Modelo de gestão da inovação: uma revisão de literatura

A literature review on innovation management tools

Envio 16.10.08 / Aceite 30.10.08

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Abstract

*The study of a complex phenomenon such as innovation, influences and effects of which are tangible in manifold contexts, traditionally requires the integration of different levels of analysis and the interaction among distant disciplines. The enterprise appears to be the fundamental agent of economic change; in this context, innovation, by intervening in the sphere of technology, constitutes a fundamental dimension also for social change. In addition, it interacts in the circle of a complex matrix of cultural, economic and institutional factors which are the base of social and economical evolution. In this context, the research questions (RQ) investigated by the authors are: "*what is innovation*?" [RQ 1] and "*which are the main evolutions of innovation management models*?" [RQ 2]. Literature on this matter has exponentially evolved in recent years. Nevertheless, innovation literature presents a large heterogeneity of results, while the innovation process concept itself is still poorly understood. In order to investigate the first research question, authors review forms and structures of innovation models developed throughout the years. At the end a discussion on the characteristics of literature evolution, through a strength-weakness analysis, is presented by the authors.*

Keywords: *innovation management, technology, models.*

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1 Introduction

The term innovation has been used in literature to describe both the process that uses new knowledge, technologies and the processes to generate new products as well as new or improved products themselves (PORTER, 1990). The difference from invention is that innovation also involves the factor of commercialization, determining the company success or failure. This appears to be the crucial point over the last few decades, as innovation has been identified by several nations or intra-nation organizations as the major factor of economic growth and wealth (EU, 1995; OECD, 1997a, b).

Organizations which operate in today markets, where global competition, rapid technological advances and resource insufficiency are pressing issues, must innovate in order to grow, to be effective and even to survive. Despite this need, after forty years of innovation studies, managerial best practices related to innovation are still very vague, as confirmed by Rothwell (1992) which highlights the lack of precise prescription for successful innovation. The innovation process is still poorly understood (COOMBS et al., 1996) and the current state of the literature contributes little to improve the understanding of the phenomenon (BECHEICH et al., 2006).

In this context, the RQ investigated by the authors are:

"What is innovation?" [RQ 1]

and

"Which are the main evolutions of innovation management models?" [RQ 2].

For achieving these results, the paper is structured as follows:

– the presentation of the research methodology;

– the description of innovation concept;

– the milestones' description of innovation processes;

– the selection and justification of a classification criterion for grouping innovation models;

– the search of innovation models, which have been developed throughout decades, and their classification through the selected criterion, in order to analyze their structure, their meaning and their evolution;

– the analysis of the innovation models through a strength-weakness approach.

2 Research methodology

The research methodology adopted in this article is a systematic review of scientific papers. A systematic review provides information about the effectiveness of interventions by identifying, appraising, and summarizing the results of otherwise unmanageable quantities of research (LIGHT and PILLEMER, 1984; MULROW, 1994). The use of systematic review is justified since in the management field, the traditional narrative literature reviews have been widely criticized for the lack of relevance due to the use of personal and usually subjective as well as biased methodologies by authors (FINK, 1998; HART, 1998). To mitigate this gap, it was proposed to apply the specific principles of the systematic review methodology usually used in medical sciences (TRANSFIELD et al., 2003). The main difference between a systematic review and a traditional narrative review is that, contrary to the latter, the former uses a rigorous,

replicable, scientific and transparent process (COOK et al., 1997). Journals' relevance for the literature review are evaluated through a search engine of an Italian database that contains over 4.500 journals and over 7.500 million articles covering the major research topics. Journals' selection for the current study has been pursued evaluating results furnished by the research engine and sorted by relevance from the keywords selected from the authors. Keywords investigated for journals' evaluation have been "Innovation in Product", "Innovation in Process", "New Product Development" and "New Product Design". Search engine furnished relevance sorted articles and the authors calculated the average journals' weights for each keyword results. Following the explained selection criterion the chosen journals have been "Journal of Operations Management", "Journal of Product Innovation Management" and "Technovation", since it represents the major founts in the debated theme of the Innovation Management, as depicted in Figure 1.

