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Artículo

The role of a public university in a global environment: networks and externalities of the R&D of the Cauca University

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ABSTRACT

This article analyzes indicators of science and technology, showing the participation of the University of Cauca in the generation of network externalities. The methodology addresses quantitative and qualitative designs. Consists of a descriptive study that covers the main indicators of R&D and network externalities from the view of the specialized literature, and an analytical study that uses the technique known as method of consensus panel of experts. The answers of the experts are processed to determine the level of consistency and identify indicators of R&D that facilitate the measurement of network externalities, such as the production of new knowledge-related products; number of networks through programs of postgraduates in national conventions; and number of graduates in specializations, master's and doctoral programs.

El rol de la universidad pública en un entorno global: redes y externalidades en I+D en la Universidad del Cauca

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RESUMEN

Este artículo analiza indicadores de investigación y desarrollo que evidencian la participación de la Universidad del Cauca en la generación de externalidades de redes. La metodología incluye diseños cualitativos y cuantitativos. Consta de un estudio descriptivo que abarca los principales indicadores de investigación y desarrollo y las externalidades o efectos de redes desde la literatura especializada, y de un estudio analítico que utiliza la técnica conocida como el método de consenso entre el panel de expertos. Dado lo anterior, se procesan las respuestas de los expertos para determinar el grado de concordancia e identificar los indicadores de investigación y desarrollo que faciliten la medición de externalidades de redes, tales como los productos relacionados con la producción de nuevo conocimiento; número de redes a partir de programas de posgrado en convenios nacionales, y número de graduados en programas doctorales, másteres y especialidades.

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O papel da universidade pública num meio global: redes e externalidades em I+D na Universidade de Cauca

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RESUMO

Este artigo analisa indicadores de investigaçao e desenvolvimento que evidenciam a participação da Universidade de Cauca na criação de externalidades de redes. A metodologia inclui desenhos qualitativos e quantitativos. Consta de um estudo descritivo que abrange os principais indicadores de I&D e as externalidades ou efeitos de redes desde a literatura especializada, e de um estudo analítico que utiliza a técnica conhecida como o método de consenso entre o painel de especialistas. Devido ao anterior, processam-se as respostas dos especialistas para determinar o nível de concordância e identificar os indicadores de I&D que facilitem a medição de externalidades de redes, tais como os produtos relacionados com a produção de novo conhecimento; números de redes a partir de programas de pós-graduação em acordos nacionais; e um número de licenciados em programas de doutoramento, mestrado e especialidades.

1. Introduction

The public university has a fundamental role in the search for social transformation in the generation of knowledge through the development of processes of teaching, research and social interaction, which, increasingly, are performed under network systems.

According to Guzmán and Trujillo (2011), the Universities work with organizational stiles that should encourage the presence of teaching and the production of knowledge through research, however more than achieving a joint in these two activities, what is evident is a differentiation between the institutions that give priority to one or the other. In the same sense Clark (1997), cited by Guzmán and Trujillo (2011), states that the institutions that focus their perspective on the research believe in the critical importance of the production of knowledge, and therefore arises the primacy of research and the decision of supporting the teaching and learning in it.

In this sense the same authors state that in Colombia there are both, public and private universities, that have reconfigured their vision and have looked to develop policies that allow incorporating research among its priorities. The latter represent consolidated institutions that have clarity in their vision, recognizing the importance of teaching and research in its policies, plans and programs of institutional development, and they have focused on fundamentals, such as the formation of a critical mass of researchers, the establishment of policies for teaching staff development and international presence.

The research, as a process consisting of multiple phases, involving the most diverse interest groups, requires the formulation and definition of problems, assumptions, systematizations and compilations of data, formulation of deductions, general propositions and, in addition, results analysis or conclusions to determine whether the assumptions made are confirmed or not and also whether they fit within the theoretical framework or the base line (Ander-Egg, 1980). This whole process, from the perspective of a public University requires the provision of networks, synergies and effective partnerships between the inputs such as human or personal talent of research, the technological, financial, and physical resources that contribute to obtain products that most of the time are represented in new knowledge (Arrow, 1962).

