

Innovation Management Models - A Literature Review

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This paper deepens the innovation process model and innovation management model. It states that the latter contains management variables not analyzed in depth, in the literature on innovation models. It also presents six proposals on models of innovation management in companies and sectors. The methodology was based on an in-depth review of 73 documents obtained via Scopus which contained the search terms “innovation management” and “model”. These documents were analyzed using Vantage Point software. The majority of authors are in agreement about innovation models and their emphasis on the “process of innovation”. However, a similar consensus was not to be found regarding “innovation management models”. This represents a barrier to theoretical analysis. Yet it is also an opportunity to propose best practices, identify patterns, and establish theories that may become the basis of future models.

Key words: *Innovation management models, Innovation models, Innovation process, Innovation, Literature Review.*

Introduction

Various studies and proposals have been made worldwide on innovation models, to explain how they take place in organizations. There has been a relative consensus on the main models of innovation processes, especially on those by Gruber & Marquis (1969), Roberts & Frohman (1978), Saren (1984), Rosegger (1980) cited by Escorsa & Valls (2003), Kline & Rosenberg, (1986), Forrest (1991), Rothwell (1994), Kumar et al. (1996), Chiesa, Coughlan & Voss (1996), Padmore, Schuetze & Gibson (1998), Cidem (2001), Hidalgo, León & Pavón

(2002), Trott (2002) and the European Commission (2004) cited by Velasco, Zamanillo & Gurutze (2007), Collins (2005) and Korobow (2007) cited by Cidet (2011), among others. The same does not happen with innovation management models or those focused on organizational structure. Although graphic conceptual models proliferate, in the papers analyzed, no specific procedures were found on how to establish and propose innovation management models for organizations or sectors. This paper seeks to provide elements to answer the following questions: Does the theory about innovation models refer to innovation management models? Are there consensuses in what is meant by the innovation process model and innovation management models? The presented study also aims to expose the main theoretical contributions about what is explained today as innovation models, and to highlight their greater emphasis on the innovation process.

The article is divided into several sections: First, some concepts about innovation models and recent studies on these management models are discussed. Then, the 3-phase methodology is exposed starting from database choice, keywords, criteria, search equations, reading and discussion of the 73 chosen documents. Results from these readings are discussed and the Vantage Point software application, with emphasis on authors, affiliations, countries, keywords and key phrases, is analyzed. Finally, there is a discussion about the studies most related to R&D processes, and those that have a focus on organizational structures or management activities; that is, innovation management models.

Theoretical Framework

For several decades, researchers from several countries have identified innovation models or broader R&D processes. The Marquis model is based on the importance of ideas in the innovation process, clarifying that these are not generated exclusively in research departments but can come from any other area of companies (Gruber & Marquis, 1969). Roberts & Frohman (1978) proposed a technological innovation process with seven stages: opportunity recognition, idea formulation, basic/applied research, prototype solution, standardization and homologation, manufacture, and commercialization.

Rossegger (1980) delved into a linear theoretical model that consists of several phases. The process begins with basic research, followed by applied research and technological development, and ends with marketing and market launch (Rosegger cited by Escorsa & Valls, 2003).

Saren (1984) identifies five types of innovation process models: departmental-stage models, activity stage models, decision-making models, conversion process models, and response models.



Forrest (1991) analyzes models such as stage models, conversion model and technology push/market-pull models, integrative models, and decision models.

Kline & Rosenberg (1986) made one of the most important contributions in innovation models, in their famous model of chain links between research, invention, innovation, and production. They explain that the central dimension which organizes innovation, if there actually is one, is uncertainty. Their proposal shows that there are several points for reducing this uncertainty, such as the final products, production, and marketing processes.

Rothwell (1994) establishes five generations of innovation models: first generation or technology push from 1950 to 1960; second generation or demand slackening from 1960 until the mid-1970s; the third-generation model or coupling-articulation, from the mid-1970s to 1980; the fourth generation or integrated model of principles from 1980 to 1990; and the fifth generation or system integration and network model after 1990.

