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## Readings on innovation process models; from linear to open innovation

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### Abstract:

The innovation process is long, complex and engages several actors. Different factors influence the construction of this process. This article presents different models of innovation process.

The objective is to present the process of developing an innovation and highlight its specificities and risks. Several models propose to conceptualize the innovation process according to different conceptions. Each model has advantages and limits. Our literature revue is based both on old and new research works on the subject.

**Keywords:** innovation; process; concept; model; literature.

**Jel Classification Codes :**O31, O32, O36.

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### 1. Introduction:

There is an extensive literature on the concept of innovation. Innovation has evolved throughout history and is widely used in various disciplines.

Innovation is an important economic lever in the age of globalisation. It's a source of competitive advantage. Companies must seize the opportunities on their side by investing in business models that stimulate innovation (Morand & Manceau, 2009).

Innovation still a current topic, despite the fact that the concept has been around since the work of Joseph Schumpeter and then Peter Drucker in the mid-20th century. Since then, the concept has become very popular and continues to be the subject of research in various disciplines, particularly in recent years with the emergence of big data, artificial intelligence and the digital boom. There is a growing interest in innovation in recent economic literature. In recent years, a number of new areas of research have emerged around the issue of innovation, including : national and regional innovation systems (Asheim, Lawton Smith, & Oughton, 2011); (Asheim B. , 2019), business models (Chesbrough, 2003); (Vils, Mazzieri, Rodrigues, Da Silva, & de Queiroz, 2017), open innovation (West & Bogers, 2017); (Nune & Abreu, 2020), entrepreneurship (Schmitz, Urbano, Dandolini, de Souza, & Guerrero, 2017); (Lounsbury, Gehman, & Ann Glynn, 2019), eco-innovation (Díaz-García, González-Moreno, & Sáez-Martínez, 2015); (Passaro, Quinto, Scandurra, & Thomas, 2023), digital innovation and big data (Mikalef, Boura, Lekakos, & Krogstie, 2019), (Wiesböck & Hess, 2020); (Di Vaio, Palladino, Pezzi, & Kalisz, 2021); etc.

This work aims at following objectives:

- ✓ Provide a definition for the concept "innovation process".
- ✓ Describe and analyse evolution and development of innovation process over the time.
- ✓ Present the main existing models of innovation, discuss their features and constraints.

This paper presents the evolving and conceptualization of innovation process models.

#### **But what is the interest of knowing innovation process models?**

Innovation models serve as a valuable source of knowledge and provide essential support for practical activities. These models have played an important role in the transition from research-oriented policies to innovation-oriented policies in which competitiveness cluster policy is emblematic.

Innovation models allow for in-depth reflexion on national innovation policy, through the incentive to innovate but also the question of the protection and valorisation of scientific research (Forest, 2014).

This modelling, within the company, makes it possible to opt for a better mode of steering the innovation activity, but also the criteria for evaluating it (Perrin, 1999).

The objective of this article is to highlight the process of developing an innovation and to bring out its specificities. Several models propose to schematize innovation process according to different conceptions. Our objective is to present an overview of the literature concerning these models. This paper will serve as a support for researchers to learn about the state of knowledge on this subject and derives proposals for further works.

Initially, we will briefly describe the concept of innovation and its main definitions; its history and origins. After giving a definition of the concept of process, we will present the existing models of innovation process with a summary of their main strengths and limits. Finally, we discuss the different characteristics of innovation processes and their risks.

## **2. The concept of innovation:**

### **2.1. Definitions:**

According to the Petit Robert, innovate means "to introduce into an established thing something new, as yet unknown" (Ferez-Walch & Romon, 2006, p. 11).

The definitions of innovation are numerous, diverse and multidimensional. They differ according to the origin of the author or his discipline. Innovation often has different meanings and corresponds to the way economists, sociologists, psychologists, managers, etc. use it (Perrin, 2001).

For Ibn Khaldun, technical innovation is a result of the evolution of crafts and arts that allow the evolution of new needs (Ibn Khaldoun, 1377).

Referring to the definitions given above, we emphasise that there is no consensus on the concept of innovation but common sense seems to include two characteristics (Gopalakrishnan & Damanpour, A review of innovation research in economics, sociology and technology management, 1997); (Cooper J. , 1998).

First, innovation perceived as a discrete object, event and/or product or service that is characterised by novelty. Newness is defined as: that which appears for the first time, which has just appeared, i.e. ideas, practices or objects perceived as new by individuals or groups of individuals (Crois, 2017). Thus, novelty derives from its recentness a value of creation, invention and which is understood in relation to the person or group of people who consider its adaptation (Ben Hamadi & Chapelier, 2013).

Second, innovation perceived as a process: which promotes change, and which is dedicated to the creative process through the generation and translation of new ideas into a marketable product or service (Thomson, 1965); (Damanpour & Evans, 1984).

The term *innovation* has several confusingly related concepts. We summarise them in the following table:

**Table N°1: Concepts close to innovation**

Related concept	Definition
<b>Invention</b>	Invention is defined as the novelty that comes from the technical order or the application of knowledge from past research to produce new technical knowledge: new production processes, improvement of existing ones (Carayannis & al, 2013).
<b>Discovery</b>	This is that which has not only been found but also perceived as leading to a significant and sudden increase in knowledge, and which is well enough established to appear irreversible (Malinvaud, 1996, p. 929)
<b>Imitation</b>	Imitation expresses adaptation through the development of a product or process that is similar or comparable to the existing one and that has the same characteristics or functions. Imitation varies from a pure and simple copy to the development of a quasi-innovation (Benyahia-Taibi, 2011).
<b>Creativity</b>	(Amabile, 1983) defines creativity as the generation of new, original and useful ideas (Mnisri & Nagati, 2012, p. 41). It reveals thinking, i.e. a set of techniques for coming up with original ideas, while innovation expresses the action that would largely come from creativity or the exploitation of new ideas to create a new product, service or practice.
<b>Change</b>	Change is defined as an action, transformation or shift from one state to another. Innovation provides an appropriate means of producing change (minor, medium and major) at different levels of the enterprise, industry and economy. Thus, bringing about innovations requires changes on several dimensions: technological, cultural, social and political (Gopalakrishnan & Damanpour, 1997) (OCDE, 1998).