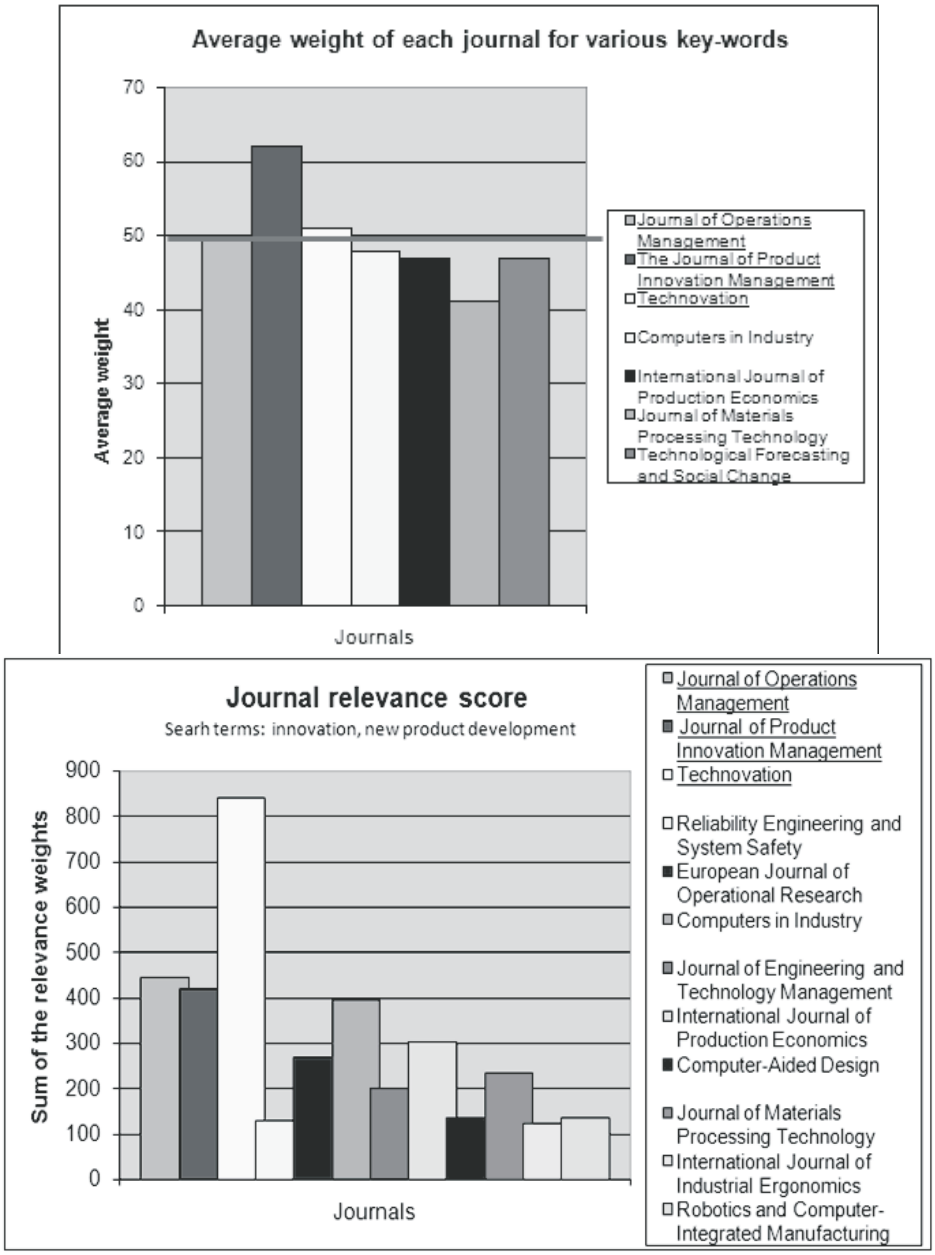

Figure 1 – Journal Selection Methodology.

Once the most important sources for conducting the review have been identified, it is important to define the research criteria. The authors adopted the methodology suggested by Becheich et al. (2006), and therefore considered only empirical articles published in scholarly journals and excluded non-empirical studies (conceptual works, qualitative studies, etc.) as well as those disseminated using a number of different mediums (book, internet, etc.). This choice allowed the authors to have a better comparable body of research, which enhances the quality of the systematic review results. Finally, it is important to mention that the literature review covers only the manufacturing sector.

Innovation in the service sector has in fact particular characteristics, as mentioned in the Oslo Manual and confirmed by several recent studies (BECHEICH et al., 2006), which require dedicated analysis. The authors extended the literature review by covering a period of five years, from January 2002 to June 2007, which guaranteed a sufficient amount of articles for validating the research. During this period, 1310 papers have been published within the selected journals. The authors read the titles and abstracts of these articles, so as to firstly exclude 1.158 of them, which were irrelevant to the research goals. The 152 remaining articles have been entirely read by 2 of the 3 authors to exclude other 55 articles which were evaluated as not inherent the purpose of the research. Therefore, the total number of articles included in the literature review has been 97. The entire review process is presented in Figure 2.

