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A MODEL OF TECHNOLOGICAL INNOVATION PROCESS

Cosmin-Mihai Nacu
"Gheorghe Asachi" Technical University of Iasi, Romania
cnacu@tex.tuiasi.ro

Silvia Avasilcai
"Gheorghe Asachi" Technical University of Iasi, Romania
silvia.avasilcai@gmail.com

Abstract:
Entrepreneurship is the new driver of modern economy. One of the most important types of entrepreneurship is the technological one, and we know that, because we are partakers of the great technological era. Technological entrepreneurship is seen as a process by some researchers, and one of the most important factors that is influencing technological entrepreneurship process from technological firms is innovation. Analysing the most relevant models of innovation process, the author proposes a conceptual model of technological innovation, a model that can be applied into technological entrepreneurship ventures.

Keywords: entrepreneurship, innovation, technological firm, business venture

1. INTRODUCTION

In the literature review, technological entrepreneurship is found under several appellations, like: “technological entrepreneurship” (Abetti, 1992, pp. 129-139), “technology entrepreneurship” (Pathak, Xavier-Oliveira & Laplume, 2013, pp. 2090-2101), “techno-entrepreneurship” (Therin, 2007), “technopreneurship” (Kamarudin & Sajilan, 2013, pp. 1-37) and “technical entrepreneurship” (Berry, 1996, pp. 487-498), the most common of them being the first two.

Technological entrepreneurship is defined as a process through which are created new opportunities [6], or as an ample process that is built based on the effort of many (Mezias & Kuperman, 2000, pp. 2090-2101), or as a process that implies the identification of high potential, of commercial opportunities based on technology, on gathering the necessary resources (Byers, Dorf & Nelson, 2005).

Another point of view from which technological entrepreneurship is seen as a process belongs to Shane and Venkataraman (Shane & Venkataraman, 2003, pp. 181-184), who are saying that this concept is a process through which entrepreneurs are putting together organizational resources, technical or technological systems and necessary strategies used by entrepreneurial firms to follow opportunities.

2. THE LINK BETWEEN ENTREPRENEURSHIP AND INNOVATION

Technological entrepreneurship is a concept closely related to the concept of innovation and represents a process through which innovations are valued; also represents a method that identifies market opportunities, a system composed of synergic elements that are exploiting the novelty and transform it into new sources that generates profit, raises the employment rate and the economic wealth. This affirmation is sustained by the theories of Schumpeter and Drucker.

The Schumpeterian theory says that the entrepreneur represents innovation, not imitation, he doesn’t care very much about profit, the most important for him is that he is innovator and he can improve the society that lives in. Also, Schumpeter affirms that the entrepreneurs were getting economic system out of his static equilibrium by creating new products and new production methods, which is in fact his famous process of “creative destruction”, identified as the economic development engine (Schumpeter, 1911).

The Drucker’s theory says that entrepreneurs from less developed countries are hardly ever realizing entirely new products, they prefer to imitate the products or processes invented in other countries and implement them in their countries. Although slightly contradictory to Schumpeter’s words, Drucker says that entrepreneurship is like a process of “creative imitation” (Drucker, 1985).

Zhang, Peng and Li are also saying that innovation is one of the most important and efficient factors on the technological entrepreneurship process (Zhang, Peng & Li, 2008, pp. 733-751).

3. MODELS OF INNOVATION PROCESS

3.1. Rothwell’s innovation models

In order to understand how innovation activities are conducted, there were many attempts to impose a certain conceptual order in the innovation process analysis. In this regard, various models of innovation process have been developed, to be possible to order our thinking on innovation.
The models of innovation process have been divided into phases or stages, which refers to fundamental research, to new scientific discoveries, applied research in which scientific discoveries are transformed into practical development of new products, processes and services. Following production processes, new innovative scientific and technical achievements are converted into tradable goods.