In the development of research systems and the delivery of expected results, for authors as Chinman and Wandersman (2004) and Ernst (2002), it is possible to detect certain trends that have marked the change of organizations focused on tangible assets to organizations designed to value more the potential to generate knowledge, skills, and know-how; and processes of internalization and normalization of knowledge and relationships with the environment.

Information useful to generate and disseminate knowledge even at the global level is transmitted through networks of research and development. This function is one of the most relevant in the conception of a public University immersed in a society where prevails the informational economy, which, it has been said, can be considered "global" to the extent that several actors are involved in a meta network. Only organizations that are part of this type of global networks are dominant and reach global recognition.

According to Castells (1997), in the dynamics of the university research it is very important "a new social morphology" conceived as a set of interconnected nodes or networks of collaborative work, which cohesion mechanism seeks in first instance to generate the conditions or the critical mass that respond to the social demands; while authors such as Souza (2001) express that however the above, and despite multiple work developed previously, there are problems on the identification, conceptualization and modeling of these research and development networks and their impacts.

However, it is appropriate to mention that reviewing the scientific literature about this particular issue, there are studies, international manuals, theory of authors as Jaffe (1996), the OCED papers and mainly, those the approaches of Coccia and Rolfo (1999), that are useful to describe the types of effects that can generate the projects funded by public research promotion agencies. The effects of research and development influence the global economy and the society becoming relevant aspects for the construction of public policy (Tassey, 1995).

In the framework of the above statements, has been identified that in the System of Research of the University of Cauca, there is not the conceptualization and modeling of these networks of research and development and their impacts. Therefore, one of the main interests of the research project[1], specifically in the field of the generation of network externalities, is to analyze what indicators of science and technology applicable to research groups, allow recording and demonstrating in an optimum way the participation of the University in the generation of network externalities, to assess the contribution to interest groups and receiving communities immersed in the global environment, in other words, the impact.

In this same sense, the project has as main objectives to characterize the profile and the type of the science and technology variables that can assessed as indicators of generation of network externalities and to establish, under the theoretical premises provided by Adam Jaffe for the Advanced Technology Program, which

[1] Project denominated "Construction of a system of indicators for the measurement of the research capacities of the University of Cauca from the perspective of knowledge management" developed by the research group Regional Models of Competitiveness, with support of the research groups GICEA and GTC of the University of Cauca.

of the variables and data available in the Research System of the University of Cauca can be taken as indicators of generation of network externalities. Being this role so important in the social dynamics, the Institution perceives the need to seek for mechanisms to identify and measure the impacts of this networks in the field of research and development, aiming to demonstrate the contribution to the development and to the economy.

Castro, Conesa, Fernández and Gutiérrez (2008), claim that through the participation in the National System of Science, Technology and Innovation[2], the public universities assume the task of addressing all that has to do with the promotion and encouragement of research that generates knowledge, which also, would be expected to contribute economically to the level of competitiveness and productivity of the country and its regions (Dorado, 2005).

There is an implicit challenge on identifying, shaping and modeling the relationships and human networks related to knowledge, their relevance and management, given the nature of science and technology indicators, and their form in networks, where it also must be taken into account the faithful fulfillment of the criteria described by Bersanelli and Gargantini (2006), as the precision, consistency, specificity, sensitivity, ease of collection, relevance, reliability and transparency.

According to the contributions of Ruegg and Feller (2003), it is evident that the R&D activities should be measured through a process of logical modeling allowing the clarification of indicators, which, regarding to impacts, must be built under the concept of externalities of knowledge, market, and network.

