
Measuring Innovation: Trends and Characteristics

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Abstract: The measurement of innovation is one of the topics that have generated more interest and controversy in the discipline of innovation management. However, due to the strong scattering studies, several approaches to this measurement have been created, which is sometimes confusing and contradictory. On the other hand, most of the literature reviews of the discipline, being mainly descriptive; do not provide a clear overview of the state of the art on the subject.

Having these facts in mind, this paper is a literature review, based on the methodology of systematic analysis of the literature, allowing a clearer picture regarding the measurement of innovation, establishing the main trends and characteristics. The study identifies that, based on the literature, the innovation viewed as an organizational capability is the most important trend at the discipline.

Keywords: Measuring innovation, systematic review, meta-analysis, trends, measurable characteristics of innovation.

1 Introduction

Within management science, a specific discipline has arisen: Innovation Management, being understood as the activities that enable an organization to generate new or improved products, production processes, internal management mechanisms or communication with their environment (Ochoa, 2011). Despite the efforts invested in creating a sufficient knowledge base for understanding the phenomenon of innovation, there are several issues to be studied and clarified, including how to measure and visualize the innovative efforts of an organization (Subramanian and Nilakanta, 1996; Romijn and Albaladejo, 2002; Hipp and Grupp, 2005; Andersson et al., 2011).

In the search for mechanisms to measure innovation, some trends have emerged, focusing on different dimensions and variables associated with innovation. One of the most important was developed by the OECD in the Frascati and Oslo manuals (OCDE, 2002, 2005). This vision outlined by the OECD aims to measure both the sources of the processes of R&D and innovation outputs. Among the elements measured is the number

of personnel involved in R&D processes and the cost generated by the use of such persons. Also, the OECD proposes to determine the total amount of expenditure on R&D, identifying what portion of these items are worn inside the R&D unit, and its correspondence with the worn out from this.

However, due to problems of applicability of the instruments raised by the OECD in various sectors and environments, as well as possible limitations to the measurement underlying purely economic (Jensen and Webster, 2009), there is a need for new measuring devices, which include, for example, profiles of people according to their propensity towards innovation, combining features such as their occupation or level of formal qualification (Rogers, 1962, 2002). Additionally, there is a need for including measurements of, not only financial resources, but also goods necessary for the development of innovative processes (Adams et al., 2006)

This document presents an inventory of the characteristics included in methodologies, methods and schemes for measuring innovation in organizations of different types. To meet this objective, the paper shows, first, the multi-methodological design used to perform the analysis. Subsequently, the sample of the documents analyzed is described and the results are presented, identifying the most frequent characteristics of measurement of innovation and the most widely accepted paradigms in the development of literature.

2 Methodological design

The study was conducted based on a multi-methodological approach (Mingers, 2006) that combined methodologies such as SSM (Checkland, 1981), Grounded theory (Murcia and Jaramillo, 2000), Systematic review and Meta-analysis of the literature (Tranfield et al., 2003). With the implementation of the last methodology, 59 relevant papers were identified, which were analyzed for major trends.

The work was performed according to guidelines proposed by the systematic review methodology, which includes activities to design the search strategy and selection of documents and the criteria for inclusion and exclusion of studies.

As a database to perform the selection of papers, SCOPUS electronic database was selected using the key terms "innovation measurement" and "measuring innovation", in fields such as title, abstract and keywords. Additionally, four criteria for inclusion of documents were designed, which are specified in the Table 1.

In the respective searches 106 and 58 items were found respectively. By consolidating the results and eliminating duplicate papers, 157 documents were found. Then, the abstract review of each of the 157 papers was conducted, 98 of these were discarded for not meeting the criteria designed, leaving 59 selected for full review. Ten documents were annexed because they are considered referents in the area, action that is allowed by the systematic review methodology, because this methodology seeks to build a research as complete as possible about the problem to be addressed (Tranfield et al., 2003). Added documents are listed in Table 2.

Table 1 Inclusion criteria document

Criteria for inclusion or exclusion of documents

Defining a model or method for measuring the innovation
 Comparing models measuring innovation
 Review (critique or support) models or methodologies for measuring innovation

Source: Own construction.

