

Technological innovation**Innovación tecnológica**

GALICIA, Ricardo†

*Universidad Iberoamericana, Prolongación Paseo de la Reforma 880, Alvaro Obregon, Lomas De Santa Fe, 01219. Mexico City, Mexico.*ID 1st Author: *Ricardo, Galicia*

DOI: 10.35429/JPE.2021.9.5.4.12

Received July 15, 2021; Accepted December 30, 2021

Abstract

Technological innovation occurs when technology is used as a means to introduce change. The process of technological innovation is essentially continuous nature. The essence of the process of technological innovation is the accumulation of knowledge over time. The assumption that the innovation process is subject to historical conditions plays a central role in the evolutionary approach and represents the fact that the evolution of a technology depends critically on the path it has followed in the past. The technological innovation process is partially irreversible. The development of technology in the context of a particular technological trajectory, generates new knowledge through a series of feedback mechanisms that improve their performance. These mechanisms strengthen this dominant technology over other alternative technologies with which it competes. The technological innovation process is affected by different types of uncertainty. Reflects the ignorance that has a priori what is the solution of the technical problem to be solved and if, indeed, you can find within the time and cost projections: What is the best technical solution is feasible?, will it work?

Technological innovation, Development of technology, Technological trajectory

Resumen

La innovación tecnológica se produce cuando se utiliza la tecnología como medio para introducir cambios. El proceso de innovación tecnológica es esencialmente de naturaleza continua. La esencia del proceso de innovación tecnológica es la acumulación de conocimientos a lo largo del tiempo. El supuesto de que el proceso de innovación está sujeto a condiciones históricas desempeña un papel central en el enfoque evolutivo y representa el hecho de que la evolución de una tecnología depende críticamente del camino que ha seguido en el pasado. El proceso de innovación tecnológica es parcialmente irreversible. El desarrollo de la tecnología en el contexto de una determinada trayectoria tecnológica, genera nuevos conocimientos a través de una serie de mecanismos de retroalimentación que mejoran su rendimiento. Estos mecanismos refuerzan esta tecnología dominante frente a otras tecnologías alternativas con las que compete. El proceso de innovación tecnológica se ve afectado por diferentes tipos de incertidumbre. Refleja el desconocimiento que se tiene a priori de cuál es la solución del problema técnico a resolver y si, efectivamente, se puede encontrar dentro de las previsiones de tiempo y coste: ¿Cuál es la mejor solución técnica es factible?, ¿funcionará?

Innovación tecnológica, Desarrollo tecnológico, Trayectoria tecnológica

Citation: GALICIA, Ricardo. Technological innovation. Journal-Public Economy. 2021. 5-9:4-12.

† Researcher contributing as first author

Introduction

Innovation is a process of turning a creative idea into a solution to a problem or a need, innovation can be realized through improvements and not just the creation of something completely new. New can mean in this sense a real world novelty or a subjective novelty from the perspective of a single company or a single worker. A number of categories of innovation are currently distinguished. Some of the relevant thematic areas are mentioned here:

- Technical innovation.
- Service innovation.
- Innovation of business models.
- Design innovation.
- Social innovation.

Innovations can be distinguished according to the form of their emergence:

- Closed Innovation, where innovators are found only within an organization.
- Open Innovation, where organizations in an increasingly diversified world with internationally dispersed knowledge can no longer rely solely on their own innovative strength, but are increasingly dependent on the integration and utilization of external information and competencies).

To streamline the entire innovation management process in the company, a series of software tools have been developed to simplify this process:

- Technology watch tools: they help the company or organization that uses them to know the latest technological trends in their field.
- Patent management tools: help to keep an inventory of all patents being worked on or acquired by the company.
- Idea management tools: they allow the collection and subsequent management of ideas from customers and company employees to turn them into innovation.

- Knowledge management tools: document the internal knowledge of companies, so that it can then be studied and applied to new business and/or product ideas. In some cases these tools focus on documenting the capabilities of internal employees and external consultants.
- In recent years, the management of technological innovation has become one of the most attractive and promising areas of study in business management.

Innovation characteristics

Most entrepreneurial efforts bring some novelty or innovation in their product or service. Customers adopt innovations depending on their perception of the advantages and risks they see in them. An innovation can be a product, a process, an idea, a new service that is perceived as something new, a new way of doing things, among potential buyers. An innovation presents a potential user with a new alternative to solve a problem, but it also represents the uncertainty of whether it will be better or worse than the existing solution.