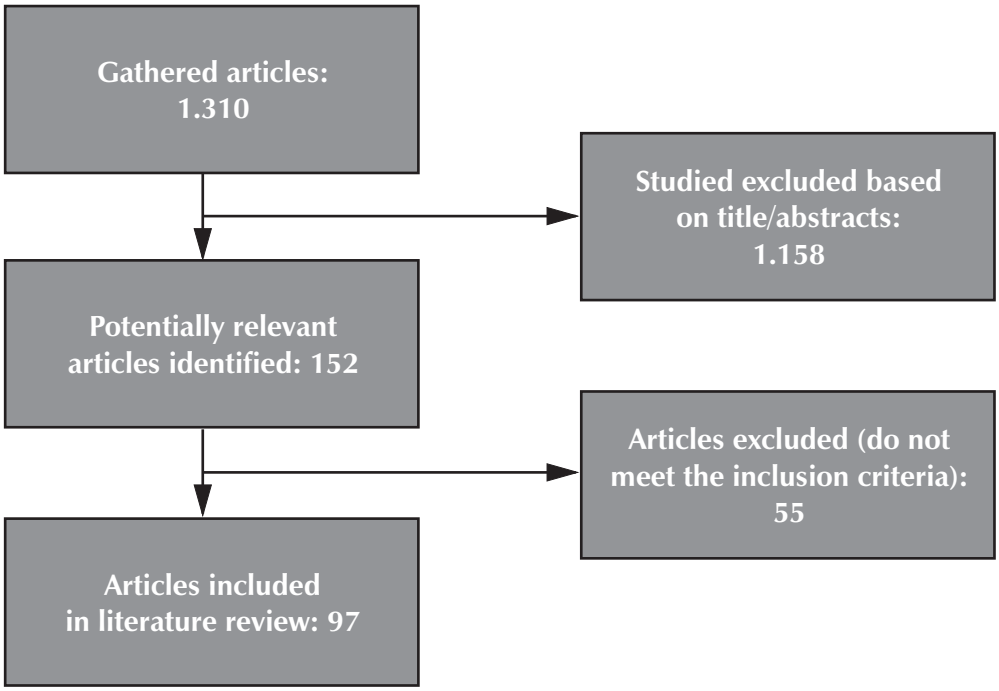

Figure 2 – Research Methodology.

Particularly, among the 97 articles found:

– 33 thoroughly discuss the innovation concept and represent the background for the research;

– 40 examine milestones of the innovation process;

– 24 present one or more innovation models.

The article deepens each of the point in the next sections.

3 Innovation concept

Porter 1990) identifies innovation as: *'a new way of doing things* (termed an invention by some authors) *that is commercialized'*. Freeman and Soete (1997) state that:

> *an innovation in the economic sense is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is used also to describe the whole* process. Of course, further inventions often take place during the innovation process and still more inventions and innovations may be made during the diffusion process.

Edquist (1997) quotes Schumpeter's definition for innovation identifying it as one of the broadest definitions in the literature. Nelson and Rosenberg (1993) argue that often an invention is successfully marketed by a different firm from the inventor and it may happen a long time after the invention first appeared. Thus, the successful diffusion of the new product or process is required in order to be characterized as an innovation.

These definitions regard the economic results of innovation. But its manifestation and its essence are still not fully understood: the heterogeneity in innovation concepts and definitions presented in literature does not help to comprehend this complex phenomenon (COOMBS et al., 1996; BECHEICH et al., 2006). To address the problem of inconsistent results, innovation researchers have developed contingency theories of innovation types. With the aim to clarify the theory surrounding the innovation concept, the classification proposed by Rosanna and Roger (2001) is seen as very appealing; the latter tries to investigate and classify different typologies of innovation, based on its manifestation. For example, Utterback (1994) defined four different innovation typologies according to the object (product/service or process) and to its impact on the market (new one or improvement of an existing one).

The traditional distinction between incremental and radical innovations is not suitable for describing the manifold and variegated cases of innovation manifestations that can be found in the reality of the entrepreneurial world. Researchers have enriched such classification by adding other distinctions of innovation based for example on modular innovation and architectural innovation (BALDWIN and CLARK, 2000; SCHILLING, 2000). A further distinction is between competence enhancing innovations (which is based on an evolution of existing knowledge) and competence destroying innovations (TUSHMAN and ANDERSON, 1986). On the bases of the technological evolution observed in the recent years, especially in the Information and Communication Technology (ICT) sector, a new innovation category has been conceptualized: disruptive innovation or killer application (CHRISTENSEN, 1997).

Although there are many definitions and typologies on the innovation topic, there are two of them that are widely recognized due to their important yet common characteristics at the base of the innovation concept: the "novelty" and the possibility to manage it. The first, the newness, is a property presented in all definitions of innovation and it is a relative concept. An innovation can be considered new to the individual adopter, to most people in the unit of adoption, to the organization as a whole, to most organizations in an organizational population, or to the entire world (ANGLE and VAN de VEN, 2000).

The second characteristic, embedded in the innovation definitions, is the notion that innovation can be managed. For example, Drucker (1994) argues that innovation is a core process for a firm; he suggests that: "in…a period of rapid change the best perhaps the only-way a business can hope to prosper, if not survive, is to innovate. This is the only way to convert

change into opportunities. This, however, requires innovation itself be organized as a systematic activity". In this latest definition innovation management appears as a fundamental task to be introduced in today's companies. Based on the features highlighted, authors give their vision of innovation, answering therefore the first research question [RQ 1]:

[RQ 1 - ANSWER]:

Innovation is a match between a market need and a technology or a business model that creates value both for the producer and the consumer. Innovation is today the most important source of rejuvenation and growth for organizations.