The process of analysis of the documents identified above was performed at two different times. The first stage focused on the approach of the OECD's Oslo and Frascati manuals (OCDE, 2002, 2005) and developments that arose in the following years (OCDE, 2007, 2010). Then, the remaining items were joined in order to establish a parallel between the dominant approach of multinational organizations and positions proposed in the literature. Thanks to this comparison, it was possible to identify common or complementary alternatives to that rose by the OECD and that have been accepted by the academy.

Table 2 Documents added to the initial results

<i>Authors</i>	<i>Title</i>	<i>Year</i>
OECD	Frascati Manual	2002
OECD	Oslo Manual (Third Edition)	2005
OECD	Science, Technology and Innovation Indicators in a Changing World Responding to Policy Needs	2007
OECD	Measuring Innovation: A New Perspective	2010
Rict / OAS / CYTED	Bogotá Manual	2001
The Advisory Committee on Measuring Innovation in the 21st Century Economy	Innovation Measurement - Tracking the State of Innovation in the American Economy	2008
Eurostat	Community Innovation Survey	2006
Eurostat	Regional Innovation Scoreboard	2009

Source: Own construction.

In the first stage of the study, the basis of grounded theory was used, which "identifies the style of data collection and theoretical analysis"¹ As well as allowing the establishment of clear categories and codes for data analysis and cultural realities facing a proposed theory (Strauss and Corbin, 1997; Murcia and Jaramillo, 2000; Glaser and Strauss, 2009).

As a result of applying grounded theory approach to the OECD, a hierarchy based on three families (Input Variables, Intermediate Variables and Output Variables) and eight categories was designed.

¹ Napoleon Murcia and Luis G. Jaramillo, *Qualitative Research: A Guide to address social studies 1st ed.* (Armenia: Editorial Kinesis, 2000), p.73

After defining the categories of analysis, the selected papers were compared with the OECD approach using Atlas TI software. This comparison identifies the matching elements with the original categories, and also looks for additional categories to provide greater variety to the measured or measurable aspects of innovation. As a result, 18 additional categories were found. The final design of the hierarchy of families and categories is summarized in Table 3.

Table 3 Family hierarchy and categories used in the study

<i>Family</i>	<i>Key</i>	<i>Category</i>
Inputs	E1	Expenditure on innovation
	E2	Investment in innovation
	E3	Innovation staff (Recruitment / training / number)
	E4	Innovation staff (Personal characteristics)
	E5	National or regional efforts and policies
	E6	Knowledge (Internal or market)
	E7	Portfolio Management
	E8	Material resources (technology, equipment, etc.)
	E9	Collaboration with companies / universities
Intermediate	I1	Innovation Staff (Salaries / benefits / bonuses)
	I2	R&D activities expenditure
	I3	Innovation Strategy
	I4	Culture and organizational structure
	I5	Organizational performance
	I6	Feedback of past processes
	I7	Knowledge Management
	I8	Project Management
Outputs	S1	Return of investment
	S2	Number of Patents or License
	S3	Marketing
	S4	Number of innovations generated / adopted
	S5	Average time of adoption / generation
	S6	Consistency in decision / generation
	S7	Degree of novelty of innovation
	S8	Impact generated by innovation
	S9	Object of innovation

Source: Own construction.

Additionally, the various studies discussed were classified according to the approach used to understand, and therefore, measure innovation. In the literature, there are positions that describe innovation as a systematic process of transformation of inputs to outputs by using a set of activities (Hipp and Grupp, 2005; Adams et al., 2006). Additionally, there are authors that focus on the outcome of the process itself and seek to quantify or evaluate innovation through this output (Jibu, 2009; Elizondo et al., 2010; Dereli et al., 2011). Moreover, innovation can be conceived as an ability or competence attributable to the organization (H.-T. Ko and Lu, 2010), which makes it necessary to see the organizational innovation as an ability to generate, absorb and diffuse innovations (Hsu, 2011; Camisón and Monfort-Mir, 2012).

