

A SYSTEM LOOK FOR TECHNOLOGICAL INNOVATION: FIRM BASED PERSPECTIVE

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Abstract

The objective of this study is to propose a model for a firm-based point of view for dealing with the process of technological innovation within a systematic approach. In keeping with this objective, the concepts of innovation and technology are summarized and technological innovation and its elements are considered. The process of firm-based technological innovativeness dealt with in an “input – process – output” process that is the fundamental system logic is also examined as an outcome especially of environmental factors and a firm’s innovativeness.

Keywords: Innovation, Technology, Technological Innovation

1 INTRODUCTION

The study of innovation process in and among organizations has evolved as a multidisciplinary endeavor (Ettlie, Bridges and O’Keefe, 1984; 682). Research into the managerial and economic aspects of technological innovation at the micro level of the industry and the firm has undergone some substantial changes in direction and emphasis since the early work of Schumpeter (Loveridge, Pitt, 1996; 205).

Over the past few years, technological innovation management has become one of the most attractive and promising areas of study in the field of management. This fact confirmed by the following developments (Nieto, 2004; 314):

- An increasing number of scholars have oriented their research towards this area
- Each year there are new scientific journals specializing in the study of innovation phenomena
- Consolidation of various academic associations.

Technological innovation has become increasingly critical for firms as they struggle to achieve and maintain competitive advantage. Trends such as globalizations, fast product-cycle times, greater competition, product commoditization and technology fusion have only added to this importance (Cardinal, 2001; 19).

2 CONCEPT OF INNOVATION

The concepts used in the study of innovation phenomena are not usually precisely defined. The alternative concepts of innovation are shown in Table 1 (Wonglimpiyarat,2004;230).

| Concepts of innovation | Scholars |
|---|--|
| A process of enhancing existing technology | Rosenberg (1976), Nelson&Winter (1977,1982), Dosi (1982) |
| A process of turning opportunities into practical use | Pavitt (1984), Tidd (1997) |
| An integrated process involving | Schott (1981), Daft (1982), Rothwell&Gardiner (1985) |
| Any new technologies and new processes | Rogers&Shoemaker (1971), Porter (1990), Voss (1994) |

Table 1. *Concepts of Innovation*

A multidimensional model of innovation includes; product-process, incremental-radical and administrative-technological innovations (Cooper,1998;500). Today, innovation is not a fad but an essential activity for the long-term survival of organizations (Cobbenhagen,2000;6). In the early studies on innovation Marquis (1969) has identified three types of innovation: radical, incremental, and systems but now it is distinguished four types (Gaynor,1996;8.2)

- Radical component innovations
- Incremental innovations to existing technologies
- Radical system innovations
- Next-generation technology innovations

Scholars from different fields are often use the innovation and technology interchangeably to signify the same idea and also instead of innovation process they may use technological change, technical progress, technological development etc (Nieto,2004;314-315).

3 TECHNOLOGY AND TECHNOLOGICAL INNOVATION

3.1 Technology

Technology has never been more important in this technological world. The word technology usually conjures many different images and generally refers to what has been described as the “high-tech” industries (Gaynor,1996;1.6-21.1). The term ‘technology’ is used to refer to the stock of knowledge about the set of all industrials techniques available at given time (Nieto,2004;315). Technology refers to the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems (Burgelman,Maidique,Wheelwright,1996;2). In management literature the term technology has been used in various senses (Table 2).

| | |
|---------------|----------------------------|
| Technology is | a production process |
| | a key competitive factor |
| | an applied science |
| | a specific process |
| | a core competency |
| | a dynamic capabilities |
| | a know how |
| | an accomplishing a task |
| | a way to do something |
| | an improve quality of life |

Table 2. *Technology Definition*

Technology is tools, devices and knowledge that mediate between inputs and outputs and/or that create new products or services (Rosenberg 1972 in Tushman,Anderson,1986;440).

There are three main theories -the product-process concept, the meta-learning concept, and the concept of technological interdependence- of technology and innovation in the management literature and lots of models (Butler,1988;15).

Because, with many innovations, the company was primarily guided by its technological possibilities (Cobbenhagen,2000;123). Some innovations are technology-based and others are facilitated by new technology (Burgelman,Maidique,Wheelwright,1996;2). Technological change has been described by technology push and demand pull or their interaction as triggers of innovation (Wonglimpiyarat,2004;230). Technology plays a twofold role in the technological innovation process: it is both the output of the innovation process as well as its principal input (Nieto,2004;315).