Kumar et al. (1996) structure five stages for innovation: Initial projection, commercial evaluation, development, manufacturing launch, and initial commercialization. Chiesa, Coughlan & Voss (1996) developed a systemic model that defines four key tasks to manage innovation efficiently: generation of new concepts, product development, process innovation, and technology acquisition.

Padmore, Schuetze, Gibson (1998) expose the linear, chain link, and cycle model. Meanwhile, Hidalgo, León & Pavón (2002) emphasize the linear model, Marquis, Kline, Rothwell & Zegveld models, and the integrated model. Trott (2002) (cited by Velasco, Zamanillo & Gurutze, 2007) explains the models of serendipity, linear, simultaneous coupling and the interactive models. The European Commission research (2004) (cited by Velasco, Zamanillo & Gurutze, 2007) exposes elements on innovation derived from science, market needs, links between actors in markets, technological networks, and social networks.

Collins (2005) establishes a three-phase model: strategic inputs, R&D process, and results. The first input is deciding on key factors and proposing 27 indicators of excellence within the three phases, although it is presented as a model of the R&D process. In one phase, reference is made to management elements in the organization, Korobow (2007) cited by Cidet (2011), which is based on two routes, from Basic Research to the market, and from the market to basic research.

Methodology

This documentary research analyzes the current state of knowledge on the topic "innovation management models". A literature review has been made, using specialized scientific journals



contained in the Scopus database. Content analysis was performed on the articles related to the subject examined. To achieve this purpose, the methodology has been developed in three phases:

Phase I (Planning): the Scopus database was chosen, since it collects high-quality scientific production around the field of study. This decision has taken into account criteria such as peer evaluation, in addition to thematic, chronological and international coverage.

Phase II (Search for information): the search strategy was applied in the fields (TITLE-ABS-KEY) to obtain data (texts inscribed in the period 1985-2017). As a final result, 73 specialized documents were obtained.

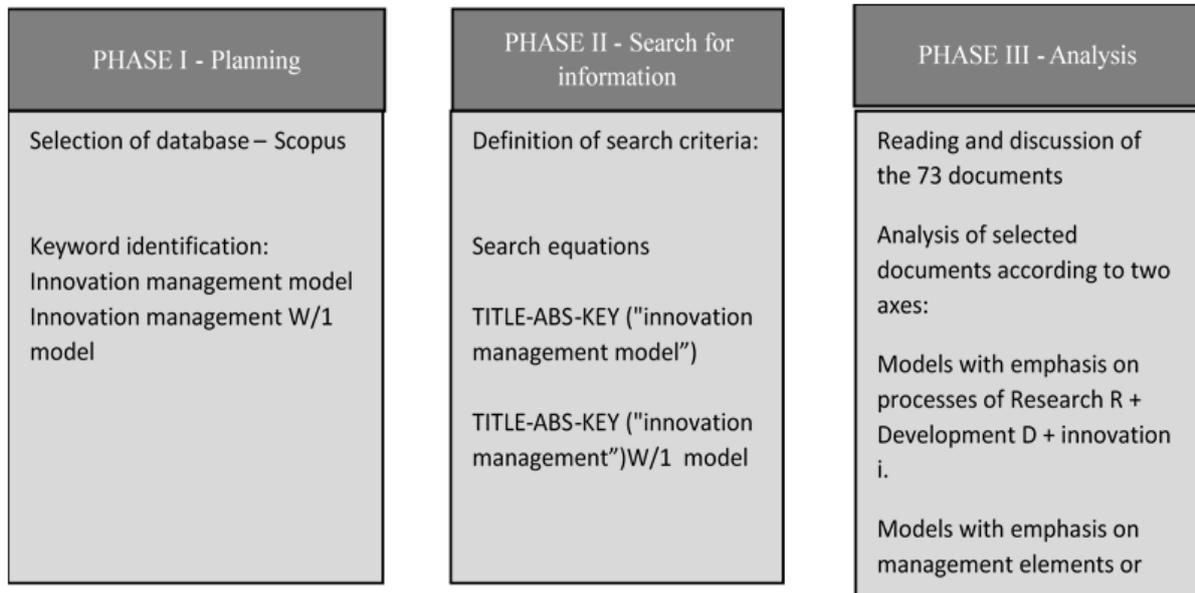
The keywords used as references were "innovation management" and "model". In total 47 papers, 23 documents in proceedings and three book chapters, directly related to innovation models, were found. Their review focused on a classification by authors, theoretical framework, methodology, and country. All investigations were verified as related to innovation models or innovation management models. The equations used were:

TITLE-ABS-KEY ("innovation management") W/I model

Phase III (Analysis): technological matrices and maps developed were studied and discussed, to analyze the type of contribution to knowledge of the subject. For this purpose, the thematic profile of documents was taken as a classification and analysis criterion, grouped according to two categories: models emphasizing innovation processes, and models with emphasis on management elements or organizational structure.

Documents from the VantagePoint software were analysed, which, through data mining, allows access to complete documents through each of its terms, treated as data to provide relevant information making use of analytical tools such as lists, matrices, relationship maps, cluster analysis, among others (Vantage Point, 2018). The software is operated as a text mining tool to discover knowledge in the search results of scientific literature databases. It is also widely used in patent analysis.

Figure 1. Phases of the methodology



Source: Own elaboration

Results

Next, the most important aspects found in the document review are presented in a timeline from 1985 – 2017. The most recent are chosen so as not to affect the extension of this paper:

Jenatabadi (2014) proposes a "conceptual model of innovation management" for food companies, which relates organizational culture, innovation, and efficiency. Organizational innovation was shown to close the gap and strengthen relationships between organizational culture and organizational efficiency. Rui, Lingsha & Lei (2014) use the knowledge innovation management system model to relate knowledge innovation management and the core company competencies.

Kudryavtseva et al. (2015) used cluster analysis for a model of development of industrial activities, focused on innovative activities. Sadykhanova, Dinara & Bayan (2015) regard the concept of open innovation, which lies in the development of internal R&D management processes aiming at a more significant interaction with the outside. This is expressed in the diffusion of technology based on joint efforts of universities, national laboratories, companies in development stages or research perspectives, markets, suppliers, consumers and branches of consortiums.

Murphy, Perera & Heaney (2015) analyze whether the constructs generated in research can be integrated for the development of a practical tool, for project stakeholders who wish to



innovate. Badi & Pryke (2015) focus on sustainable energy innovation and private financing initiative projects, with application in schools.

Gomes et al. (2016) conducted a systematic literature review from 1993 to 2016 on the concept of the innovation ecosystem, to analyze concepts, trends, and research opportunities. They found a transition between business ecosystems and innovation ecosystems, where the latter related to value creation. They describe six research trends, including innovation management. They also highlight elements such as risk management, project management, radical and disruptive innovations.

Kłos, Skrzypek & Dabrowski (2016) state that effective innovation management, and product and process innovations stimulation can support strategy development in manufacturing companies. They establish a “model of innovation management system” (IMS) in custom design engineering companies, in addition to the IMS model created for the development of new products. Sivula & Kantola (2016) carried out a research in which they used a four-phase innovation management model: search, select, implement and capture. This study contributes to the understanding of the types of crowdsourcing used in innovation management. His second contribution is to correlate the types of crowdsourcing in the phases of innovation management.

Maier et al. (2017) identified and analyzed innovation management systems models. Xie, Li & Xie (2017) found common aspects based on an analysis of the situation in Chinese companies' management with weak foundations of management. They found five bottlenecks in management which limit efficiency in innovation: strategic management, cultural representation, management organization, mechanisms, and execution.

Bagno, Salerno & da Silva (2017) analyze innovation management models presented in the literature, with an emphasis on those that contain graphic representations. The authors establish that these representations strongly communicate the central propositions of each model, accelerating their position and influence in academic and business environments. The article proposes a typology of innovation management models, highlighting biases, gaps, strengths, and weaknesses. It also discusses the conflicts related to the limits of the innovation process. Finally, it proposes an emerging approach related to radical innovation, design thinking, and start-ups.