Source: prepared by the authors (Godin, 2008) proposes other conceptions of innovation.

**Table N°2: The different conceptions of innovation**

Conception	Development
<b>Innovation as a process of doing something new</b>	-Innovation as imitation -Innovation as invention -Innovation as a discovery
<b>Innovation as reflect of human capacities specific to creative activity</b>	-Innovation as imagination -Innovation as an entity -Innovation as creativity
<b>Innovation as change in all spheres of life</b>	-Innovation as cultural change - Innovation as social change; -Innovation as organisational change;

Source: adapted from Kotsemir, M., & Meissner, D. (2013). Conceptualizing the Innovation Process – Trends and outlook. Munich Personal RePEc Archive MPRA.

(Godin, 2008) has outlined the genealogical history of the category "innovation". This category has evolved over time and is one of the key features in psychology, philosophy, sociology and economics. The first idea, innovation is seen as the process of doing something new and is linked to three concepts (imitation, invention, discovery). The second idea, innovation is about novelty (stemming from human creativity). The third idea, innovation is seen as a break with the past or as creative destruction.

## 2.2. History and origins of innovation:

It is clear that the use of the concept "innovation" cannot be limited but it has given rise to many theories and reflexions in different aspects (economic sociological, anthropological and even organizational).

### 2.2.1. Economical aspect:

The Austrian author Joseph A. Schumpeter (1883-1950) was the first to highlight the concept of innovation in the economic field. Innovation is seen as a source of economic growth and leads to a change or upheaval in the economic structure. It turns out that the role of the entrepreneur is fundamental in the theory of innovation and economic dynamics.

Thus, Schumpeter proposes the expression "creative destruction" where innovation produces growth and allows the destruction and restructuring of economic activities. The creative destruction logic is at the origin of economic fluctuations or in the form of economic cycles. The innovative entrepreneur is the actor who creates a temporary monopoly situation through the execution of new combinations on the market.

### 2.2.2. Sociological aspect:

Sociological thinking considers innovation as a social action (Chapin, 1917) or a committed practice, inscribed from the outset in a given social system that "constitute so many inescapable supports of meaning and generally innovations serve to unblock desire" (Karsz, 2007, p. 406). Indeed, innovation is seen as a capacity to adopt a change or solve a problem in a creative way. Social dynamics are seen as a determining factor in the emergence and diffusion of innovation. The sociological aspect of innovation explains the social reality that emerges in the values, rules, norms that meet both the ability to promote new behaviour or attitudes (Harrison, 2012)

### 2.2.3. Anthropological aspect:

Innovation is a cultural change and unexpected use that is embedded in human behaviour such as understanding consumer behaviours, as innovation inevitably changes people's attitudes, lifestyles and practices (Godin, 2008).

### 2.2.4. Organisational aspect:

Innovation expresses the organisational and managerial field in which the exploration and exploitation of new ideas takes place within a particular institutional order or organisational context. Innovation is therefore the managerial process embedded in the development of new tasks, practices and command procedures (Bouwen & Fry, 1993).

## 3. The innovation process:

In its first conception in traditional economic analysis, the question of the genesis of innovation was not asked. Innovation is defined as the result of a choice. It is the product of the economic act (Forest, 2014).

Traditional economic analysis thus focuses on the consequences of technological change without reflecting on its origin and content. This not only limits the scope for reflection, but also deprives of the means for policy, whether economic or technological (Salomon & Schméder, 1986).

From these criticisms, innovation process models have emerged. The term process is defined as: an ordered sequence of facts or phenomena, following a certain pattern and leading to a determined result (Larousse, 2007, p. 2020).

An innovation process can be defined as the set of activities that are implemented to transform a product idea into an effective realisation (Lachman, 1993, p. 45). According to (Cooper R. , 1979), an innovation process "begins with an idea, developed by technical and marketing activities that take place in departments in which decisions are made and information flows" (Tomala & al, 2001, p. 2).

In industrial economics, the innovation process is defined as a process of transformation and diffusion on a market of technological solutions developed by a company (Ferez-Walch & Romon, 2006).

### **3.1. The different models of the innovation process:**

Innovation does not happen by chance and does not emerge spontaneously. It is the result of complex realities. To create, a large number of different, sometimes divergent factors must be brought together (Lachman, 1993). It is a concrete process, a succession of steps or activities aimed at implementing an idea, turning it into a new product or process.

We must stress here that «there is no consensus among scholars in this area as to the number of generations and their names (...) because different views on the innovation process result in different explanations of the origins and processes» (Barbieri & Teixeira Álvares, 2016, p. 117).

Six models for generating innovation process can be discussed in order of appearance. Five models are inspired by Rothwell's work (Rothwell R. , 1994). The last model (open innovation) appears in the 2000's.

#### **3.1.1. The hierarchical model:**

The hierarchical or linear model of innovation consists of a linear and sequential sequence of stages corresponding to the phases from idea to market launch, without feedback loops or the possibility of returning to previous stages.

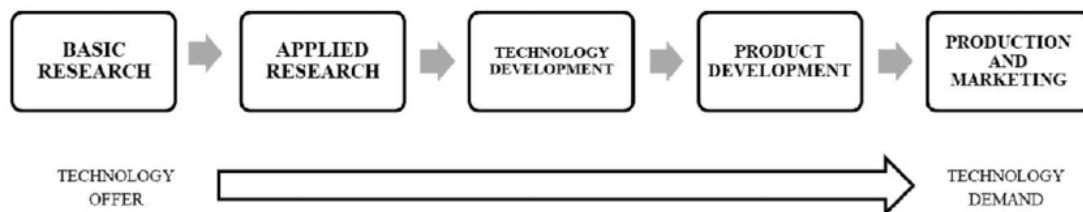
Within the economic theories of innovation, two models of innovation have often been opposed: the Science Push model and the Demand-Pull model. Schumpeter was associated with the former, while Schmookler was a strong advocate of the latter, and both models simply reiterate two well-known categories in economics: supply and demand (Perrin, 2001).