3.2 Technological Innovation

Innovation refers to the economic application of new idea and technological innovation is described as a process which transforms idea to the commerce (Subrahmanya,2005;269). Innovation also characterizes as “a change in technology which is manifested in the development of new products” (Methe 1992 in Stock,Greis,Fischer,2002;537). Change, competition, strategy concepts are get more important in 80’s and technological innovation has become the strongest engine driving society since the 1980s. Yet, technological innovation is not a new phenomenon which suddenly emerged as part of the space age. It has been around and shaped our life for thousands of years. Today’s companies gain their competitive advantage and economic benefits largely from innovation. The role of technological innovation in this point is for business success (Gaynor,1996;9.1-9.2) and in many industries technological innovation is now the most important driver of competitive success (Schilling,2005;1). By the way technological innovation can create new industries and transform or destroy existing ones (Cooper,Schendel,1976;61).

At the origin of the technological innovation process are inventions or discoveries. The criteria for success regarding inventions and discoveries are technical rather than commercial (Burgelman,Maidique,Wheelwright,1996;2-3). Technological innovation is used to refer to the process through which technological advances are produced. Technological innovation has been considered as a process that generates information from information but also knowledge which reverts exclusively to the innovator (Nieto,2004;319-320).

In the innovation surveys there are two main approaches to measure the performance of innovation activities. While subject approach is analyses firm, in object approach technological innovation is the unit of analyses. Main criteria of classification in object approach is technological fields (Archibugi,Sirilli,2000;7).

In modern business organizations technological innovation is normally aimed at the development of new products and processes (Loveridge,Pitt,1996;209). Managers and scholars have been interested in the differences between radical and incremental innovation process in organizations (Knight 1967 in Green,Gavin,Aiman-Smith,1995;203).

Nowadays scholars are arguing the continuous-discontinuous and disruptive technological innovations. Basically technological innovation can be considered from at least three perspectives (Loveridge and Pitt,1996;274-275):

- Technological development
- The impact of technological development on firm and industry structures
- The process by which organizations formulate and implement strategic technological change

Product-process, radical-incremental or technological innovation should be described as a system in the organization. As the complex system of factors shaping innovation at the firm level is referred to as the “innovation dynamo” (Oslo Manual;20). In this study, it is mentioned that technological innovations should be held in a system concept. The research objective is to explain the variables and indicators of technological innovation process in a firm.

4 TECHNOLOGICAL INNOVATION AS A SYSTEM

Innovation can be seen as an event, the introduction of something new to the business world, as well as a process (Janszen,2000;4). Technological innovation can be viewed as taking place a broader innovation process, or “metasystem” of an organization (Twiss 1980 in Brown, Karagozoglu,1989;11). The innovation models conceptualized into three steps from 50’s to 90’s (Archibugi,Sirilli,2000;6). From the year 50’s to 80’s linear, in the year 80’s chain-linked and in the year 90’s systematic approach was seen in the innovation models. Today, still systematic approach is current in the business sectors.

A simple definition of systems is suggested by Ackoff as a set of parts or collection of elements which constitute an indivisible whole satisfying three conditions (Gaynor,1996;16.3):

- The performance of the whole is affected by every one of its parts
- The contributions of each is related to or dependent on some other part
- Combinations of parts into subgroups will cause the subgroups to have the same properties

All technology systems are functionally defined open systems, accepting inputs, and transforming these into outputs. The road toward building any complex system is usually rocky, twisted path, full of the potholes of tradeoff analysis and decision making (Gaynor,1996;12.7-16.5).

Technological innovations are often categorized into different types. Different types of innovations require different kinds of underlying knowledge and have different impacts on the industry’s competitors and customers (Schilling,2005;37). But all the types of innovations appear after a developing process. As systematic thought is important for the companies, technological innovations are also must held in a systematic view.

Steele (1989) pointed out that technologies are systems and until the total system is managed, success in innovation and firm cannot be assured (Harrison,Samson,2002;53).

For successful technological innovation to occur, the process of innovation needs to be carefully managed. The complex nature of the innovation process has been emphasized by many authors (Saren,1984; Forest,1991; Kanter,1989) (Harrison,Samson,2002;54-55). But with a systematic view and firm based perspective is not held with in a wide range.