Eito-Brun & Sicily (2017) study an "innovative activity model" for software-based product development. It identifies activities and practices that lead innovative product development, applied in software micro-enterprises. Researchers conclude that the management of systematic innovation and open innovation models are not exclusive to large companies. They can also take place in small software companies.



Iglesias, Correia & Maldonado (2017) show an application of open innovation in the Spanish and Portuguese tourism sector through social networks, via a cluster analysis of 135 companies.

Table 1 lists authors with the names of the innovation management models established by them in the Scopus documents:

Table 1: Innovation management models proposed by author

Author	Innovation management model IMM
Shankar, Spanjol (2005)	Adaptive Innovation Management Model
Fielden y Malcolm (2006)	Bounded innovation management Model BIMM
Rahman et al (2010)	IMM - Innovation Management Model in education
Kłos, Skrzypek, Dabrowski, (2016)	IMS - Model of innovation management system
Eito-Brun, Sicilia (2017)	Innovative activity model

Source: Own elaboration

Regarding results obtained from the Vantage Point software application, focused analyses were carried out on critical phrases, keyword correlation, authors, keyword cluster and authors' matrix by affiliation. Other analyses were carried out with this tool, but they generated results summarized in Figures 2 and 3.

Figure 3. Keywords

VP Cluster Map of Palabras Clave (Cleaned)



Source: Own elaboration based on VantagePoint results

Figure 3 maps factors which groups the terms of a list, into groups of terms that tend to appear in documents together. That is, each of these clusters is shown as a node on the map. For example, "entrepreneurship" appears in total in two documents; once along with the term "innovation management system", and again in a document without association to another keyword. The keyword "innovation management system" appears in 27 documents, 18 of them unrelated to other keywords on the map. It also appears twice with "open innovation", twice with "collaboration", once with "collective learning process", twice with "competition", once with "entrepreneurship" and once with "product innovation".

Discussion

A consensus was found in the reviewed literature regarding what was established in innovation models or R&D processes. However, the same did not happen with innovation management models (IMM). It is not easy to find patterns in these models from a theoretical analysis, models which can be found in technical documents, or presentations on companies' web pages, institutions that launch graphic models that try to group management elements.

Some include innovation processes. Others do not. Therefore, the discussion focused on authors who address the innovation process or R&D models, and companies and institutions more aligned with innovation management models.

Innovation Process Models

Palucha (2012) focuses on innovation models. The paper is intensive as to linear models, demand-pull, technology push, chain links, stage-gates, product lifecycles, and open innovation. It is not focused on innovation management models. The author concludes with the importance of open innovation, but without deeper analysis as to platforms and the role of start-ups. The author analyzes innovation models and establishes their importance, depending on the possibility that these models help in problem-solving, regarding development processes as complex processes. The models cited are technology-push and demand-pull sequence models and parallel or chain models, citing Kline & Rosenberg (1986).

Murphy, Perera & Heaney (2015) in their literature review emphasized innovation, definitions, classifications and their management. Elements of the innovation process regarding Morin's technological functions, are mentioned. The model emphasizes projects. The proposed conceptual model explicitly mentions the innovation process based on Slaughter (2000) and Marquis (1969). Moreover, the process of obtaining is based on seven stages, in a construct on the classification matrix of restrictions. It takes into account concepts of linear algebra, where the stakeholders participate in projects.

Gomes et al. (2016) deal with innovation ecosystems and six currents for new research. The innovation management current is implicitly related to innovation management models. Only business models and generation of value are discussed, and not innovation management models, when dealing with open innovation and their ecosystems. In conclusion, the paper studies the innovation process and not management activities.