3 Sample of documents reviewed.

After reviewing the distribution of the 59 papers by year of publication, it is clear that there is a growing interest on the subject, as shown in the Figure 1. This growing trend can be related to the publication of the Frascati and Oslo manuals (OCDE, 2002, 2005), as the first approach to standardized instruments and ways of measuring innovation (Monnier and Josset, 2008; Monnier and Zolghadri, 2010). As a complement, this behavior can be explained by increased levels of global competition, which has led organizations to seek new and better ways of generating innovations as source of sustainable competitive advantage (Jensen and Webster, 2009; Choi and S.-seok Ko, 2010). Added to this, an exponential growth in business models based on services has been showed, which requires different mechanisms for measuring and displaying innovations, because most of the resources invested in those innovations are intangible, a condition that distances the possibility of using measurement schemes brought from manufacturing (Kuczmarski, 2001; Birchall and Tovstiga, 2006; Arzola and Mejías, 2007; Hertog et al., 2011).

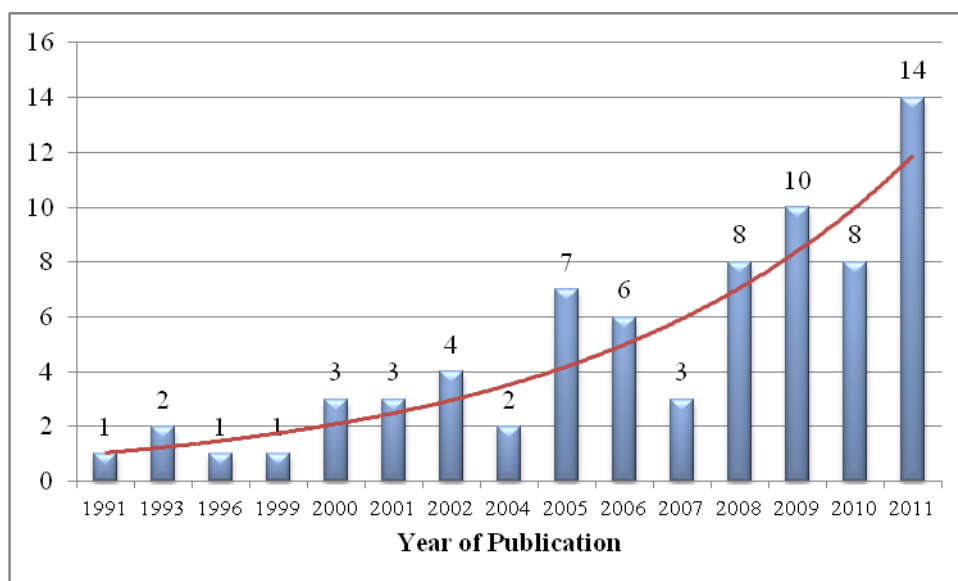


Figure 1 Number of articles published per year

Of the 59 documents studied, nine correspond to focus on innovation as a process, 21 to innovation as a result and 29 to approach innovation as an organizational capability. The relationship of the documents sorted by focus is on Table 4.

Table 4 Items analyzed by measurement approach

<i>Approach</i>	<i>Authors</i>
Innovation as a process	(Cañibano and García-ayuso, 2000) (OCDE, 2002) (OCDE, 2005)

<i>Approach</i>	<i>Authors</i>
Innovation as a result	(Hipp and Grupp, 2005)
	(Adams et al., 2006)
	(Arzola and Mejías, 2007)
	(Ortiz et al., 2007)
	(Guan and Chen, 2010)
	(Potnis, 2010)
	(Coombs et al., 1996)
	(Johannessen et al., 2001)
	(Walker et al., 2002)
	(Acs et al., 2002)
	(Flor and Oltra, 2004)
	(Coccia, 2005)
	(Becheikh et al., 2006)
	(Shapiro, 2006)
	(Pikkemaat and Peters, 2006)
	(Volo, 2006)
(Van Der Panne, 2007)	
(Ghazalian and Furtan, 2007)	
(Campbell et al., 2008)	
(Monnier and Josset, 2008)	
(Conte, 2009)	
(Jibu, 2009)	
(Monnier and Zolghadri, 2010)	
(Roper et al., 2010)	
(Elizondo et al., 2010)	
(Hertog et al., 2011)	
(Dereli et al., 2011)	
Innovation as an organizational feature	(Hitt et al., 1991)
	(Subramanian and Nilakanta, 1996)
	(Wilson et al., 1999)
	(Souitaris, 2001)
	(Kuczmariski, 2001)
	(Romijn and Albaladejo, 2002)
	(Bilalis et al., 2004)
	(Caloghirou et al., 2004)
	(Negassi, 2004)
	(Bhaskaran, 2006)
	(Birchall and Tovstiga, 2006)
	(Mankin, 2007)
	(Rejeb et al., 2008)
	(Su and Cui, 2008)
	(J.-ying Liu, 2009)
	(Wang and Bu, 2009)
(Balatsas et al., 2009)	
(Regnell et al., 2009)	
(Alegre et al., 2009)	