### a. The 1st generation science push model (technology push):

The science push model or hierarchical innovation model, is a model developed in the 1950s initiated by Joseph Schumpeter who argued that innovation is driven by science and that technical progress is an entity exogenous to the market (Chouteau & Viévard, 2007). Innovation is a linear process that emerges from a unidirectional flow that originates in science and research and development activities and ends in a commercial application (Cortes Robles, 2006). R&D entities are the nerve centre of innovation. Innovation involves applied research or the development of inventions that lead to new production and the marketing of new products. Innovation therefore consists in giving a concrete and practical use of the invention. The 1st generation science push (or technology push) model is also called the ladder model because the innovation process progresses gradually, gradually, towards increasingly practical solutions (Perrin, 2001).

This model is presented as follows:

**Fig N° 1: Sciences push model of innovation (or technology push)**



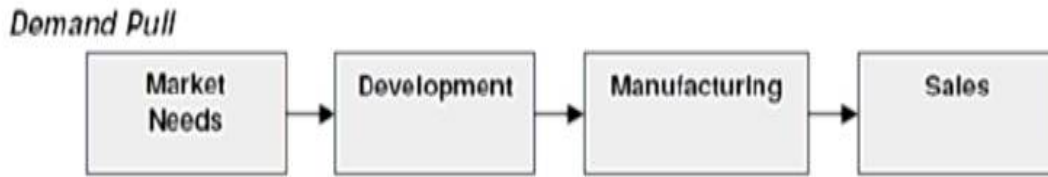
Source: Adapted from Rothwell, R. (1994). Towards the Fifth generation Innovation Process. *International Marketing Review*.

This model is still used in particular in high-tech industries, where R&D investments often exceed 10% of turnover (Le Loarne & Blanco, 2009).

### b. The 2nd generation "demand pull" model:

(Schmookler, 1966) initiated this principle, according to which it is not science that drives innovation but the market: it is demand that drives and explains innovation (Chouteau & Viévard, 2007). The demands of the market are taken into account by an entrepreneur, inventor or company that seeks innovative solutions to meet them. Innovation is thus based on the identification of customer expectations by the firm's marketing department. It is driven (pulled) by the requirements of the demands formulated on the markets. In this context, market opportunities, listening to customers and identifying their needs and expectations play a crucial role in the development of an innovative and satisfactory offer (Soparnot & Stevens, 2007). This model is presented as follows:

Fig N°2: Demand pull model of innovation



Source: Motilal, C. B., Sankat, C. K., & Pun, K. F. (2014). INNOVATION MANAGEMENT IN SMALL AND MEDIUM-SIZED ENTERPRISES: A REVIEW OF RECENT DEVELOPMENTS AND MODELS. 2014 Conference: The Challenges of Project Engineering and Management in a Sustainable World; 5-6 December 2014, (pp. 192-198), p194.

Demand is a factor that shapes innovation activity in several ways. "It influences the development of new products as firms modify and differentiate products to increase sales and gain market share" (OCDE, 2005, p. 51). Demand can force firms to improve their production and distribution processes to reduce costs and lower prices. In summary, the market is the source of ideas for directing R&D activities according to this view.

**3.1.2. The 3rd Generation Model: Process Model of Combining R&D and Marketing**

As the name suggests, the 3rd generation models propose a combinatorial or coupling process between the first two models: science push (or technology push) and demand pull (or market pull).

Third generation model are a mix of the 2 first generations. Research push and demand pull could fluctuate according to the phases of the innovation process and coexist naturally.

a. **The coupling model:** It is presented as follows:

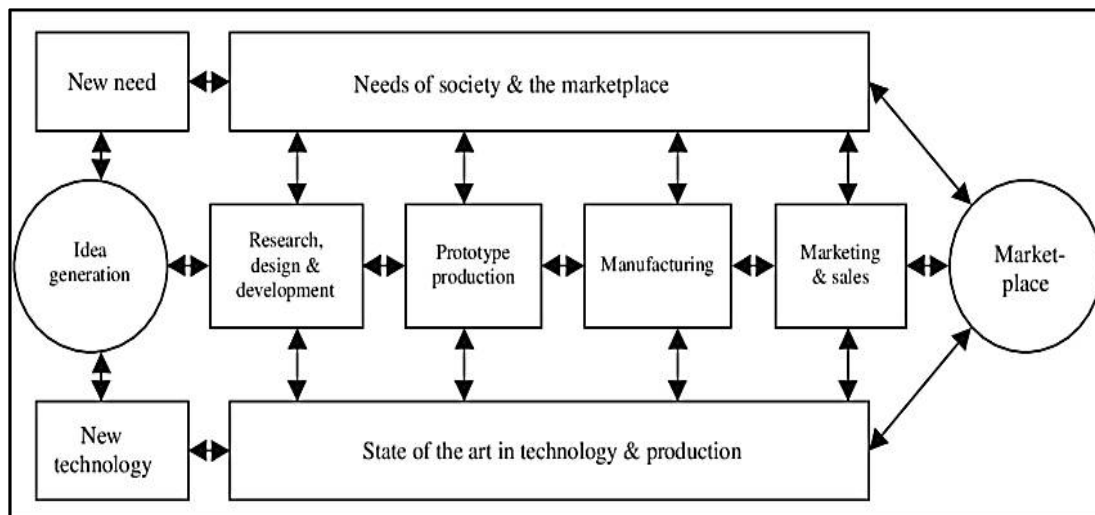


Fig N°3: The Coupling model

Source: Molas-Gallart, J., & Davies, A. (2006). Toward Theory-Led Evaluation: The Experience of European Science, Technology, and Innovation Policies. . American Journal of Evaluation, p6.