Bagno, Salerno & da Silva (2017) study the four groups of innovation management models proposed. Two of them - the linear model and the funnel models - are focused on the innovation process. As such they are not models of innovation, organizational structure, or innovation management models. The Scopus search equation only took into account the innovation process, and the web search terms of "knowledge" with the terms "innovation management" + "model" did not use proximity indicators. Although they reviewed the literature and mention seminal authors, other studies were needed. Within innovation management models in groups 3 (models focused on strategy, organization and interactions between organizational elements) and 4 (models focused on capabilities) is where the most significant contributions are made to organizational structure models. The authors highlighted the seminal work on innovation in different forms of organizations.



Burns & Stalker (1961) review the interdisciplinary characteristics of innovation management and its relationship with an organizational focus and functional activities, as described by Tatikonda & Montoya (2001), and McDermott & O'Connor (2002). They also address a model of the Utterback innovation process (1971), Kline & Rosenberg (1986) and their chain link model, Rothwell (1994) and the first to fifth generation models, Cooper (1993) and the stage-gate model, Pugh (1991) and the model for development of new products called the total design model, Clark & Wheelwright (1992) and the funnel model, Docherty (2006) and the open innovation funnel model, the Levy (1998) model for high-tech companies, and Huizingh (2011) and the open innovation model.

Eito-Brun & Sicilia (2017) consider innovation process models in their review, such as Lackner (2013), Open Innovation by Siemens, Fetterhoff & Voelkel (2006) or the five-stage model. They also consider: the search for opportunities, evaluation of market potential, recruitment of partners for development, marketing, and extension of the innovation offer, Corbin et al. (2007) or the model relating innovation and knowledge management, Eversheim (2009) or the model for large manufacturing companies which have resources to develop long-term innovation programs. In the literature review, they took into account the ISO/IEC 29110 standard. It provides a process model for software and systems development as a framework or benchmark between software engineering, innovation management activities and products, as well as the standards UNE 166001, and 166002. These standards explain that they exceed the capabilities of microenterprises and do not encourage innovation, according to the authors.

Innovation Management Models

Fielden & Malcolm (2006) focused on creativity, organizational culture and the culture-productivity relationship. They conclude that the model was applied differently in each organization. It has three main elements: incentives, transformation, and outcomes. It is similar to Zartha's (2015) proposal, an analysis and subsequent prioritization by experts of an innovation management model in organizations of the productive sector, based on input variables, a process of transformation, and output.

Rahman et al. (2010) consider only eight references in their study and focus more on Malaysian institutions of higher education and their role in the country's recent commitment to innovation. There are gaps in what is considered an innovation management model and its validation. Researchers cite authors who have developed tools in innovation management. Abdalla, Bitzer & Morton (2005) propose a tool with three elements: reduce and optimize resource use, consumers oriented to sustainability, and economic and environmental friendliness. Wrzalik, Kieltyka & Kuceba (2008) comprise a management model of technological innovation using fuzzy logic, to analyze national or organizational innovation.



Elements such as rules databases, assessment mechanisms, inference, and membership functions of the model are evaluated.

Zartha et al. (2015) focus on alignment between future studies, innovation strategies, and innovation management models, with a bias towards soft systems methodology. It is not an exclusive text about innovation management models. In fact, its references were based on two international standards on R&D management: the UNE 166002 standard (Aenor, 2006), and the British standard (BSI, 2008), in practical cases of organizations.

Kłos, Skrzypek & Dabrowski (2016) propose an innovation management system integrated with an ERP database that includes product and process configurator, using a practical model in an engineering company.

Dorin et al. (2017), in their literature review identified and analyzed innovation management systems. They found a series of common aspects; the question is how to carry out excellence in the management of innovation.

Xie, Li & Xie (2017) found that the five elements or bottlenecks interact with each other and constitute a style of modern innovation management, on which they built the pentagon model; an innovation management model to be used by Chinese companies.