<i>Approach</i>	<i>Authors</i>
	(Chuang et al., 2010)
	(C.-chu Liu et al., 2010)
	(Choi and S.-seok Ko, 2010)
	(Zeng et al., 2010)
	(H.-T. Ko and Lu, 2010)
	(Antonelli and Colombelli, 2010)
	(Andersson et al., 2011)
	(J.-ying Liu, 2011)
	(Hsu, 2011)
	(Camisón and Monfort-Mir, 2012)

Source: Own construction.

4 Results and discussion.

As mentioned above, the documents identified in the light of the characteristics found using the grounded theory were analyzed. Figure 2 shows the distribution of characteristics used by each of the approaches. It can be seen that the mechanisms for measuring innovation based on the organizational innovation approach tend to uniformly cover the three types of variables, behavior that is attributable to the systemic vision that is given to innovation in this type of propositions.

Meanwhile, those paradigms under the approach of innovation as a result focus on visible manifestations, completely removing the intermediate variables of the process, without neglecting the inputs to generate these outputs.

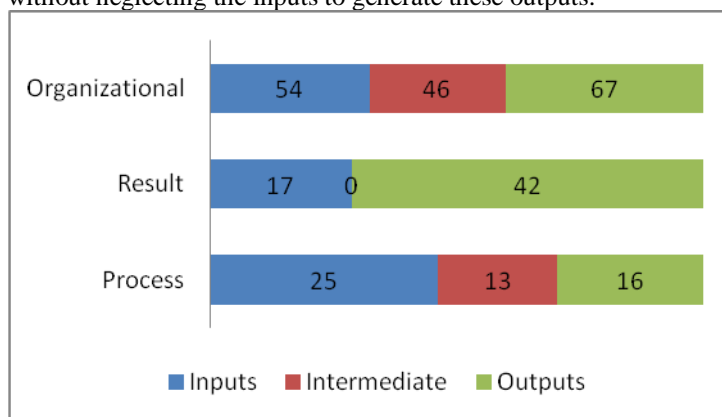


Figure 2 Distribution of characteristics for each approach

A similar behavior occurs in the proposals that focus on innovation as a process that transforms inputs into outputs; this group includes the OECD approach. Although this approach takes into account processing activities, it continues to observe a greater weight in assessing outputs as the way of visibility of innovation.

Figures 4-6 show the aggregate number of occurrences of each of the categories in the three types of approaches to measure innovation. It is possible to observe that the trend in

organizational innovation approach covers a larger number of characteristics, sheltering the two remaining approaches, which means that understanding innovation as an intrinsic element of the organization requires to consider a wider range of parameters to explain and measure the innovative phenomenon. This fact confirms that the organizational innovations approach is the trend in the analyzed literature.