The general pattern of the coupling model presents an interaction between different components of R&D and the market or as a matching medium. The coupling between technological capability and market needs is

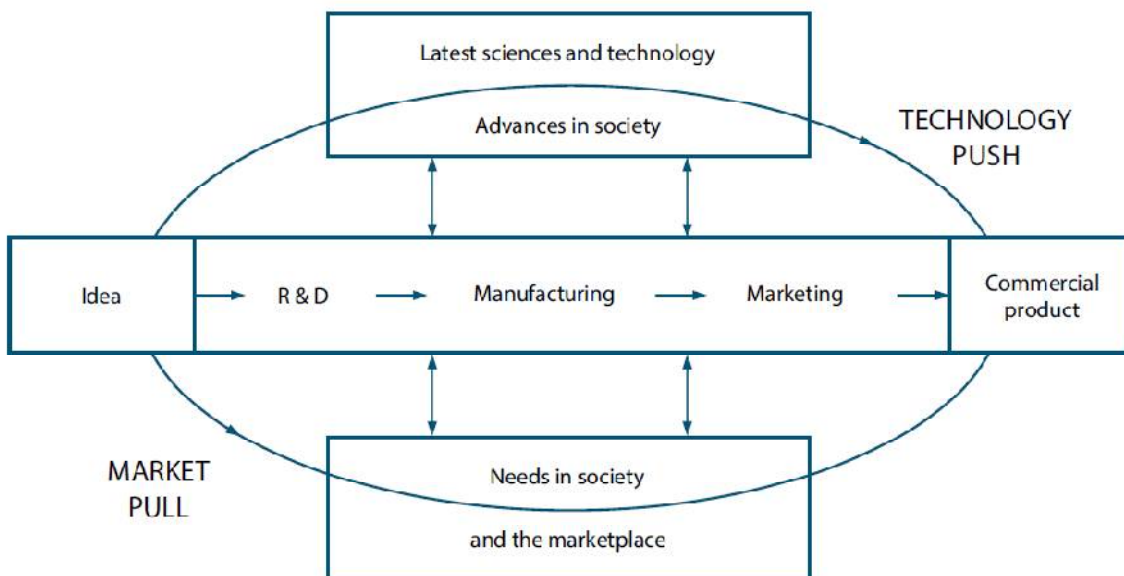
important with a feedback link between a series of distinct phases, i.e. the active monitoring between technological and market aspects (Molas-Gallart & Davies, 2006).

### b. Interactive Model:

In the 1970s, the coupling model spread with an interactive approach between customer needs and research. According to this vision, the main challenge is inter-organizational marketing-research communication. Interactive model was developed by (Rothwell & Zegveld, 1985). The authors extended the idea of (Mowery & Rosenberg, 1978) of the importance of interactions of the innovation process of corporate functions involved. They linked between the conventional linear approach adopted by businesses and the external research institutions and market.

In this model, the source of innovation is unknown; the flows of knowledge and information are not linear and continuous. « Interactive innovation is emerging with the latest developments in science and technology, needs in the society and in the market, and organizational skills. Innovation is not just between R&D or production and marketing, but between science technology and all functions linked to the market » (Kose & Güner, 2018, p. 376).

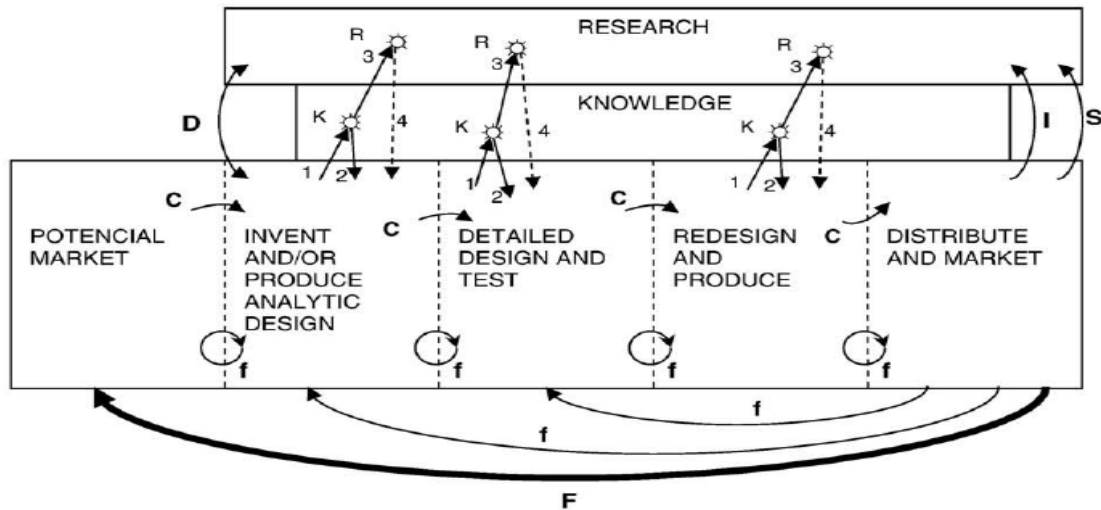
**Fig N°4 : Interactive Model of innovation**



**Source:** Romanowski, R. (2019). The Nature of Innovation Management. Dans R. Romanowski, *Managing Economic Innovations – Ideas and Institutions*, p13, adapted from (Rothwell & Zegveld, 1985).

### 3.1.3. The 4<sup>th</sup> generation model: chain-link model

Initiated in the 1980s, in this model (also called integrated model), the innovative process is not a linear scheme but an iterative and looping one. The most representative model of this generation is that of (Kline & Rosenberg, 1986).



Chain-linked model showing flow paths of information and cooperation. Symbols on arrows: **C** = central-chain-of-innovation; **f** = feedback loops; **F** = particularly important feedback.

**K-R:** Links through knowledge to research and return paths. If problems solved at node K, link 3 to R not activated. Return from research (link 4) is problematic - therefore dashed line.

**D:** Direct link to and from research from problems in invention and design.

**I:** Support of scientific research by instruments, machines, tools, and procedures of technology.

**S:** Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

**Fig N°5: The chain-link model**

Source: Caraça, J., Lundvall, B.-Å., & Mendonça, S. (2009). The changing role of science in the innovation process: From Queen to Cinderella? *Technological Forecasting and Social Change*, p3.