4 Milestones of Innovation Processes: what the literature offers

The definition of successful innovation relates to the discussion of various models of innovation which break down the innovation process into various stages (PALMBERG, 2006). Through the literature review carried out, the authors realized that the innovation process has some common basic activities which guarantee the generation of ideas for new product and process development and the management of the entire innovation process. These fundamental activities are substantially represented by the *generation of ideas [1]*, which potentially could become new products or processes after implementation, by *the acquisition of full knowledge [2]* on the generated ideas and by *the complete implementation and market monitoring [3]* in order to verify customer satisfaction and after sales. Each of these three topics has been more deeply investigated in literature by the various authors, in order to better understand their features and identify the basis for a step-by-step innovation model.

The literature review carried out remarked the availability of 40 papers discussing these milestones, in particular: 17 on "ideas generation", 15 on "acquisition on full knowledge" and 8 on "complete product/process implementation and monitoring", as shown in Table 1.

Table 1 – Resources for the Activities which Constitute the Milestones of Innovation Processes

Ideas Generation and early R&D activity
Stuart, McCutcheon, Handfield, McLachlin, Samson, "Effective case research in operations management: a process perspective". Journal of Operations Management 20 (2002) 419–433.
Savioz, Blum, "Strategic forecast tool for SMEs: how the opportunity landscape interacts with business strategy to anticipate technological trends". Technovation 22 (2002) 91–100.
Narula, "R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation". Technovation 24 (2004) 153–161.
Buyukdamgac," Process of organizational problem definition: how to evaluate and how to improve".Omega 31 (2003) 327 – 338.
McAdam, "Knowledge creation and idea generation: a critical quality perspective". Technovation 24 (2004) 697–705.
Drejer, Jorgensen, "The dynamic creation of knowledge: Analysing public–private collaborations". Technovation 25 (2005) 83–94.
Lichtenthaler, "Corporate diversification: identifying new businesses systematically in the diversified firm". Technovation 25 (2005) 697–709.
Swink, Song, "Effects of marketing-manufacturing integration on new product development time and competitive advantage". Journal of Operations Management 25 (2007) 203–217.
Macpherson, "Learning how to grow: resolving the crisis of knowing". Technovation 25 (2005) 1129–1140.
Calantone, Droge, Vickery, "Investigating the manufacturing–marketing interface in new product development: does context affect the strength of relationships?". Journal of Operations Management 20 (2002) 273–287.
Tsai, "R&D productivity and firm size: a nonlinear examination". Technovation 25 (2005) 795–803.
Leenders, Wierenga, "The effectiveness of different mechanisms for integrating marketing and R&D". The Journal of Product Innovation Management 19 (2002) 305–317.
Dowling, Helm, "Product development success through cooperation: A study of entrepreneurial firms". Technovation 26 (2006) 483–488.
Primo, Amundson, "An exploratory study of the effects of supplier relationships on new product development outcomes". Journal of Operations Management 20 (2002) 33–52.
Liu, Chen, Tsai, "An empirical study on the correlation between the knowledge management method and new product development strategy on product performance in Taiwan's industries". Technovation 25 (2005) 637–644

(cont. Table 1)

Stump, Athaide, Joshi, "Managing seller-buyer new product development relationships customized products: a contingency model based on transaction analysis and empirical test". The Journal of Product Innovation Management 19 (2002) 439–454.
Linderman, Schroeder, Zaheer, Choo, "Six Sigma: a goal-theoretic perspective". Journal of Operations Management 21 (2003) 193–203.
Applied R&D and Knowing Activity
Nobelius, "Linking product development to applied research: transfer experiences from an automotive company". Technovation 24 (2004) 321–334.
Coldrick, Longhurst, Ivey, Hannis, "An R&D options selection model for investment decisions". Technovation 25 (2005) 185–193.
Kessler, "Leveraging e-R&D processes: a knowledge-based view". Technovation 23 (2003) 905–915.
Verma, Sinha, "Toward a theory of project interdependencies in high tech R&D environments". Journal of Operations Management 20 (2002) 451–468.
Keizer, Halmana, Song, "From experience: applying the risk diagnosing methodology". The Journal of Product Innovation Management 19 (2002) 213–232.
Chen, Lee, Tong, "Analysis of new product mix selection at TFT-LCD technological conglomerate network under uncertainty". Technovation 26 (2006) 1210–1221.
Efstathiades, Tassou, Antoniou, "Strategic planning, transfer and implementation of Advanced Manufacturing Technologies (AMT). Development of an integrated process plan". Technovation 22 (2002) 201–212.
Mekhilef, Le Cardinal, "A pragmatic methodology to capture and analyze decision dysfunctions in development projects". Technovation 25 (2005) 407–420.
Menor, Tatikonda, Sampson, "New service development: areas for exploitation and exploration". Journal of Operations Management 20 (2002) 135–157.
Goldstein, Johnston, Duffy, Rao, "The service concept: the missing link in service design research?". Journal of Operations Management 20 (2002) 121–134.
Hong, Vonderembse, Doll, Nahm, "Role change of design engineers in product development". Journal of Operations Management 24 (2005) 63–79.
Haque, K.S. Pawar, Barson, "The application of business process modelling to organisational analysis of concurrent engineering environments". Technovation 23 (2003) 147–162.
Swink, Talluri, Pandejpong, "Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs". Journal of Operations Management 24 (2006) 542–562.
Ottosson, "Dynamic product development of a new Intranet platform". Technovation 23 (2003) 669–678.
Pullman, Moore, Wardell, "A comparison of quality function deployment and conjoint analysis in new product design". The Journal of Product Innovation Management 19 (2002) 354—364.
Implementation and Controlling Activity
Debruyne, Moenaert, Griffin, Hart, Hultink, Robben, "The impact of new product launch strategies