Innovations are not always adopted quickly

- Some innovative ideas can take many years to spread and be adopted by consumers. The diffusion of an innovation depends on consumers' perception of five characteristics:
 - Relative advantage - the perceived superiority of an innovation compared to an existing product or solution. This advantage can be of an economic or efficiency nature.
 - Compatibility - how well the innovation fits with a potential buyer's existing values, systems and practices.
 - Complexity - how the innovation is perceived in terms of difficulty to understand or use. The more difficult it is perceived to be, the slower its adoption will be.
 - Experimentation - how much a potential buyer can experiment with the innovation before adopting it. The more you can experiment and test, the faster it will be adopted in the marketplace.

- Visibility - how visible the innovation and its benefits are to potential buyers. The greater the visibility, the greater the adoption.

Key elements of innovation and technology management

The concepts of management and innovation are closely related, Luhmann (1997 p. 89) suggests that innovation is -...a counter-inductive decision process, a decision process that decides differently from what was expected and thus, changes expectations, which, associated with the definition of management that Albomaz and Fernandez (1997) previously pointed out, denote an interest in changing paradigms in action. Lundvall (1992) suggests that innovation management could then have two denotations:

1. Disciplinary area that in specific regions, has as its object the study of strategies, conditions and systems for managing resources and opportunities that allow stimulating creativity, promoting it, linking it with the environment and introducing the results to the dynamics of organizations with rationality and effectiveness.
2. A series of activities carried out by a manager or specialized team of managers, aimed at accelerating the transformation of ideas into innovations, linking at all times sufficient stakeholders in a regional framework and seeking that such innovations provide satisfaction to each participant without generating conflict in the variables of environment, public opinion, institutional, commercial, consumer and regulatory interests.

Innovation models and processes

The perceived model of the innovation process and its practice have evolved, and these changes are summarized in the five generations (Rothwell, 1994). First generation. Technology push. From 1950 to the second half of the 1960s, the dominant model of innovation was the so-called technology-push. It is a linear model that assumes an orderly progression from technological discovery, through applied research, technological development and production activities, to conclude in new products to the market.

Second generation. The pull of necessity or the market. Third generation. Linkage model.

Fourth generation. Integrated model. Although the third generation model of the innovation process contained feedback loops, it remained essentially sequential. The fourth generation model is characterized by being parallel but integrated,

Fifth generation. Integration of systems and networks. It consists of the use of sophisticated electronic tools that increase the speed and efficiency of product development throughout the entire innovation system, i.e. inside the firm, but also outside, suppliers, customers and partners, essentially the fifth generation of the innovation process is the fourth generation but with a new technology of technological change to increase the speed and efficiency of innovation.

Miller and Morris (1999, pp.281 and 282) propose an innovation process consisting of four phases:

Phase 1. It is the transformation of the initial idea into the conceptual definition of the family of applications, driven by the technology, products, services or distribution platform, or the combination of platforms.

Phase 2. The improvement community takes responsibility for the project. The objective is the definition of a validated dominant design for new platforms or new platforms for existing dominant designs.

Phase 3. Development of new products, services, distribution families and method development.

Phase 4. Development of market activities for a product family, specifically for new products, services and processes.

Another innovation model is the one proposed by Utterback (2001) which has an engineering approach where technological and economic factors determine the feasibility of innovation. He proposes a model for the innovation process consisting of six stages:

1. Initiation of the process. The stock of existing technological knowledge, i.e. the state of the art, suggests the possibility of an innovation capable of satisfying a present need of society. Or this need provokes the search for the knowledge and technologies that allow us to achieve an innovation with which the detected need is eliminated.
2. Formulation of the idea. A pre-design is made and submitted for evaluation. This is a fundamentally creative stage, in which it is essential to recognize both the technical and economic feasibility of the future innovation. The evaluation of the cost of the process is of great importance, since the company will have to commit the necessary resources for the development of the subsequent stages.
3. Formulation of the problem. Sometimes the information is available to solve the problem immediately. On other occasions the information has to be obtained through research and development activities. At this stage, unforeseen problems arise and new solutions appear that need to be evaluated and decided upon. Sometimes the difficulties that arise cannot be solved, and the process has to be suspended temporarily or permanently.
4. Problem solution. This can be original, in which case we find ourselves with an invention that will increase the stock of available technological processes. Or it can solve the problem by adapting an existing invention, in which case it is an imitative invention.
5. Refinement and development. During this stage, prototypes or small quantities are manufactured according to the planned specifications. The necessary tests and technical evaluations are carried out to determine the possibilities of manufacturing or use of the new product or process.
6. Use and diffusion. Innovation does not take place until the product, whether a good or a service, has been introduced or the process has been applied for the first time in the market, at which point diffusion begins.