The model of (Kline & Rosenberg, 1986) presents the innovation process as a retroactive process that takes place in several phases or feedback loops during the interaction between scientific research and the different stages of the innovation process.

In the figure above, the model represents multiple phases with flow arrows: C, F, f, K-R, D, I and S (Le Loarne & Blanco, 2009):

- The letter C (central innovation chain) represents five phases, three of which are related to the design and test phases of a new prototype and the other two are related to commercialisation;
- The letter F (feedback loop) represents the long feedback related to the potential market and the final commercialisation of a product;
- The letter f (particularly important feedback) represents the short feedback between the different phases: invention, testing and production;
- The letter K-R represents the link between knowledge and research;
- The letter D represents the direct link between research and the different design phases;
- The letter I and S represents the feedback loop between the innovation output and research.

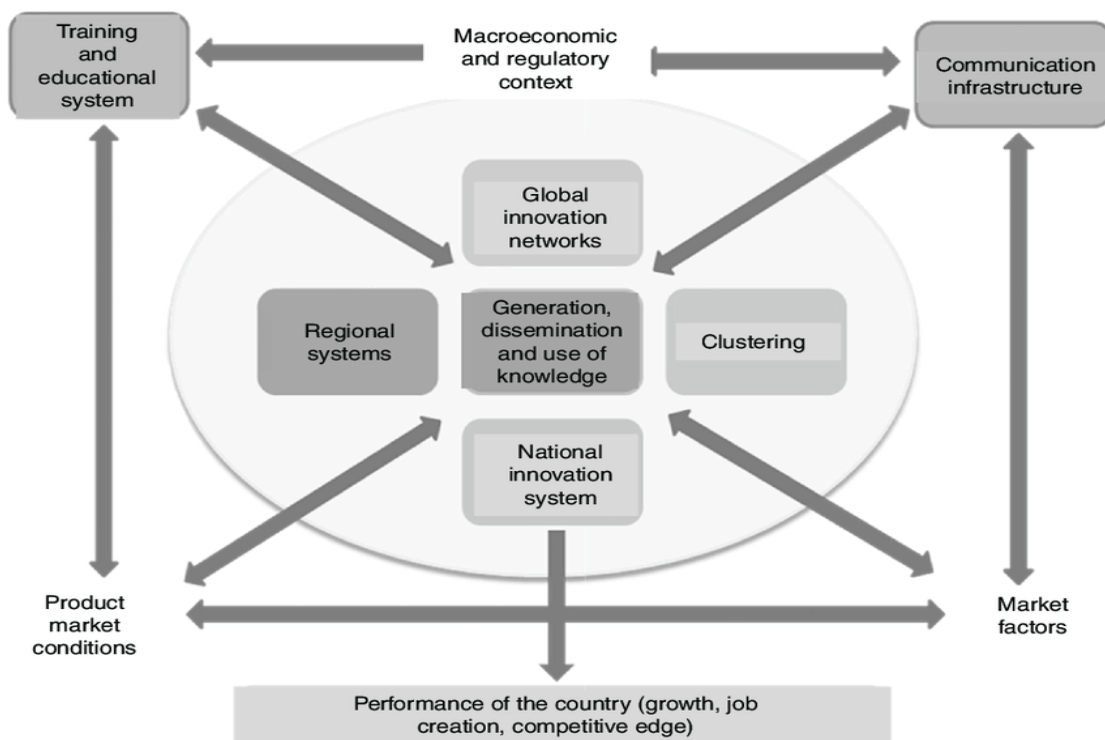
### 3.1.4. The 5th generation model: The system integration process model and network innovation (SIN)

This is a model developed from the mid-1990s and which prevailed until the 2000s called the Systems Integrations and Networking Model or SIN. During this period, the great importance for companies is the rapid innovation centred on the implementation of integration strategies and adaptations between different actors. This model, originally conceived by (Rothwell R. , 1992), is bilaterally oriented towards greater flexibility with the business strategy (Cortes Robles, 2006), thus the challenges go beyond the simple issue of marketing and/or research to include other partners inside and outside the company. The model illustrates two phases of integration:

- A vertical phase that focuses on customer, supplier and competitor relationships;
- A horizontal phase that seeks to obtain a framework for R&D, marketing and production groups.

During this period, the literature has highlighted the influence of 'macro-institutions' on the dynamics of innovation by providing the necessary proximity to interactions and collective learning in the geographical and spatial context. This is the emergence of key concepts such as : This is the emergence of key concepts such as: "national innovation system", "innovative environment", "industrial district" (Nelson, 1988); (Freeman, 1991); (Lundvall, 1992). These approaches seek to provide explanations of : the role of economic agents who drive technical change both at the level of institutions (industrial firms, universities, public and private laboratories) and at the level of economic policy which aims to promote innovation and growth (industrial and technological public policies, public-private relations, joint ventures, alliances, innovators' networks) (Bellon & Niosi, 1994).

Fig N°6: The system integration process model and network innovation



Source: Silva, F., Araújo, E., & Moraes, M. (2016). Innovation development process in small and medium technology-based companies. . RAI Revista de Administração e Inovação, p180.