(cont. Table 1)

on competitive reaction in industrial markets". The Journal of Product Innovation Management 19 (2002) 159—170.
Ziamou, "Commercializing new technologies: consumers' response to a new interface". The Journal of Product Innovation Management 19 (2002) 365–374.
Linton, "Implementation research: state of the art and future directions". Technovation 22 (2002) 65–79.
Chiu, Chen, Shyu, Tzeng, "An evaluation model of new product launch strategy". Technovation 26 (2006) 1244–1252.
Narasimhan, Kim, "Effect of supply chain integration on the relationship between diversification and performance: evidence from Japanese and Korean firms". Journal of Operations Management 20 (2002) 303–323.
Takayama, Watanabe, Griffy-Brown, "Remaining innovative without sacrificing stability: an analysis of strategies in the Japanese pharmaceutical industry that enable firms to overcome inertia resulting from successful market penetration of new product development". Technovation 22 (2002) 747–759.
Drejer, Gudmundsson, "Towards multiple product development". Technovation 22 (2002) 733–745.
Koufteros, Vonderembse, Doll, "Integrated product development practices and competitive capabilities: the effects of uncertainty, equivocality, and platform strategy". Journal of Operations Management 20 (2002) 331–355.

Thanks to the accomplished literature review which gave the authors the comprehension of the innovation process characteristics and the analysis carried out on the relevant papers, the authors have been able to formalize the classification of innovation management models, presented in the next section.

5 The classification criterion of innovation management models

The development of the framework proposed in this paper is the result of action research conducted in an enterprise network. The study followed firstly a deductive approach analyzing the evolution of innovation models. In doing this we adopted the classification based on the innovation generation (ROTHWELL, 1992; PERUNOVIC, CHRISTIANSEN, 2005), through which it is possible to classify all the existing innovation models in five different groups, each with specific characteristics, as depicted in Figure 3.

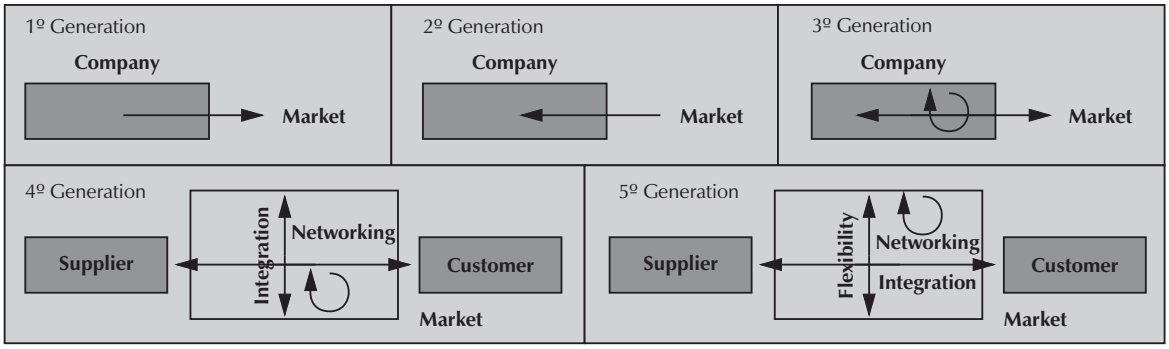

Figura 3 – Five generations of innovation.

The degree of completeness, complexity, effectiveness and efficiency of such models has been refined throughout the years, reaching good results to support innovation management. In particular:

1 – Technology push model.

It was developed in the 1950s by observing technology evolutions. Firms were able to evaluate technological opportunities and companies create innovative products based on available technologies (KAMEOKA, ITO and KOBAYASHI, 2001). The innovation process was perceived as sequential and starting by internal R&D activities.

2 – Market pull model.

It was developed from the mid-1960s to early 1970s: the ideas for an innovation started within the market, among customers and from their needs.

3 – Coupling model (ROTHWELL, 1994).

It was defined in the 1970s as a coupled model of previous push and pull concepts. It was still a sequential model, like the previous one, but with feedback loops. The coupling model recognized necessity of creating innovation by using both approaches, technological company readiness and true customers' needs. New innovative capabilities, such as internal networking and share of information between various teams involved in a new product development (NPD) shyly have started to emerge.