The culture of innovation

Like people, companies have a personality that distinguishes them from one another and gives them their own identity. At the organizational level it is known as organizational culture and can be defined as a set of meanings, ideas, values, beliefs, behaviors and concepts shared by its members that determine their behavior. Beliefs and other elements of culture inhibit or encourage development, that is, they hinder or support a person, an organization or a people to grow, progress and develop. Changing what exists in order to feel better is the result of a culture that implies modifying beliefs, practices, behaviors and processes. Different studies (Banegas, 1999; Garcia, 1999, Angel, 2006) on the subject define characteristics of a culture of innovation, among which we find: greater creativity, ubiquitous and permanent education, cultural mosaic, passion applied to a project, development of trust, social recognition, incentives, risk acceptance, anticipation of needs, project control, acceptance of change, etc. Innovation for innovation's sake is meaningless, its product does not measure its social, legal, ecological impact and is not coherent with people, organizations and peoples; a culture of innovation that does not measure and control the consequences is not ethical.

He points out that innovative culture is not merely legal or economic institutions. It has a deep social background that needs to be stirred up and promoted and that requires continuity and vehemence.

The sources of innovation

Peter Drucker (2002) explains in -The Discipline of Innovation a number of sources that can give rise to an innovation process, four of them within a company or industry:

1. Surprise: the unexpected success or failure, the unexpected event produced externally, but within the immediate environment.
2. Inconsistencies or dissonances: Observing in depth the reality of what customers and society need is an infallible source of innovation.
3. The needs in the internal processes of the company and the presence of weak steps in the same.

4. Changes in markets as a result of product life cycles and rapidly changing customer needs.

Add three additional sources of opportunity outside a company, in its social and intellectual environment:

1. Changes in the values and perceptions of individuals and society.
2. Changes in demographics: This is one of the most important changes, the results of which will affect societies, the economy and business.
3. New knowledge and new technologies, which affect most of the processes of industrial service and agricultural companies.

Strategic management of technology. The problem addressed by innovation management is clear. In order to remain in the marketplace, the company requires that its offer and the way it is created and supplied remain in a continuous state of change and, in order to do so, the company must:

- Monitoring the environment for signs of the need to innovate and potential opportunities that may arise for the company. Its purpose is to prepare the organization to face the changes that may affect it in the more or less near future and thus achieve its adaptation.
- Focus attention and efforts on a specific strategy to improve the business, or to provide a specific solution to a problem. Even the best-resourced organizations cannot consider covering all the innovation opportunities offered by the environment, and must select those that can contribute most to maintaining and improving their competitiveness in the market.
- Train the chosen strategy by dedicating the necessary resources to implement it. This training may involve simply purchasing a technology outright, exploiting the results of existing research, or conducting a costly search for appropriate resources.

- To implement the innovation, starting from the idea and following the different phases of its development until its final launch as a new product or service in the market, or as a new process or method within the organization.
- Learning from experience, which implies reflecting on previous elements and reviewing experiences of both success and failure. In this sense, it is necessary to have an evaluation system that feeds and ensures continuous improvement in the process of technological change itself.

Technological innovation process

The process of technological innovation is a process that encompasses the spectrum of activities that begins with the search for technological needs of organizations in the productive sector and extends to the commercialization, in the market of these organizations, of products, processes, equipment, etc., derived from research and development (R&D) efforts or other mechanisms.

In this way, the realization of technological innovations, among other conditions:

- It involves satisfying the demands of the productive sector, through the use of technical changes that, when placed in the market, produce economic and social consequences.
- It does not necessarily imply the execution of SDI projects. The generation of technical changes may be essentially based on technical information available in the literature, technical standards, patents, etc., or on the purchase of technology produced by third parties (innovation by Adoption).
- Necessarily requires the context of productive sector organizations that incorporate technical changes into their production systems and attribute economic and/or social significance to them.

Thus, for research and development projects to have economic/social consequences, they need to be linked to specific technological needs of existing organizations in the productive sector.