Table 2: Elements of innovation management models and authors

Author	Elements of innovation management models
Fielden & Malcolm (2006)	Bounded innovation management model (BIMM) where creativity, organizational culture, and culture-productivity relation are taken into account. The resulting model has three main elements: incentives, transformation, outcomes.
Rahman, et al. (2010)	They cite Abdalla, Bitzer & Morton's (2005) model, which contains three elements: reduce and optimize the use of resources, consumers oriented to sustainability and economic and environmental friendliness. They cite Wrzalik, Kieltyka & Kuceba's (2008) model, which includes a management model of technological innovation using fuzzy logic, where elements such as databases and inference mechanisms are evaluated. They introduce the innovation management model (IMM) in education.
Kłos, Skrzypek & Dabrowski (2016)	In their innovation management system (IMS) they propose an integrated innovation management model with an enterprise resource planning (ERP) database that includes a product and process configurator. They used a practical model in an engineering company.
Xie, Li & Xie (2017)	They found that the five elements (strategic management, cultural representation, an organization for management, mechanisms, and execution) interact with each other and constitute a modern innovation management style, on which they built the pentagon model; a model of innovation management to be used by Chinese companies.
Shankar & Spanjol (2005)	They analyze the adaptive innovation management model, connecting markets, consumer problems, and understanding, to link the internal capacity of organizations with customers' problems customers. The model requires culture and infrastructure for its implementation.
Eito-Brun & Sicilia (2017)	In modelling innovative activity for small software companies, it identifies activities and practices to carry out the development of innovative products, and



	emphasizes the interface between innovation management activities and software development processes.
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Source: Own elaboration.

Other organizational structure models with greater emphasis on management activities, involving or not involving innovation models, were identified, among them: The research and development centre of the electricity sector (Cidet, 2011) that is based on six organizational capacities and makes explicit the relationship between internal processes and sectors, project management processes, competitive intelligence, cooperation processes, and information sector; the GIDI model of construction companies (Correa, Yepes & Pellicer, 2007) that assesses the satisfaction of stakeholders, with an emphasis on the customer and the culture of innovation. Other models of innovation management are reported by authors and organizations from different sectors and countries; for example, that reported by Solleiro & Ocotlán (2013) for Mexican pharmaceutical companies, another by Camacho (2015) for a third level hospital, one by Mantilla (2017) for an oil company, another by COTECMAR (2018) for a science and technology corporation for developing the maritime naval industry, the model for Mexican SMEs (technology management manual, 2018), the competitive model of the Andalusian Institute of Technology IAT (Cidet 2011), the model of an energy production, distribution and marketing company (Iberdrola, 2007). The latter were reported in technical documents of company websites or undergraduate theses with case studies focused on organizations.

Conclusions

The development of new innovations requires the interaction of innovation management models (models related to the organizational structure that supports the development of innovation), and innovation models (models directly related to the process of innovation and the way in which products or services are developed). Innovations can originate from scientific research, applied research and experimental development.

Innovation process models are related to the phases or stages carried out, to move from ideas or research to new or improved products, services or processes. On these models, generally conceptual and graphical, there is a consensus in the specialized literature which has been an input for organizations and institutions from different sectors and countries to identify or propose models for innovation, whether or not based on R&D.

IMM innovation management models do not readily show patterns that allow an organization, institution or sector to have clear elements to start, identify or propose a model. Yet sectoral studies and company proposals are found. Most do not explicate the way they



identified or prioritized model variables, nor their behaviour regarding information and knowledge flows among the activities that make up their IMM, nor the way in which its dynamics or its evolution can be understood in time.

Literature shows that several authors and institutions confuse or use a single term to refer to innovation or R&D, and innovation management models. For example, some studies refer to models from the first to the fifth generation, as models of innovation and others as innovation management models. Other studies refer to innovation processes and management or organizational structures under the term "innovation models". This represents a problem for theoretical analysis and conceptual strength, especially in what should be part of an innovation management model. It is also an opportunity to make contributions on good practices, patterns, and theories that can become the basis of models of innovation management.

Interest has been increasing in innovation process models since the 1960s. Several are the basis of R&D processes that have been applied in organizations and institutions. Models of innovation management, or organizational structure based more on management elements, are more intensive in the last decade. They correspond to business proposals, and studies referenced in books, standards, and scientific articles.



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