4 – Integrated model.

Innovation starts being considered as a fundamental process within firms. R&D activities, engineering and production processes are integrated within companies (HEIN and ANDREASEN, 1985) and horizontal collaboration are developed with the leading partners. In the fourth generation the collaboration and networking concept emerges and it appears an important task to pursue innovation.

5 – Functional integration innovation model.

This generation should enable companies to decrease both NPD time and cost by supporting the previous integrated model and networking with sophisticated computerised tools.

Through this classification criterion, authors can group innovation management models, found in the literature review, as presented in the next section.

7 Presentation of the Literature Review

In this section the models on innovation management found in the literature review by the authors are classified through the classification proposed by Rothwell. All the models are grouped in Table 2.

Table 2 – All models found in literature review

The first generation
Science-Push linear theory: Cantisani, 2006.
A typical new product development (NPD) management process: Vuola and Hameri, 2006.
Innovation and entrepreneurship: Hindle and Yencken, 2004.
Factors for the decision making of NPD in the pharmaceutical industry: Takayama and Watanabe, 2002.
Product & process development at Volvo Aero Corporation: Karlsson, Trygg and Elfstrom, 2004.
Dual innovation process: Linton, 2002.
The second generation
Demand-Pull linear model: Cantisani, 2006.
The innovation process, adapted from Majaro: McAdam and McClelland, 2002.
The interface between marketing and manufacturing operations in the innovation process: Brown and Fai, 2006.
From research ideas to commercial results: Camarinha-Matos and Afsarmanesh, 2007.
Patterns of technological innovations in small engineering enterprises – Bangalore and England: Subrahmanya, 2005.
The third generation
Coupling model: Galanakis, 2006.
The CRIE model: Kerr and Ivey, 2003.
Stages in the third generation of the innovation process: Edwards, Delbridge and Munday, 2005.
Front End of the Innovation Process: Borjesson, Dahlsten and Williander, 2006.
New Concept Development Model: Borjesson, Dahlsten and Williander, 2006.
Various stages in the cycle of Innovation process: Uddin, 2006.
The innovation and diffusion interactive processes: Uddin, 2006.
Innovation plan diagram in BDG: Kumar and Snavely, 2004.
Candidate factors in each phases of NPD: Sun and Wing, 2005.
Evoluted Coupling Model: Bernstein and Singh, 2006.
An interactive geometric innovation process model: Cantisani, 2006.
Chain-linked model of innovation: Cantisani, 2006.
The fourth generation
An operational model for NPD in toy companies: Sun and Wing, 2005.
Theorising Innovation in SMEs: Edwards, Delbridge and Munday, 2005.
Integrated Innovation Model: Galanakis, 2006.
The systems innovation process model: Dooley and O'Sullivan, 2003.
Fourth generation Model: Dooley and O'Sullivan, 2003.
The role of incubator in the Innovation Process: Rothschild and Darr, 2005.
Classical business idea/technical concept development in fourth generation of Innovation: Ottosson, 2004.
Dynamic product development: Ottosson, 2004.
DPD starts from a 'wish' while IPD starts from a market 'need': Ottosson, 2004.
The innovation and supply chain diamond: Singhal and Singhal, 2002.
KNOWVATION modules and innovation process: Park, Kim, 2006.
The fifth generation
Functional Integration Innovation Model, fifth generation of innovation: Galanakis, 2006.
5G innovation process; systems integration and networking (SIN) underlying strategy elements: Galanakis, 2006.
Elements in the model for learning in the continuous product innovation process: Chapman and Hyland, 2004.
The creative factory concept: Galanakis, 2006.

8 Analysis of the innovation models

The degree of completeness, complexity, effectiveness and efficiency of innovation models have been refined throughout the years, reaching good results to support innovation management: the classification proposed by Rothwell et al. in fact starts from the simple "technology push" concept of innovation (the first generation), to the more complex and complete "functional integration innovation model" (the fifth generation of innovation), through the other three, 'Market pull model', 'Coupling model' and the 'Integrated model' (the second, the third and the fourth generation of innovation). The classification of all the models found with the systematic review through the five generations of innovation grouping is presented in Table 3.

The evolution, from the first to the fifth generation of innovation, is evident and the growing complexity and completeness are the most important changes between them, as underlined through the strength/weakness analysis

Table 3 – Generations of innovation

	Features	Strengths	Weaknesses
First Generation	-Linear -Consecutive -Technology push	-Simple -Radical innovation	-Lack of feedbacks -No market attention -No networked interactions -No technological instruments
Second Generation	-Linear -Consecutive -Market pull	- Simple -Incremental Innovation	-Lack of feedbacks -No technology research - No networked interactions -No technological instruments
Third Generation	-Linear - Consecutive -Fusion of market analysis and technology push	- Simple - Radical and Incremental innovation -Feedbacks between phases	- No networked interactions yet -No technological instruments
Fourth Generation	- Consecutive -Parallel sub-activities -Social Interaction	- Actor networking -Parallel phases	- Complexity increment of reliability -No technological instruments
Fifth Generation	-Parallelism -Social interactions -Strong Technological means	-Pervasive innovation -Use of sophisticated technological instruments -Networking to pursue innovation	- Complexity increment of reliability

Thanks to the analysis proposed, authors can answer to the second research question [RQ2]:

[RQ 2 - ANSWER]:

The main evolutions of the innovation management models are to be viewed under three different points of view: features, strengths and weaknesses.