In this context, emerges the concept of externalities in the analytical framework of the so-called welfare economy; economists use the externality term to demonstrate the premise that some of the benefits of public research and development channeled through the public universities are transferred to other economic agents other than the research group or Faculty that undertakes the research.

According to the theory of Jaffe (1996), the research and development externalities are created in a situation of combination of the resulting new knowledge of an effort of research, and the placing on the market of merchandise with the new technology in terms of a product, process or service.

The generation of research externalities, produces that some benefits that are created for the economy or the society when the Public University undertakes a research project based in networks (or when it increases its involvement in a number of stages or phases of a certain project), it does not take into account the calculation of the cost / benefit ratio for recipients.

In the specific case of the public University, the social rate of return to the research generally exceed the private return ratio and because in the impacted environment the organizations shall take their decisions based on the private return rate, from the private research finally there will be not projects undertaken even if they are socially desirable.

As it is standed out by the welfare economics, there is created a "market failure" in the expression of public research and development when there are assigned less global resources of the society to the research than it was desirable.

Given the nature of the public and in accordance with the economic approaches described by Jaffe (1996), the research and development externalities can be taken as an example of positive externality, in fact, the concept of positive externalities is very closely related to the concept of "public good". In cases such as those submitted by projects whose private benefits are very diffuse, but which are socially desirable or necessary and that therefore they should be assumed by the government.

Despite the importance of the R&D externalities and their relationship with the welfare economy and the public goods, the numerous academic and interdisciplinary research about the network externalities, has been developed basically on theoric aspects, leaving aside the empirical corroboration of their effects and implications. To solve this problem, during the last ten years, emerged a great number of researches that begin to corroborate the impact of the network effects on the strategy for enterprises, the structure of markets, consumption patterns and the development of public policies (Guzmán and Trujillo, 2011). Therefore, becomes relevant the study of science and technology indicators, that enable to show the participation of the University of Cauca in the generation of network externalities, in such a way that it would display the contribution to interest groups and receiving communities.

The main objective of this study is to identify the generation of externalities, mainly referring to network spillovers, from the indicators system designed to measure the research capabilities of the University of Cauca from the perspective of the knowledge management. Therefore, this article is designed in four sections that take up the generation of externalities from the research and development of the University of Cauca. The first is a theoretical framework which includes concepts such as environment, global economy, public University, networks and spillovers; the second refers to the methodology, which corresponds to a mixed approach that combines quantitative and qualitative aspects; the third, presents the results of the research including the generation of network, knowledge and market externalities; finally some brief conclusions are presented.

2. Theoretical framework

This section presents the concepts of environment and global economy, externalities and network, as well as ideas about network externalities in the public university and its relationship to the global economy. The first subsection presents the concept of environment and global economy. The second subsection describes the role of the public university in the global economic system. In the third subsection shows the notion of network in the global economy from the perspective of the public university. Finally, the subsection fourth presents the analysis of the research and development network externalities as a mechanism for the measurement of impact of the public university.

2.1. The concept of environment and global economy

From different views of the economy as a science and for more than two decades, there has always been and maintained a broad debate that aims to explain the phenomenon of the globalization of the economy, which has emerged as a palpable reality after the intervention of the technologies and its consequent effect of annulment of the geographic barriers (Hidalgo, 2011).

So far, this phenomenon has been analyzed under the perspective of multiple political and economic variables, there are premises that guided by the approaches underlined by the international relations economy and international political economy, basically express that thanks to the effect of technologies a global economy has been formed and it is changing the way that people share, use and buy knowledge.

The different views that in this regard provides the economic thought address the phenomenon by analyzing the change in the

[2] According to Pineda (2002) for the Colombian Administrative Department of Science, Technology and Innovation - Colciencias, the public research organizations, in which the universities occupy the most representative role, are part of the National System of Science, Technology and Innovation, which is an open system consisting of policies, strategies, programs, methodologies and mechanisms for the management, promotion, financing, protection and dissemination of the scientific research and technological innovations, as well as public, private or mixed organizations that perform or promote the development of scientific and technological activities and innovation.

role of the nations in cross-border economic relations and the importance that begin to collect various public and private actors and stakeholders to the new reality.