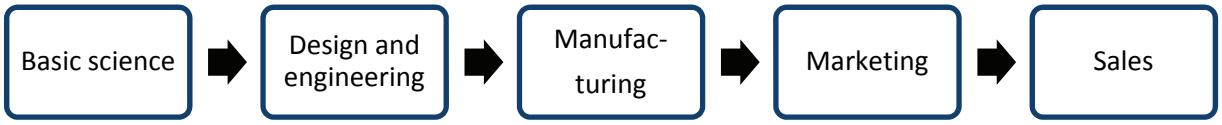
Roy Rothwell provided a historical perspective of the innovation process, suggesting that the views of the nature of innovation process evolved from a linear model, in ’50s and ’60s, to complex and integrated models of ’80s –’90s. Innovation models are detailing relationships and information flows

between departments of industrial companies in relationship with customer (Rothwell, 1992, pp. 221–239 and Rothwell, 1994).

Rothwell identified five generations of innovation models, which shows the stages of evolution of economic reality and economic thinking of the scientists' community.

The first generation of linear models occurred between the '50s and '60s and was named "Linear model of innovation". This models were represented by "technology push" models or "innovation pushed by technology". The technological innovations are arising on the spur of research and development: innovation process begins with a discovery or a fundamental research, goes through an invention, which is then exploited by manufacturing and production activities and is ending with marketing and selling new innovative product or new innovative process that are "pushed" to the market. (Figure 1)

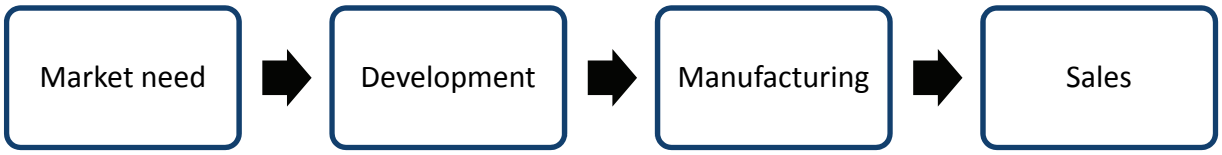
Figure 1: Technology push model



Source: Rothwell, 1992, pp. 221–239

In this approach, the innovation process consists of sequential steps, conceptually and temporally distinct, characterized by unidirectional relationships, without feedback.
The second generation of linear models occurred between the '60s and '70s, being called "market pull". In these models, innovations stem from a perceived market requirement that influence the direction and rate of technological development and research and development (R&D) has only a reactive role in the innovation process. The orientation of entire innovation process takes place to meet customer's demands. (Figure 2)

Figure 2: Market pull model



Source: Rothwell, 1992, pp. 221–239

The third generation of linear models is the so-called "coupling" innovation process, which can be considered as a combination of "technology push" and "market pull" models. This model is centred on an interactive process with emphasis on the effects of feedback between market and research phases of previous linear models.

The "coupling" innovation process is logically sequential, though not necessarily continuous and it can be divided into interrelated phases functionally distinct, but that interacts through feedback to previous stage. The model suggests that suppliers and customers need to be tightly "coupled" in integrated teams of product development.

The fourth generation of linear models, created in the '80s –'90s, were called functionally integrated models of innovation processes, characterized by product integration and development simultaneously, instead of sequential manner of involvement of company departments that are responsible for the design and development of new products. These models are based mainly on product development methods used by Japanese automotive industries and electrical products (Galanakis, 2006, pp. 1222–1232).

The fifth generation of linear models, emerged in the 1990s, are the processes of systems integration and network innovation, with the acronym SIN. These models are based on a more general integration of systems and organizations, on the formation of collaborative networks of innovative "actors"

innovators, comprised of key suppliers, customers, other industrial companies, universities, communities which includes firms and not only, in order to take advantage of technologies combination and solve problems of great complexity of new products.

The linear models are giving also some sources of product ideas, like basic science from “technology push” model, or market need from “market pull” model.