The main progresses in the features regard the parallelism between phases in the models, the consideration of both market pull and technology push, the importance of social interactions to create new value and strong technological means.

The evolutions however imply from a side an increment of the models efficiency, the individuation of new sources to innovate, new methodologies and techniques, from the other side it surely implies the growth of complexity and difficulty in the applicability of the models.

9 Conclusions

Innovation concept is in continuous evolution today and it can take on different manifestations, depending on its dimensions, frequency, realization modality and outputs. Many studies on this topic have been developed in recent decades and, today, criteria to classify it and the environments to guarantee innovation development are increasingly clear. Linear innovation models have moved forward greatly, since efforts have been made by researchers as well as firms to include many feedback factors within the innovation models. However, the innovation process is thus still poorly understood as mentioned by Coombs et al. (1996) and the current state of the literature contributes little to improving an understanding of the phenomenon.

In such a scenario, this article contributes a better understand of the innovation concept and its evolutions and the ways to manage it. ❖❖

References

ANGLE, H.L.; VAN de VEN, A.H. "Suggestions for managing the innovation journey". In: VAN de VEN, A.H.; ANGLE, H.L.; POOLE, M.S. (Eds.). **Research on the management of innovation**: the Minnesota studies. New York : Oxford University Press, 2000.

BALDWIN, C. Y.; CLARK, K. B. **Design rules**: the power of modularity. Cambridge, Massachusetts: The MIT, 2000. v. 1.

BECHEICH, N.; LANDRY, R.; AMARA, N. Lessons from innovation empirical studies in the manufactoring sector: a systematic review of the literature from 1993-2003. **Technovation**, v. 26, p. 644-674, 2006.

BERNSTEIN, B.; SINGH, P. J. An integrated innovation process model based on practices of Australian biotechnology firms. **Technovation**, v. 26, p. 561-572, 2006.

BORJESSON, S.; DAHLSTEN, F.; WILLIANDER, M. Innovative scanning experiences from an idea generation project at Volvo Cars. **Technovation**, v. 26, p. 775-783, 2006.

BROWN, S.; FAI, F. Strategic resonance between technological and organisational capabilities in the innovation process within firms. **Technovation**, v. 26, p. 60-75, 2006.

CAMARINHA-MATOS, L. M.; AFSARMANESH, H. Results assessment and impact creation in collaborative research: an example from the ECOLEAD project. **Technovation**, v. 27, p. 65-77, 2007.

CANTISANI, A. **Technological innovation processes revisited**. Technovation, Amsterdam, v. 26, n. 11, p. 1294, nov. 2006.

CHAPMAN, R.; HYLAND, P. Complexity and learning behaviors in product innovation. **Technovation**, v. 24, p. 553-561, 2004.

CHRISTENSEN, C. M. **The innovator's dilemma**: when new technologies cause great firms to fail. Boston, MA: Harvard Business School, 1997. p. 1-225.

COOK, D. J.; MULROW, C. D.; HAYNES, R. B. Systematic reviews: synthesis of best evidence for clinical decisions. **Annals of Internal Medicine**, v. 126, n. 5, p. 379-380, 1997.

COOMBS, R.; NARANDREN, P.; RICHARDS, A. A literature-based innovation output indicator. **Research Policy**, v. 25, p. 403-413, 1996.

DOOLEY, L.; O'SULLIVAN, D. Developing a software infrastructure to support systemic innovation through effective management. **Technovation**, v. 23, p. 689-704, 2003.

DRUCKER, P. **Innovation & entrepreneurship**. New York: Harper & Row, 1994.

EDQUIST, C. Systems of innovation approaches: their emergence and characteristics. In: EDQUIST, C. (Ed.). **Systems of innovation**. Pinter: Technologies, Institutions and Organizations, 1997.

EDWARDS, T.; DELBRIDGE, R.; MUNDAY, M. Understanding innovation in small and medium-sized enterprises: a process manifest. **Technovation**, v. 25, p. 1119-1127, 2005.

EU. European Union. Green paper on innovation. Brussels: European Commission, 1995.

FINK, A. **Conducting research literature reviews**: from paper to the internet. London: Sage Publications, 1998.

FREEMAN, C.; SOETE, L. **The economics of industrial innovation**. 3th ed. Pinter, 1997.

GALANAKIS, K. Innovation process: make sense using systems thinking. **Technovation**, v. 26, p. 1222-1232, 2006.

HART, C. **Doing a literature review**: releasing the social science research imagination. London: Sage Publications, 1998.