### 3.1.5. The 6th Generation Model: Open Innovation Model

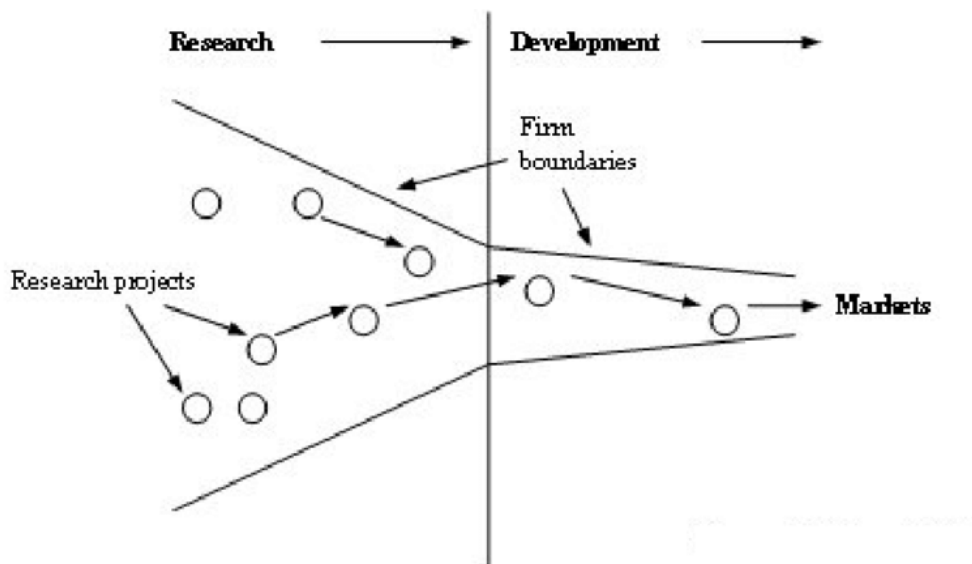
This approach was initiated in 2003 in the United States by Chesbrough, professor and director of the Center for Open Innovation at the University of Berkeley (USA).

The expression "open innovation" signifies a change in the traditional format where innovation is immersed in a multilateral (internal and external) and open to the outside world, i.e. innovation cannot be an individual, isolated process but a collective action allowing the integration of the flows of knowledge and expertise of the company's ecosystem: public research laboratories, suppliers, customers (Autissier & Bensebaa, 2010).

Collaborative innovation is defined as a set of inter-organisational relationships dedicated to the joint development of innovation (El Hilali & al, 2020), i.e. innovation is an open process under the influence of the ecosystem in the context of which companies have connections with each other (research laboratory, consultants, etc.) for the sharing of ideas, knowledge, skills and opportunities.

(Chesbrough, 2003) distinguished between the notions of open innovation and closed innovation. "The novelty of Chesbrough's concept is based on a fact that the process of open innovation became an integral part of the innovation strategy of an enterprise and its business model" (Świadek & Koziol-Nadolna, 2010, p. 172). He defines the guiding principles by two different models according to the diagrams below.

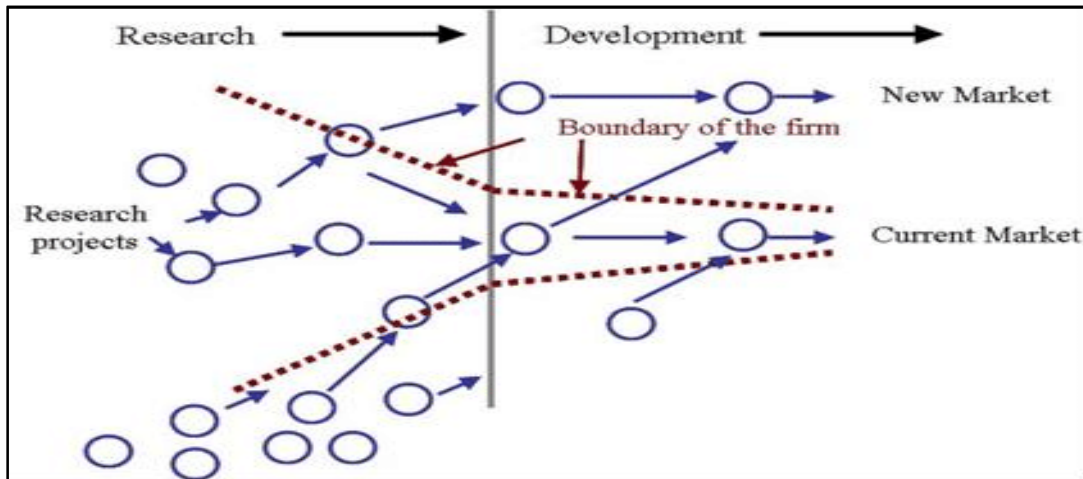
Fig N°7: Closed innovation process according to (Chesbrough, 2003)



Source: Krause, W. (2018). An approach to enable and advance open innovation for small and medium-sized enterprises. Dissertation presented for the degree of Doctor of Philosophy in Industrial Engineering at the Faculty of Engineering at Stellenbosch University, p28.

The closed innovation model is referred to as the traditional vertical integration model, which is based on the belief that the innovation process takes place exclusively within the boundaries of the company. This model is characterised as a funnel format where the project to develop a new product is initiated from the knowledge and technologies that the company possesses.

Fig N°8: Open innovation process according to (Chesbrough, 2003)



Source: Kasztler, A., Apilo, T., & al. (2012). Practices, future requirements and building blocks of a new innovation model, INNOSEC\_D2.1\_v100, AIT Austrian Institute of Technology GmbH, p38.

This model is visualised as an outward-looking funnel format where the innovation development project can be launched from internal and external knowledge and technology. It is characterised by a high flexibility towards the external environment and can reach external knowledge through different ways of acquisition (e.g. patent, licence, joint venture) or different forms of collaboration (e.g. co-design, alliances).

Authors (Gassman, Enkel, & Chesbrough, 2010), (Isckia & Lescop, 2011) identify three dimensions of the open innovation model (Aichouche & Boussalem, 2016, p. 15):

- The Outside-in processes: enriching a company's own knowledge base through the integration of suppliers, customers, and external knowledge sourcing can increase a company's innovativeness.
- The Inside-out processes: involve externally leveraging ideas across various markets, selling intellectual property, and multiplying technology by directing ideas towards the external environment.
- The Coupled process: Linking outside-in and inside-out by working in alliances with complementary companies during which give and take are crucial for success.

### 3.2. The different characteristics of innovation processes:

The different models of the innovation process, as described before, have several characteristics that we develop in the following paragraphs.

#### 3.2.1. Creative destruction process:

The phenomenon of creative destruction is classified as a key factor of growth by (Schumpeter J. , 1942, rééd. 1974) according to the logic: the new replaces the old or the effect of destabilisation and the contained regularisation of the economic structure. This corresponds at the macro-economic level to the destruction of old structures (old sectors, old industries) and at the micro-economic level since innovation creates new products, new activities or trades and new jobs, by making certain products or even the activity of certain companies, certain production processes and sometimes the trades linked to them disappear.