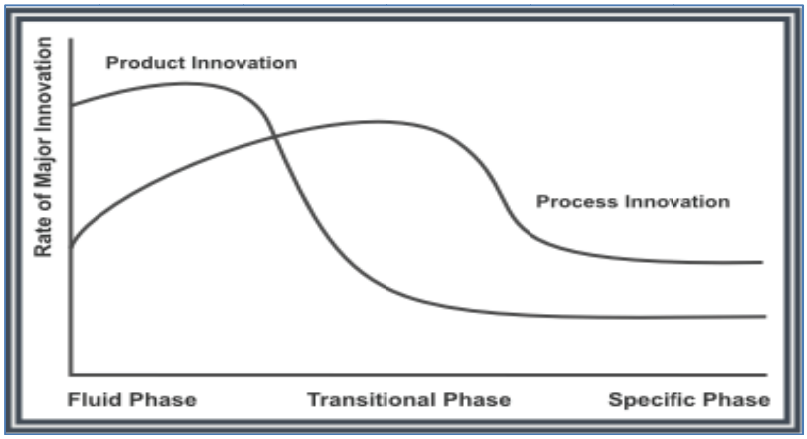
3.2. Abernathy-Utterback model

In this dynamic model of product and process innovation (Figure 3) is considered predominant product innovations in the early stages of the innovation process, while process innovations are flexible and firm seeks to gain competitive advantage by maximizing product performance (Utterback & Abernathy, 1975, pp. 639-656).

As time passes, the focus moves on variations of competitive products and the production process becomes more rigid, with the formation of "islands of automation".

Now predominant process innovations, necessity of increasing production volume. In the third stage, the predominant product innovations and incremental process, because competition is focused on minimizing costs. Abernathy-Utterback model is not applicable in all industries, but especially suitable for automotive, electronic, mechanical, chemical.

Figure3: Abernathy-Utterback model



Source: Utterback and Abernathy, 1992, pp. 221–239

In order to understand how innovation activities are conducted, there were many attempts to impose a certain

3.3. Stage-gates model

To realize new products were developed stage-gate process systems (Cooper, 1990, pp. 44-54). Stage-gate (Figure 4) processes are successful in industries and areas dominated by "market-pull" innovations.

Figure 4: Stage-gate mode

Source: Cooper, 1992, pp. 221–239

This kind of model gives the need of a condition to be satisfied before every stage.

3.4. Van de Ven model

Professor Andrew H. Van de Ven and his colleagues have developed a general model of innovation processes, based on the following:

- Innovation development takes place in a regular progression of stages or phases, or in a random sequence of probable events;
- Innovative behaviour is unpredictable and involves a random or multiple variables mechanism;
- The development of innovation converge to a final result that is somewhat different from the initial condition;
- The journey of innovation occurs predictably.

The authors of this model consider that innovation is an iterative process, convergent and divergent, thus generating innovation projects have a linear map from baseline to the end, but partial results are precursors for new ideas. Innovation means addressing the unknown, unforeseen events, ambiguous goals, so it is inherently a chaotic process. So this model comprises three stages: initiation, development and implementation or completion.

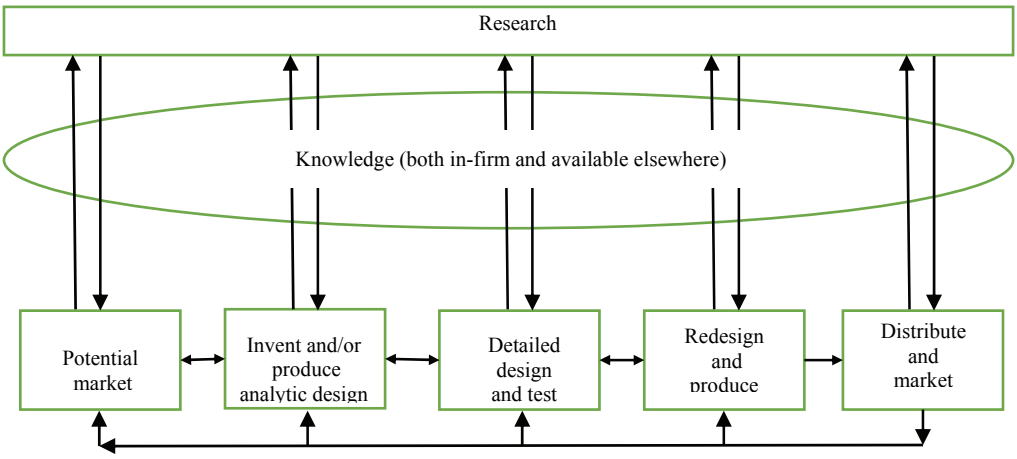
3.5. Chain-linked model

Interactive models differ substantially from the linear ones, they are an alternative to them, being more precise in describing the complex relationships within innovation processes. In the category of interactive models is chain-linked model (Figure 5) (Kline & Rosenberg, 1986, pp. 275-305). According to this model, innovation arises from the interaction of companies' market opportunities and technological opportunities.