In the literature innovation models classified in different. One generalize classification is static (*Incremental versus Radical, Abernathy-Clark Model, Henderson-Clark Model, Innovation Value-Added Chain, Strategic Leadership View, Familiarity Matrix, Quantity and Quality of the New Knowledge, Teece Model, Strategic Choice*) and dynamic models (*Utterback-Abernathy Dynamic Model of Innovation, Tushman-Rosenkopf Technology Life Cycle Model*) (Afuah,1998;14-41). And the other one is Roothwells’ five generations of innovations models. First one is technology push, second need pull, third coupling model, fourth integrated model and the fifth is systems integration and extensive networking model which is flexible and customized response and available for continuous innovation (Wonglimpiyarat,2004;230).

Xu et al. (1998) proposed a firms' innovation system coverage. They said in general studies should cover the following topics:

- The infrastructure of firms' innovation system
- The characteristics of each subsystem of firms' innovation system
- The correlation of each subsystem of firms' innovation system
- The dynamic change of firms' innovation system

There are lots of innovation process models like Wilson (1966), Harvey and Mills (1970), Hage and Aiken (1970), Zaltman et al. (1973), Kimberley (1981), Rogers (1983) etc. The models focus on the relative emphasis on pre and post adoption stages, the initiation of the process, and where the process ends (King in West and Farr,1990;40-43). The pattern of technological innovation that occurs, with respect to a given product or process, has been theorized to be the result of many different factors (Butler,1988;16).

From these view points we also describe a system model of technological innovation process with the factors that effected process directly. A technological innovation process in a firm can be described as shown in Figure 1.

Innovation can be studied at various levels which are the firms environment, the firm and the project or equipment, plant, firm or industry (Cobbenhagen,2000;27, Butler,1988;18). In this study we held the technological innovation basically at the firm level but also with determinants which are affecting the firms' technological innovation process.

Such a system is composed of several organizational elements; we held these system inputs, technological innovation process, outputs, resources that are internal and external factors and firm's innovativeness. But we don't just held only incremental or radical innovation like Ettlíe et al but general view of technological innovation is our base.

Input

While the managerial variables that enter the process of technological innovativeness within the system structure are differentiated into the categories of "decision" and "implementation", the basic inputs that make up the process are technology, creativity, innovation, and knowledge.

Based on general system theory it can be stated that the decision inputs exercise control and influence over the behavior of the implementation inputs throughout the multistage innovation process (Brown,Karagozoglu,1989;11). One of the main points in innovation activity is R&D which takes on a wide variety of functional forms related to problem-solving (Oslo Manual,2005;26).

Process

The process of technological innovation may be achieved on two levels: the research phase and the product development phase. The steps involved in the emergence of technological innovation on the other hand consist of stimulation, proposal selection, problem solving, and output realization.

While uncertainty associated with the technological innovation process provides a fertile breeding ground for organizational politics, significant innovation events in a firm's history actually suspend politics because the situation is such a radical jolt to the typical processes subject to politics (Prasad,Rubenstein,1992;5).