### 3.2.2. Learning process:

According to (Dosi, Teece, & Winter, 1990), innovation has emerged as a learning process whereby repetition and experimentation facilitate the diffusion of knowledge and know-how within the organisation. Over time, tasks are performed in a different and faster way and new opportunities in operating procedures are constantly being experimented with, especially through what is called "learning by doing", according to which learning allows for the renewal and accumulation of skills (Arrow, 1962).

### 3.2.3. Creative process:

As early as 1926, the neuroscientist Wallas demonstrates that good ideas come from a creative process and four key stages express the creative potential (Benoit-Cervantes, 2008, p. 88):

- Impregnation: expression of different perceptions of the same problem;
- Divergence: the ability to move away from the problem in order to return to it from another angle;
- Convergence: the ability to transform ideas into solutions that address the original problem;
- Evaluation and sorting of ideas for further development.

Innovation is the result of a creative process that aims to foster the emergence of new ideas to find and solve problems. In general, the creative process is a process that begins with a problem or idea and ends with the realization of that idea, resulting in the innovation.

which depends to a large extent on individual or collective abilities, skills, creative thinking and motivation.

### 3.2.4. Collective process:

Innovation represents a collective process through the exploitation of internal competences on the one hand and external competences on the other. The notion of "absorptive capacity of an enterprise" was initiated by Cohen and Levinthal in 1990 (Cohen & Levinthal, 1990), is the capacity to acquire a knowledge base and new information and to apply it for commercial purposes. According to (Laperche, Munier, & Hamdouch, 2008), the collective nature of the innovation process is found in the inter-organisational relationships that the company builds with external partners (ecosystem, networks, poles, clusters, incubators) and the dynamics of

interaction between the company's external players make it possible to speed up the innovation process and reduce risk and uncertainty.

### 3.2.5. Diffusion and technical progress processes:

The processes are built around formal and informal transfers of information, knowledge and experience. Innovation is largely based on the use of tangible and intangible resources. Furthermore, the production and diffusion of knowledge is derived from innovations through communication channels and interactions between members of a social system. Thus, technical change results from (Reynier, 2008, p. 25):

- ✓ The knowledge produced by the R&D activity, which is characterised as a positive externality
- ✓ The set of productive capacities of an individual: his qualifications, his experiences, his knowledge, etc.).
- ✓ The effect of learning and experience gained through practice.

### 3.2.6. Strategic, marketing and financial processes:

Innovation is the transformation of an idea or invention, which does not emerge spontaneously, but results from a complex process and through the articulation of numerous activities (fundamental research, applied research, prototype or pilot realisation, industrialisation and commercialisation,) which are carried out thanks to multiple means (financial, informational, human). Innovation is seen as a strategic vector that enables one or more companies to improve their market position. To this end, innovation requires a strategic change of direction (change in working practices) directly linked to management styles. Each innovation mode is linked to the strategic capability of the firm: survival, differentiation or value creation (Abernathy & Clark, 1985).

### 3.2.7. Public policy process:

State innovation policy focuses on the critical parameters of promotion, diffusion and protection of innovation. The state plays a particularly decisive role in guiding the innovation process through R&D expenditure, the establishment of large public research programmes that enable the assimilation of technological and scientific knowledge and the creation of new skills. The different actors (State, R&D organisations, industry) participate through the set of interactions, cooperation based on knowledge and know-how, on information sharing and collective intelligence, and on mutual trust between stakeholders (Taylor, 2016, p. 125).

### 3.2.8. Innovation as a social process:

Innovation is a process that arises from interactions of a social and cultural nature between multiple individuals or actors, such as the Schumpeterian entrepreneurial persona or the linkage between various modes or skills of a community. Innovation occurs as a social process that has its roots in frequent (daily and mutual) social learning between individuals or groups. The dynamics of innovation depend to a large extent on the capacity of the community.

### 3.2.9. Voluntary process that entails some risk:

Innovation is a voluntary act on the part of an individual or a group of individuals whose objective is to respond voluntarily and pragmatically, with a strong and constant commitment to absorb or leverage change for new benefits. However, great innovations take time to develop; innovation processes are linked to the challenges of uncertainty and the notion of risk. Innovation is a project whose results can only be observed in the medium to long term and this risk is inherent in the innovative nature of projects (Ulgen, 2007, p. 45).

The level of risk is different and higher in the upstream stages of the innovation process (idea development, research, proof of technical feasibility). Thus, the factors likely to cause a project to fail are diverse and classified according to the nature of the risk:

**Table N°3: Different risks linked to innovation**

Nature of the risk	Explanations
<b>The commercial risk</b>	<ul style="list-style-type: none"> <li>- The absence of market research and limited knowledge of customer needs;</li> <li>- The speed of change in customers' needs and requirements and the unpredictability of demand;</li> <li>- A product that is easy to copy or the presence of similar products on the market;</li> <li>- Lack of knowledge of the behaviour and reaction of competitors in the market;</li> </ul>
<b>Technology risk</b> - Level of R&D investment not determined	<ul style="list-style-type: none"> <li>- Technological change and shortened technology life cycles limit the speed with which the business responds to changing technology requirements;</li> <li>- Standards, regulations and other requirements can displace technologies;</li> <li>- Lack of knowledge and skills;</li> </ul>
<b>Managerial risks</b>	<ul style="list-style-type: none"> <li>- Limited experience in managing innovation projects;</li> <li>- A tense working climate and low employee motivation;</li> <li>- A problem of strategic orientation and speed of finding solutions</li> </ul>
<b>Financial risk</b>	<ul style="list-style-type: none"> <li>- Limited funds to implement innovations;</li> <li>- R&amp;D investment is high and not guaranteed;</li> <li>- Problem of evaluating projects in the long term and uncertain profitability</li> </ul>

Source :Janssen, F. (2016). *Entreprendre: Une introduction à l'entrepreneuriat*. Bruxelles: de Boeck Superieur, p104.