The chain links is based on the perception of market opportunities and/or inventions, that are followed by an analytical project, for a new product or process, designed to meet the market's requirements. In the next stage, the actual development of innovation occurs through a detailed design and testing, after which they complete volume production, and finally, marketing and distribution to accelerate sales.

There isn't a simple one-way progression from one stage to the next, this model involves feedback loops between the steps of the innovative process.

Figure 5: Chain-linked model



Source: Kline and Rosenberg, 1992, pp. 221–239

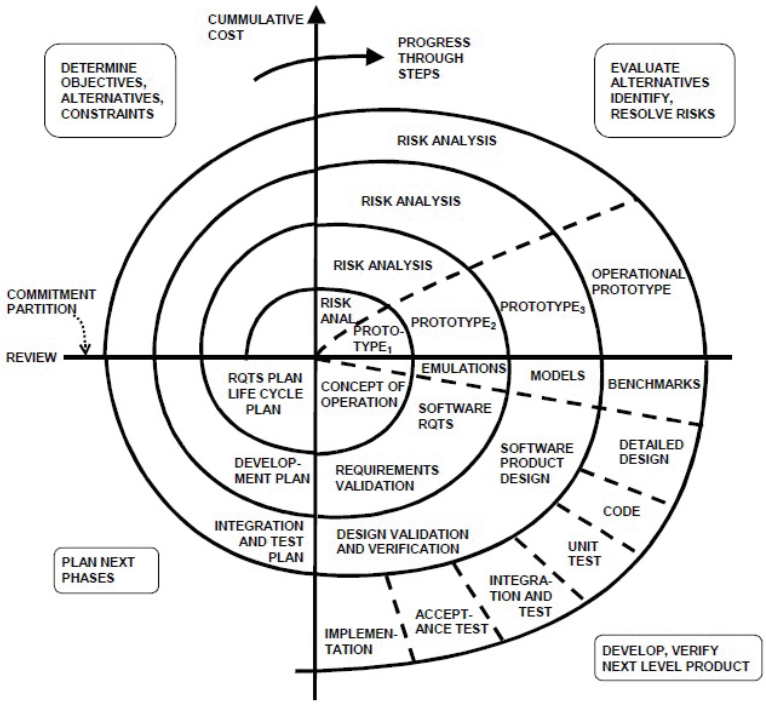
3.6. The spiral model

The spiral innovation model (Figure 6) is designing product development as a spiral representation, where each loop is a phase of the process (Boehm, 2000). Spiral development process is convenient

for software development, this process works easily with emergent properties and partial solutions software, such as interfaces, algorithms or alternative sequences of events.

The principle of spiral development is an evolutionary model for systems development. This model combines the iterative nature of prototyping with systematic approach of process phases. Each phase of the development process ends with risk assessment and building a prototype is a working version of the software. Complete and final version of the product will be produced only after an appropriate number of iterations. Each prototype is used to determine whether the project should be continued, stopped or regressed at earlier stages.

Figure 6: The spiral model



Source: Boehm 2000

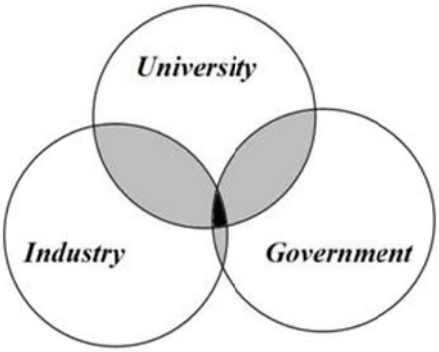
3.7. Triple helix model

The “triple helix” model (Figure 7) of university-industry-government relations is a neo-evolutionary model of the innovation process, it is a model for the analysis of innovation in a knowledge-based economy.

“Triple helix” (Etzkowitz, 2002) is an innovation spiral model that describes multiple mutual relations in different points of the accumulation of knowledge process.

The triple helix is characterized by three dimensions. The first dimension is the internal transformation in each helix, such as the development of lateral connections between companies through strategic alliances or assumption by some universities to economic development mission. The second dimension is the mutual interactions of a propeller influence over another. The third dimension is creating a new overlay of trilateral networks and organizations, the interaction of the three propeller, made in order to reach new ideas and formats for the development of “high-tech”.

