, S. and Bowen, H. K. 1999. Decoding the DNA of the Toyota Production System. ***Harvard Business Review,*** 77(5): 97-106.

Stevens, G. A. and Burley, J. 1997. 3000 Raw Ideas = 1 commercial Success. ***Research Technology Management,*** May-June, pp.16-28.

Studt, T. 2005. Measuring innovation…Gauging your organization's success. ***R & D Magazine***, 47(2): 42-44.

Sull, D. N. and Houlder, D. 2006. How companies can avoid a midlife crisis. ***MIT Sloan Management Review***. 47(3): 26-34.

Sutton, R. I. 2002. Weired ideas that spark innovation. ***MIT Sloan Management Review***. 43(2): 83-91.

Teece, D. J. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing, and public policy. ***Research Policy*** 15: 285-305.

Thomke, S. 2003. R&D Comes to Services. ***Harvard Business Review***, 81(4): 70-79.

Thomke, S. and von Hippel, E.2002. Customers as Innovators: A New Way to Create Value. ***Harvard Business Review***, 80(4): p74-81.

Tushman, M. L., and Anderson, P. 1986. Technological Discontinuities and Organizational Environments. ***Administrative Science Quarterly***. 31(3): 439-465.

Tushman, M. L. and O'Reilly III, C.A. 1996. Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change, ***California Management Review***, 38(4): 8-31.

Ulrich, D. A. W. 2002. An innovation protocol. In Hesselbein, F,. Goldsmith, M. and Somerville, I. eds. ***Leading for Innovation.*** San Francisco: Jossey-Bass, pp.215-224.

Utterback, J. M. 1994. ***Mastering the Dynamics of Innovation***. Boston: Harvard Business School Publishing Corporation.

Verloop, J. 2004***. Insight in Innovation: managing innovation by understanding the laws of innovation.*** Amsterdam: Elsevier.

Vernon, R. 1966. International investment and international trade in the product cycle. ***Quarterly Journal of Economics.***

Von Bertalanffy, L 1975. ***Perspectives on General System Theory***. New York: George Braziller.

Von Hippel, E. 1999. Creating Breakthroughs at 3M, ***Harvard Business Review***, 77(5): 47-57.

Von Hippel, E. 2005. ***Democratizing Innovation***. Cambridge, Massachusetts: The MIT Press.

Vonortas, N.S. 1997. ***Corporation in Research and Development.*** Boston: Kluwer Academic Publishers.

Wynne, M. 2006. Value Innovation. ***Global Cosmetic Industry***. 174(8): 60.

Xu. Q., Chen, J., Xie, Z., Liu, J., Zheng, G. and Wang, Y. 2007. Total Innovation Management: a novel paradigm of innovation management in the 21st century. ***Journal of Technology Transfer.*** 32: 9-25.