#### 4. Results and discussion:

According to (Kotsemir & Meissner, 2013, p. 3), « the evolving understanding of innovation as a process of activities raises new challenges to innovators (...) expressed in the increasing complexity of innovations which are in turn also determined by the complexity of the surrounding framework conditions. As a result, innovation is getting more complex due to the growing number of information sources, diverse knowledge and fields of application. In this light, innovators need to analyze and process more information for the same purpose ».

Mastering the innovation process enables companies to accelerate the emergence and success of innovation. The different models that we describe in this paper are a representation of the innovation process. They can be used in organisations; a new model will emerge for each new innovation. There is no ideal or universal model of innovation process.

These models emphasize the importance of sources of innovation and inspiration, which have largely evolved over time. It has been noted that each time the source or trigger of innovation changes, the stages in the process also change.

Analysis of these models also reveals the gradual abandonment of the idea of sequentially innovation stages. This means that the different phases overlap and that there are feedback loops between the different phases. According to(Hamel, 1999, p. 22), “in a linear world, only nonlinear strategies will create new wealth (...). I believe non-linear innovation is the competitive advantage for companies intent on winning in the new economy”.

We review the different process models according to their progressive appearance:

**Table N°4: Historical perspective of innovation process models**

Generation	Models	Main authors	Main features	Strengths	Limits
1st G 1950-1960	Technology push	Schumpeter (1942) Usher (1955)	Simple linear sequential process. Emphasis on R&D and science	Simple Radical innovation	Unidirectional process linked to the company's internal R&D capacity. The processes are costly, risky, long Lack of feedbacks No market attention No networked interactions No technological instruments
2nd G 1960-1970	Market pull (need)	Schmookler (1966) Myers & Marquis (1969)	Simple linear sequential process R&D based on customer wishes and marketing.	Simple Incremental innovation	Unidirectional process, linked to customer needs Uncertainty of demand Lack of feedbacks No technology research No networked interactions No technological instruments
3rd G 1970-mid 1980	Coupling model	Mowery & Rosenberg (1979)	Interaction of different functions Interaction between different elements and feedback loops among them	Simple Radical and incremental innovation Feedbacks between phases	Two-way process linked to R&D and demand The information circuit is closed No networked interactions yet No technological instruments
	Interactive model	Rothwell & Zegveld (1985)	Combination of push and pull models	Feedbacks between phases	Two-way process linked to R&D and demand The information circuit is closed
4th G 1980-1990	Integrated model (chain-linked model)	Kline & Rosenberg (1986)	Simultaneous process with feedback loops; integration with the firm, upstream with key suppliers and downstream with demanding and active customers. Emphasis on linkages and alliances	Actor networking Parallel phases	Complexity increment of reliability No technological instruments
5th G 1990	Networking model (System integration and networks (SIN))	Rothwell (1992)	Systems integration and extensive networking Flexible and customised response Emphasis on knowledge accumulation and external linkages.	Pervasive innovation Use of sophisticated technological instruments Networking to pursue innovation	Complex innovation process, linked to different forms of proximity Complexity increment of reliability
6th G Since 2000	Open innovation	Chesbrough (2003)	Open innovation, self-learning system Internal and external ideas as well as internal and external paths to market can be combined to advance the development of new technologies	Internal and external ideas as well as internal and external paths to market can be combined	Assumes capacity and willingness to collaborate and network Risks of external collaboration

**Source :** adapted from different sources (Campodall'Orto & Ghiglione, 1997)and (Rothwell R. , 1994), (Kozioł-Nadolna & Świadek, 2010); (Meissner & Kotsemir, 2016)and : [Innovation Model Analysis \(ipacso.eu\)](http://ipacso.eu).

Finally, we agree with(Kotsemir & Meissner, 2013, p. 18)that: « in course of the evolution of the innovation process models it has become a widespreadand commonunderstanding how innovation actually occurs, that innovation itself is not a result but a process and a flow of activities which aim at solving a problem be it known or unknown, be it understood or not understood in all its implications to society at different levels ».

### 5.Conclusion:

The 21st century has seen major changes in international markets, increased competition, short product and service cycles and rapid technological progress. Innovation is becoming a costly and risky process. Companies need to review their innovation models, with greater openness to partnerships and the creation of innovation networks with other organizations.

The topic of innovation has given rise to an extensive literature with a variety of definitions and classifications of types of innovation.

The innovation process is complex and involves several actors. Numerous classifications of process models exist such as (Marinova & Phillimore, 2003), (Tidd, 2006)or (Bochm & Frederick, 2010). We used (Rothwell R. , 1994) classification with arrangements and actualisation.

The way innovation works is defined by certain aspects (R&D, demand, proximity, network) and is characterized by different movements, sometimes linear, involving a single path of activity, retroactive movement, an integration system or open movement. The critic of one model becomes the extension of another. And each company may have each own innovation process model that can changes from innovation to other.

In addition, some authors propose different perspectives of innovation processes. The latter is a variable process: linear, interactive and open. This means that the innovation process is multidimensional and complex. It depends on many factors, sometimes distinct, where it focuses on the company's competences, resources, culture and practices towards innovation.

The innovation process involves the role of proximity and interactivity between actors to facilitate the production and dissemination of knowledge.

Contemporary models of innovation emphasize the importance of external relationships for innovators. These relationships can take various forms, such as acquiring and integrating knowledge and technology from sources outside of the organization(Meissner & Kotsemir, 2016).

Future research should address practical questions: **To what extent are innovation processes in emerging countries different from those in developed countries? How applicable are these models in the real world?**

More studies are needed to analyse the role of universities in creation of new ideas and drive students toward innovation and creative thinking. Also, the role of universities in developing more skilled workers for the companies.

At the end, innovation is certainly the result of a creative act. This does not exclude the importance of managing the process from design to implementation, but also the management of people and skills in order to produce a marketable product or service. The currently predominant paradigm of open innovation should be enriched by placing greater emphasis on the human resources involved in innovation.

For a company, innovation is not an end in itself but rather a means to achieve its strategic objectives. To achieve this, it must be well managed, the company's activities must evolve, and it must develop by constantly relying on novelty.

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