Figure 7: Triple helix model



Source: Etzkowitz, 2002

4. METHODOLOGY, RESULTS AND CONCLUSIONS

The research methodology is based on comparative analysis between the upper presented models.

Fligure 8: Summary results from comparative analysis of the innovation process models

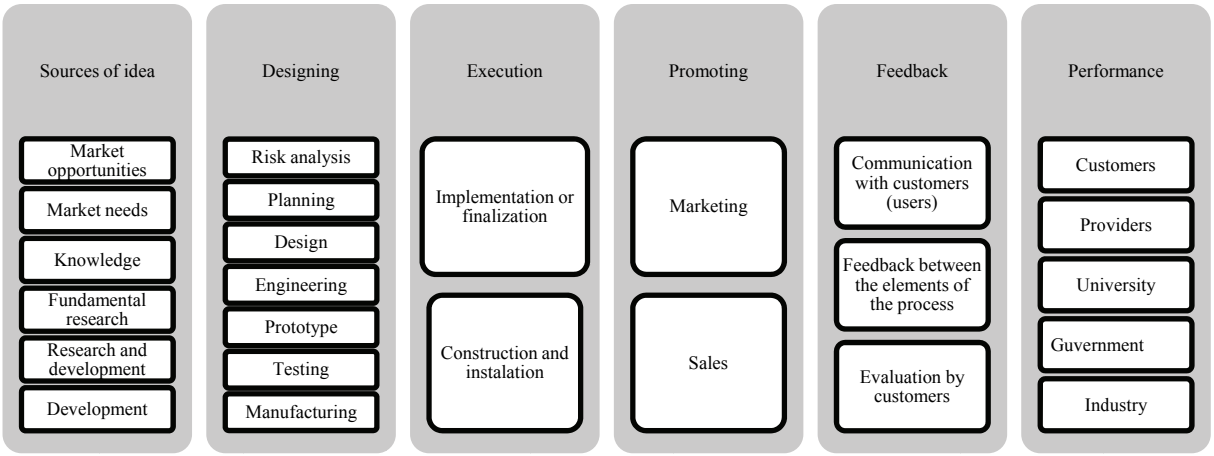
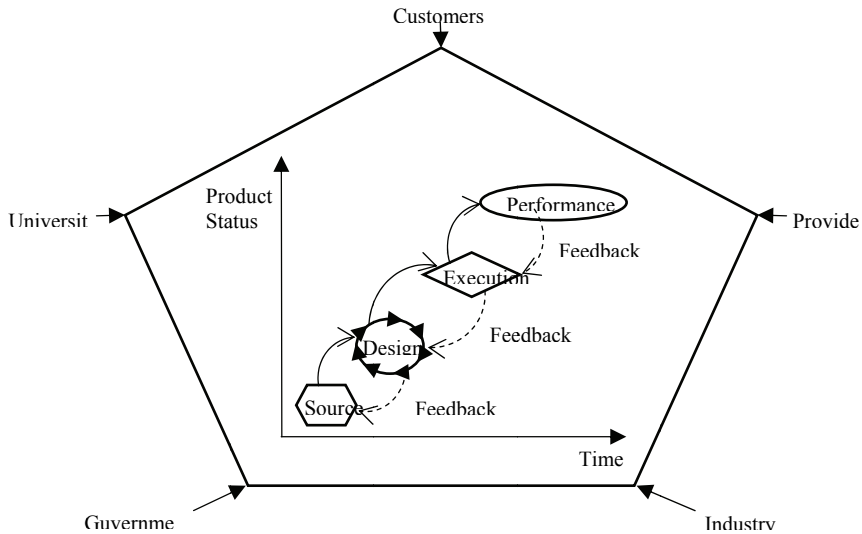


Figure 9: Geometric model of the technological innovation process



From each model is extracted every component, is analyzed and from this analysis results new categories (Figure 8) of elements that define technological innovation process.

The grouping of elements from Fig. 5 is performed according to the sequence of steps for realizing a given product and according to the factors involved in this process.

The comparative analysis and this grouping of elements leads to a proposed model of the innovation process, which can be applied in any field (Figure 9).

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