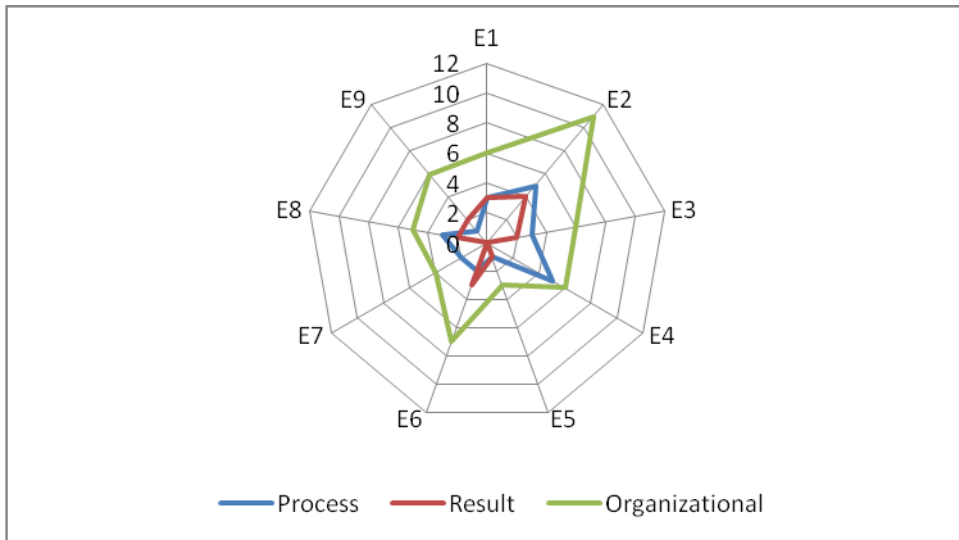


Figure 3 Occurrence of the input characteristics for each approach

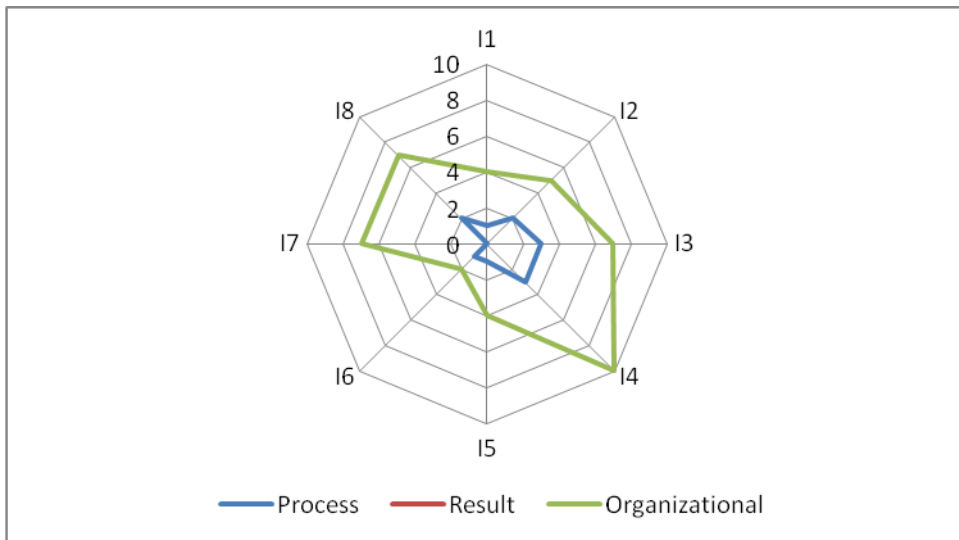


Figure 4 Occurrence of intermediate characteristics by type of approach

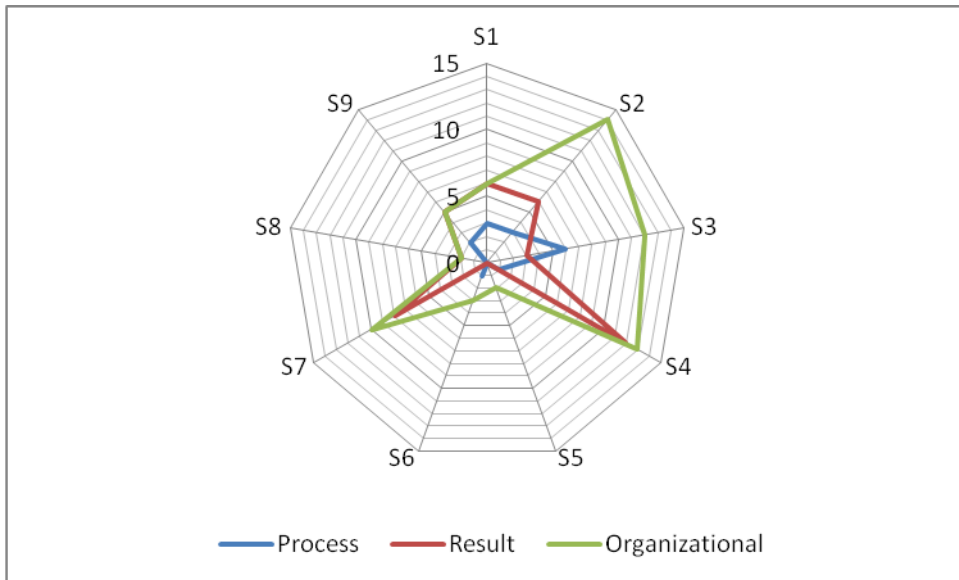


Figure 5 Occurrence of the output characteristics of each approach

After analyzing each of the characteristics independently, it was found that investment in innovation (E2), culture and organizational structure (I4) and the number of innovations generated or adopted (S4), complemented by the number of patents or licenses (S2), are the most frequent items mentioned in the literature. The summary of the occurrence of each characteristic is showed in Figure 7.

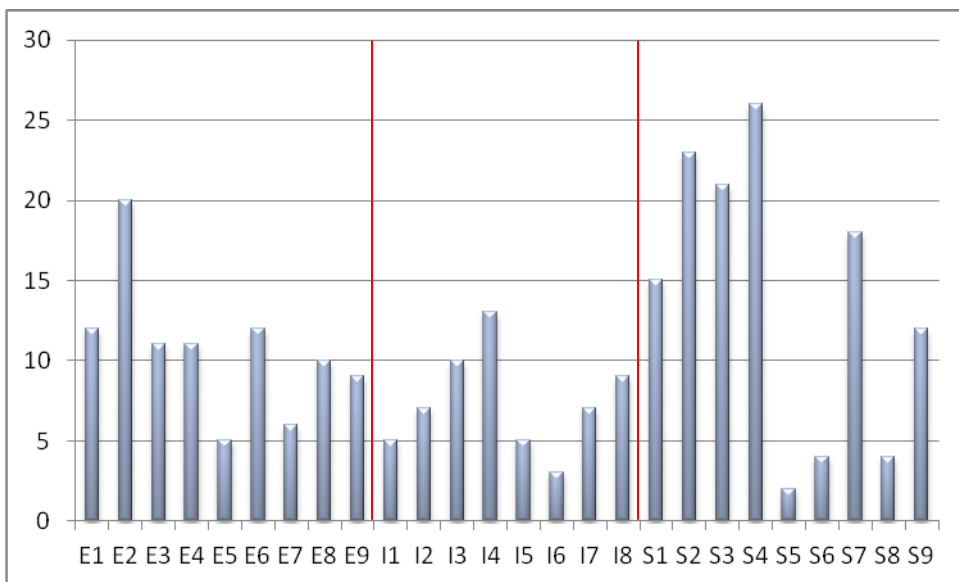


Figure 7 Summary of the occurrence of each characteristic

The investment in innovations is understood as the efforts of the organization to generate or adopt innovations (Souitaris, 2001; Conte, 2009; Guan and Chen, 2010).

Also, the culture and organizational structure includes, not only the formal conditions of internal organization, but the informal lines of communication, the willingness of the organization towards innovation, the mechanisms of motivation and other aspects that internally promote the formulation, development and implementation of solutions or innovative ideas (Adams et al., 2006; Regnell et al., 2009; H.-T. Ko and Lu, 2010). Finally, the number of innovations are created or adopted by the organization, supplemented by the number of patents or licenses. These two features are related to the ability to clearly identify successful attempts of innovation within an organization (Birchall and Tovstiga, 2006), including innovations that go beyond the scope of what is patentable, either by their intangible nature, or by an internal choice of the organization (Jensen and Webster, 2009; Conte, 2009; Hertog et al., 2011).

Conclusions

The measurement of innovation is one of the essential aspects to make a correct and appropriate management of it. However, due to scattering of proposals in the literature, it has been difficult to build mechanisms to perform a standardized and comparable measurement across sectors and environments.

Among the proposals found in the literature, there are three approaches to measure innovation: innovation as a process, innovation as a result and innovation as an organizational capacity. Each of these approaches has its own vision of the concept of innovation and its implications.

After reviewing the literature, it is possible to conclude that the main trend is the approach to innovation as an organizational capacity, not only for having the greatest number of items which qualify for this view, but because they include a systemic view of innovation spanning a wider range of measurable characteristics.

It was also found that investment in innovation, culture and organizational structure and the number of innovations, patents and licenses generated, are the features that have had the greatest acceptance in the literature.

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