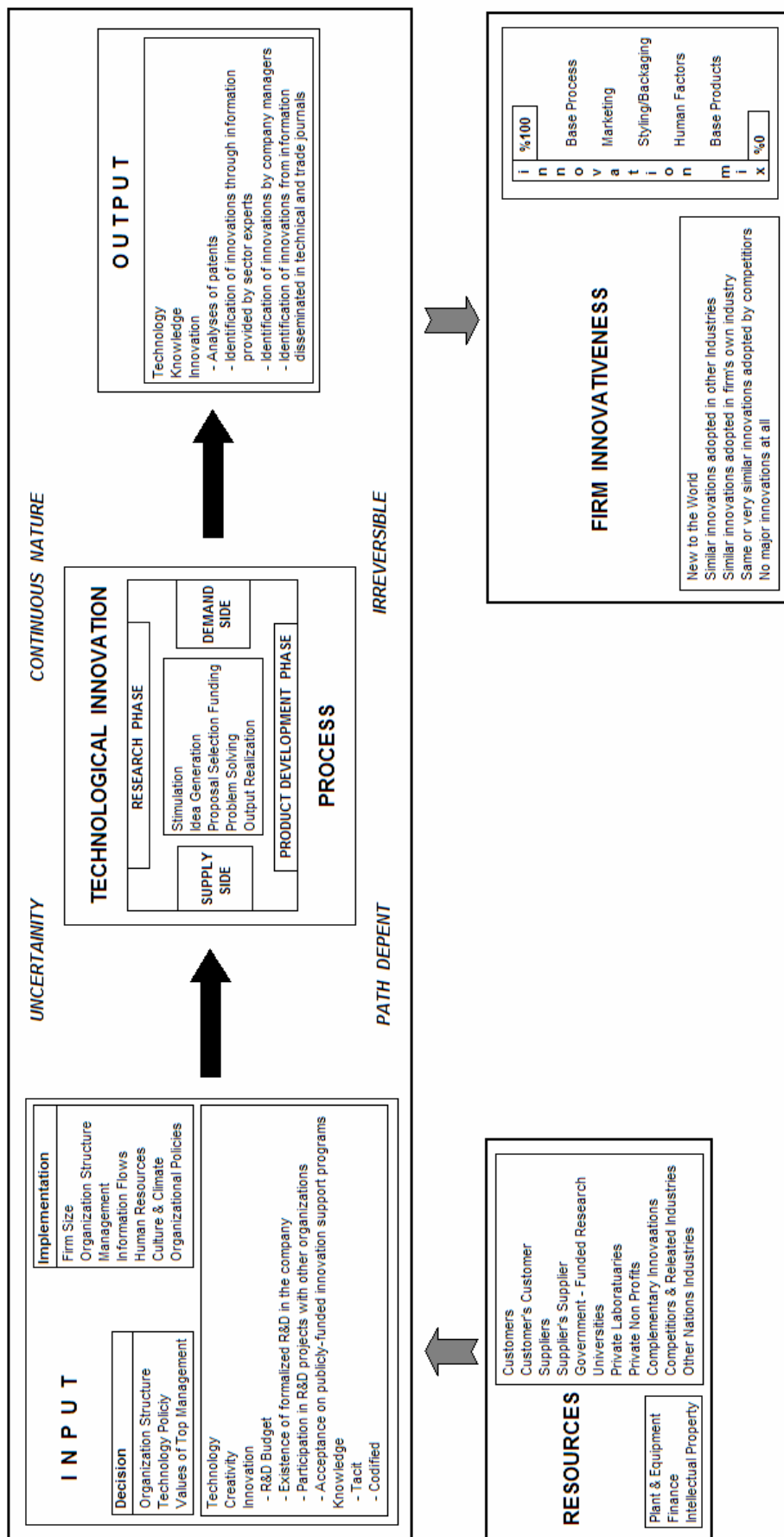


Figure 1. A System Model of Technological Innovation

Developed from Brown and Karagozlu 1989, Butler 1988, Flor and Oltra 2004, Fritsch and Lukas 2001, Gaynor 1996, Hall and Martin 2005, Hollenstein 2003, Kampas 2003, Nieto 2004, Ali 1994, Xu et al. 1998, Prasad and Rubenstein 1992

Resources

The resources that have an impact on the process of technological innovation may be divided into two groups: those originating from within the company and those that come from outside. Similarly in addition to the resources that are specific to the process, there are also resources that have an indirect impact on it.

Contemporary frameworks for evaluating technological innovations contend that innovative success is dependent upon the ability of firms to acquire and assimilate new knowledge without disrupting value chain members such as suppliers, customers and complementary innovators (Hall, Martin, 2005; 273).

Output

The outcomes of the process of technological innovation are information and innovation. At the same time, these three concepts serving as inputs for the process also make up the infrastructure of the business. The technologies that are the fundamental output impact firm strategies at three levels: products, processes, and administrative/support activities (Bond and Houston 2003, 122). The output of the technological innovation process should be an input to the system as feedback providing a base for forthcoming innovations.

Firm Innovativeness

The outcome of the innovative process that a business creates with the innovative capacities that it possesses is that business's general innovative index. The innovations that companies come up with can be grouped into five separate categories (Romijn and Albaladejo, 2002);

- New to the world
- Similar innovations adopted in other industries
- Similar innovations adopted in firm's own industry but its innovations differ in identifiable ways from other companies' innovations
- Same or very similar innovations adopted by competitors
- No major innovations at all

Decisions which are based on described resources, knowledge and technology, implemented by means of organizational variables will affect on the different categories of innovations.

CONCLUSION

Numerous efforts have been made over the years to present definitions and conceptual explanations on the subjects of innovation, technology, and technological innovativeness by means of a variety of approaches and models.

In this study, an attempt has been made to define the variables involved by taking up the concept of technological innovativeness within a systematic structure. The approach taken is a general system approach that is firm-based.

Because this model is theoretical, the variables need to be tested. In the future, with quantitative and qualitative studies this model can test and new variables may add on this model. It will be beneficial to also consider the process of technological innovation on the more micro and macro levels and on a sectoral basis as well.

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