The correlation between technological functions, the different technological innovation alternatives and the development planning of productive sector organizations is discussed, under the concept that this development depends on specific innovation strategies which, in turn, are influenced by national policies and strategies.

According to Donald G. Marquis' study, there are three types of innovations:

Innovations that refer to the management of complex systems where technological change is present in the foreground. Example: space projects, defense projects, etc. It is characterized by the existence of long-term planning.

Radical (leapfrog) innovations are those that represent the most radical technological development and cause changes in the industry. Examples: the B.O.F. converter. (Basic Oxygen Furnace), xerography, etc. They originate from the application of gradual innovations from other sectors or areas of activity or from the application of new scientific knowledge, generated from basic research projects and require significant investments.

Incremental innovations are those that are essential to the survival of the company and derive from improvements that do not substantially change existing products, processes or equipment or from development that may involve development or research efforts. Development and engineering. This type of innovation is more involved as an economic factor than the other two innovations.

Innovation is not the product of a single action, rather it is the integration of several interrelated processes, such as the conception of an idea, the invention of a new item, the development of a new market, etc. Innovation can be developed from conception to implementation by a single organization. But it is often deduced from contributions from outside sources, made in other places and at different times.

The process model considers technology and the market as sources of initiation and supply, dividing it into different stages and events. These events may or may not be linear. The innovation process starts with a new idea, which includes the stage of recognition of the technical possibility and potential.

The innovator must have an updated knowledge of the state of the art and technical knowledge to support their estimates of technical feasibility. They must also be up to date with social and economic demands in order to be able to recognize a demand and differentiate it by determining whether it is potential or real.

Determining demand is important

The next stage is the formulation of the idea, which consists of the association and fusion of the concepts of the satisfied demand and the technical possibility, this fusion of knowledge gives rise to the design concept. This is a true creative act in which the association of both elements is essential. The idea or design concept is merely the identification and formulation of a problem in order to make a decision. If this is favorable and funds are allocated, the stage of the search for information for the solution of the problem posed is entered. If the problem-solving activity is carried out, a solution should be found.

The solution to the problem may be the verification of the initially stated problem.

Innovation management support tools

It is useful to know some of the most common innovation management tools or practices. Table 1 shows how certain tools can help in the management of the key elements of the innovation process, and for their use they can be combined in various ways and, since some of them have a dual or multiple purpose, it is not necessary to apply all of them.

Thus, for example, teamwork can solve many of the problems of interface management and good project evaluation will benefit portfolio management. These tools are not an end in themselves, nor are they chosen to be applied in isolation, but are intended to become an integral part of innovation management.

In principle, all the tools identified can be applied to any type of company, and it is mainly up to the management to adapt and adjust them to the particular needs and characteristics of each company.

Tools	Watch	Focus	Train	Implement	Learn
Market analysis	X	X		X	x
Technological perspective	X	X			
Benchmarking	X	x			x
Patent analysis	X	X			
Audits	x	X			x
Portfolio management		X			x
Project evaluation		X	x		x
Creativity	x	X	X	X	x
Management of intellectual and industrial property rights			X		
Interface management			X	X	
Project management			X	X	
Networking	x	X	X	X	x
Team operation		X	X	X	x
Change management				X	
Adjusted operation		X		X	x
Value analysis		X		X	
Continuous improvement				X	X
Environmental assessment	x	x			X
X Tool fully applicable at this stage x Tool with potential application at this stage					

Table 3

Source: COTEC Foundation (Ed. 2001). *Book Innovación Tecnológica: Ideas Básicas*.
http://www.uca.es/recursos/doc/Unidades/consejo_social/1801800_1032010103532.pdf

IT stands for innovation and transformation

It's no secret that the IT professional has one of the toughest jobs in the technology industry. In today's mobile-first, cloud-first world, they are responsible for managing the tensions between public and private cloud, device pervasiveness and traditional management, and balancing data access with data protection.

Every IT professional faces these challenges and, as a result, it is understandable why these unsung heroes are often unsure about their future. As every organization in the world becomes increasingly reliant on software and technology, CIOs and IT professionals can drive business strategy and transformation.

They can help their companies launch new business capabilities with the cloud, intelligently leverage and use data to improve productivity across devices. IT can help very good companies become great companies.