HEIN, L.; ANDREASEN, M. M. **Integreret produktudvikling**. København: Jernets Arbejdsgiverforening, 1985.

HINDLE, K.; YENCKEN, J. Public research commercialization, entrepreneurship and new technology based firms: an integrated model. **Technovation**, v. 24, p. 793-803, 2004.

KAMEOKA, A. I. D.; KOBAYASHI, K. **A cross-generation framework for deriving next generation innovation process model**. Ishikawa: Japan Adv. Inst. of Sci. & Technol., 2001.

KARLSSON, M.; TRYGG, L.; ELFSTROM, B. O. Measuring R&D productivity: complementing the picture by focusing on research activities. **Technovation**, v. 24, p. 179-186, 2004.

KERR, C. I.; IVEY, P. C. The engineering doctorate model of consultant/researcher/innovator/ entrepreneur for new product development: a gas turbine instrumentation case study. **Technovation**, v. 23, p. 95-102, 2003.

KUMAR, S.; SNAVELY, T. Outsourcing and strategic alliances for product development: a case of Banta Digital Group. **Technovation**, v. 24, p. 1001-1010, 2004.

LIGHT, R. J.; PILLEMER, D. B. **Summing up**: the science of reviewing research. Cambridge, Mass: Harvard University Press, 1984.

LINTON, J. Implementation research: state of the art and future directions. **Technovation**, v. 22, p. 65-79, 2002.

MCADAM, R.; MCCLELLAND, J. Sources of new product ideas and creativity practices in the UK textile industry. **Technovation**, v. 22, p. 113-121, 2002.

MULROW, C. D. Rationale for systematic reviews. **BMJ**, v. 309, p. 597-599, 1994.

NELSON, R. R.; ROSENBERG, N. Technical innovation and national systems. In: NELSON, R. R. (Ed.). **National innovation systems**: a

comparative analysis. Oxford: Oxford University Press, 1993.

OECD. **National innovation systems**. Paris: OECD, 1997a.

OECD. 1997b. **Oslo man**ual: proposed guidelines for collecting and interpreting technological innovation Data. Paris: OECD, 1997b.

OTTOSSON, S. Dynamic product development: DPD. **Technovation**, v. 24, p. 207-217, 2004.

PALMBERG, C. The sources and success of innovations: determinants of commercialization and break-even times. **Technovation**, v. 26, p. 1253-1267, 2006.

PARK, Y.; KIM, S. **Knowledge management system for fourth generation R\&D**: knowvation. Technovation, v. 26, p. 595-602, 2006.

PERUNOVIC, Z.; CHRISTIANSEN, T. B. Danish innovative manufacturing performance. **Technovation**, v. 25, p. 1051-1058, 2005.

PORTER, M. E. The competitive advantage of nations. New York: Macmillan, 1990.

ROSANNA, G.; ROGER, C. A critical look at technological innovation typology and innovativeness terminology: a literature review. **The Journal of Product Innovation Management**, v. 19, p. 110-132, 2001.

ROTHSCHILD, L.; DARR, A. Technological incubators and the social construction of innovation networks: an Israeli case study. **Technovation**, v. 25, p. 59-67, 2005.

ROTHWELL, R. Successful industrial innovation: critical success factors for the 1990's. **R&D Management**, v. 22, n. 3, p. 221-239, 1992.

_____. Industrial innovation: success, strategy, trends. In: DOGSON, M.; ROTHWELL, R. (Eds.). **The handbook of industrial innovation**. United Kingdom: Edward Elgar, 1994.

SCHILLING, M. Towards a general modular systems theory and its application to inter-firm product modularity. **Academy of Management Review**, v. 25, p. 312-334, 2000.

SINGHAL, J.; SINGHAL, K. Supply chains and compatibility among components in product design. **Journal of Operations Management**, v. 20, p. 289-302, 2002.

SUBRAHMANYA, M. H. B. Pattern of technological innovations in small enterprises: a comparative perspective of Bangalore (India) and Northeast England (UK). **Technovation**, v. 25, p. 269-280, 2005.

SUN, H.; CHUNG, W. W. Critical success factors for new product development in the Hong Kong toy industry. **Technovation**, v. 25, p. 293-303, 2005.

TAKAYAMA, M.; WATANABE, C. Myth of market needs and technology seeds as a source of product innovation: an analysis of pharmaceutical new product development in an anti-hypertensive product innovation. **Technovation**, v. 22, p. 353-362, 2002.

TUSHMAN, M.; ANDERSON, P. Technological discontinuities and organizational environments. **Administrative Science Quarterly**, v. 31, p. 439-465, 1986.

UDDIN, M.; KAMAL. The role of diffusion of innovations for incremental development in small enterprises. **Technovation**, v. 26, p. 274-284, 2006.

UTTERBACK, J. M. **Mastering the dynamics of innovation**. Harvard: Harvard Business School Press, 1994.

VUOLA, O.; HAMERI, A. P. Mutually benefiting joint innovation process between industry and big-science. **Technovation**, v. 26, p. 3-12, 2006.