Reasons for innovation failure

In market economies, innovation and investment are closely related, because it is not only that a potentially profitable innovation stimulates investment, but also that a high level of investment tends to stimulate innovation in order to take advantage of the latest technological advances. The main impetus for successful innovation comes from the market, from an existing or potential demand:

- Market factors.
- Administration.
- Capital.
- Regulations.
- Technology.
- Other aspects.

The main barriers to the innovation process are the following:

- Bureaucracy.
- Communication problems.
- Poor project formulation.
- Problems in technology transfer.
- Risk aversion (by tradition and custom).
- Absence of technology executives and managers.
- Poor relationship with and knowledge of the market.
- Lack of timely and adequate financing.
- Structure of the industrial sector.
- Lack of or inadequate management of critical roles.

Proposal for the process of successful innovations in Mexico

The development of a proper process for successful innovations requires the observation and analysis of existing information, and it is here where it should be pointed out that:

GALICIA, Ricardo. Technological innovation. Journal-Public Economy. 2021

1. The fundamental innovation process is the one presented by Marquis and, depending on the particular conditions of each organization, the process must be adapted.
2. The innovation process is independent of geographical location; however, its most important constraint is the organizational system itself and its culture, since it will be these that promote innovative responses to the problems presented by the environment.
3. In our country the conditions for innovations are, as in the rest of the world, more propitious to the pull of the market and of these the gradual ones. Among other things, due to the size of the national market and the size of the organizations we have; without this meaning that we are exempt from radical innovations or the push of technology.
4. The fundamental condition is an administrative system with an orientation towards the client, innovations and their assimilation in the organization that allows the generation of new knowledge.

From the above it is to consider the need for the environment to help satisfy:

- The establishment of processes for organizational diagnoses, where existing technological capabilities are taken into account.
- The promotion and dissemination of endogenous knowledge, that is, knowledge developed within the organizations.

On the part of the organizations, it is necessary:

- Establish processes that help monitor the environment in both market (pull) and technological system (push) elements.
- Develop strategic alliances with systems external to the organizations themselves (colleges and universities) to assist in the development of innovative solutions.

- Development and establishment of quality programs, as these are largely responsible for continuous improvement or incremental innovation.

Conclusions

Innovation in our days is the starting point for companies and IT leaders to create value and when we talk about value I mean being a differentiator for our customers and users. Ideas to make the world more accessible, with opportunities for all, more open, digital and mobile, better connected, faster, secure, efficient, sustainable, intelligent, where innovation is the engine towards more advanced technology companies that help improve our society. But technological innovation is a conviction of the shareholders of the companies, it is dictated in the policies and embodied in the corporate strategy aligning the efforts of the entire company and the partners and stakeholders:

- Clients.
- Suppliers.
- Partners.
- Society.
- Universities (agreements).

And all available talent must be utilized by working in a collaborative, interdisciplinary and global network.

References

- 1) Sara Ortiz Cantú, Alvaro R. Pedroza Zapata. (2006). ¿ Que es la Gestión de la Innovación y la Tecnología (GinnT)? . Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO) , Journal Technol. Manag. Innov. Vol. 1, No.2 ISSN: 0718-272. file:///Users/martha/Downloads/315- 440-1-PB.pdf
- 2) Fundación COTEC (Ed. 2001). Innovación Tecnológica: Ideas Básicas. http://www.uca.es/recursos/doc/Unidades/consejo_social/1801800_1032010103532.pdf

- 3) Edward B. Roberts, Generating technological innovation, Technol, Management, 31 (1): 11-29, de enero-febrero 1988, Manual de Gestión en Tecnología, Mc Graw Hill, Gerard Gaynor, 1999, p.187, <http://www.tecnologiaycalidad.galeon.com/tecnologia/5.htm>
- 4) Revisat MEDISAN Dra. Nilia Victoria Escobar Yéndez . Innovación Tecnológica. http://bvs.sld.cu/revistas/san/vol4_4_00/san01400.htm
- 5) Brad Anderson, Vicepresidente Corporativo para Windows Server y System Center en Microsoft. (2015). TI representa innovación y transformación. <http://www.cioal.com/2015/05/05/ti-representa-innovacion-y-transformacion/>
- 6) Nieto Antolín Mariano. Características Dinámicas del Proceso de Innovación Tecnológica en la Empresa. Investigaciones Europeas de Dirección y Economía de la Empresa. Vol. 9, No.3, 2003, pp 111-128 ISSN:1135-2523.