The perspective of the phenomenon of the global environment has also been addressed from the representationism, stating that such reality occurs before the eyes of the observer, and in opposite way, that it is a reality constructed by the observer, to understand the phenomena of the environment, which would be located in a constructivist position. As a consequence of these opposing positions, the scientific community is often placed in a neutral point, in fact, an eclectic field, seeking the combination of the two flows to address the problem properly. Some economists have called this position as "enactive approach".

From the point of view of an enactive approach, any phenomenon related to the global economy is manifested to the observer, and the observer uses it to build various interpretations of the reality. The role of the public University, seen from this scope, becomes very relevant if it is analyzed under the transnationality concept, which involves analyzing cross-border economic relations as relations that are not international any more or between nations but global or global economic relations, between agents and not between countries (Hidalgo, 2011). Multiple indicators of science and technology show the intervention and independent participation of universities in this global system without contributions or assistance from their Governments.

In the traditional international economy, the international economy was assumed as the sum of multiple parties that were represented by national economies or of each of the countries. However, under the view of this approach it is possible to analyze the cross-border and internal economic relations as a whole where prevails the role of the institutions over the role of their governments.

So, and under the shadow of this theory, this article is based on the premise that there is a global economic system that arises in the social relations among them, in which, of course, there are economic relations, understood as those involving production, distribution, exchange, and consumption. Based on the approaches of Hidalgo (2011), the economic relations based on the market, free exchange of goods and services and factors of production covered by the concept of private property or capitalist would primarily be analyzed.

In the economic relations between the University, the government, the enterprises and the interest groups (including teachers, students, administrative and the receiving community), there are links with other human beings and organizations of different geographical locations around the world. This group of people and their interactions make up an entity that is part of the so-called economic global system, which stands out, is characterized or acquires identity by its type of organization, which, apart from being capitalist, is heavily influenced by the concept of networks, thanks to the effects of synergy and their respective contributions in the relationship benefit cost of the interactions.

2.2. The public university and the global economic system

Public universities, given the principle of autonomy that covers them, acquire characteristics of institutions of civil society. These organizations, also immersed in the global economic system, retain the ability to exercise freedom of thought. This important feature makes the difference comparing to other social actors, as it could be other universities or private institutions that given its property belong to the elite of the global economic system, representing private or corporate interests and in some cases cultural, religious or ideological, which carry them to show different modalities of action under restrictions in their degree of freedom (Medellín and Nieto, 1999).

The above should be addressed with care, because it should not be forgotten that being immersed in a global world, and thanks to the systemic nature of reality, they end up ceding or giving up part of their rights of freedom of thought and expression to the requirements of the system and the Government. However, everything related to freedom, expressed through the University autonomy is relevant because of the role of the public University in social management, for example, its role in addressing aspects and needs that the private sector disregards and which are priorities for the development and the economy of the regions.

This role is primarily based on the ability of a University declared as autonomous to create scientific knowledge to solve various problems and spread it without bias or ideologies, likewise in its responsibility to educate human talent to be able to respond to the most authentic demands of the society. If this role is exercised correctly from the public, the universities provide externalities that benefit recipients whose geographical location does not have physical limits thanks to technologies.

2.3. The notion of network in the global economy: a view from the public university

Castells (1997) addresses the most relevant in social and economic aspects of the current era. His work is focused on characterizing capitalism as a model influenced by networks, there are valuable contributions to its conceptualization. This author defines the network as a set of interconnected nodes which is of great importance since it is conceived as the center of power in today's society. He noted that around it there are organized multiple processes and functions of great impact and refers to the network as a new social morphology.

These unions link institutions, companies, markets, organizations and media, having within a dynamic and logic (sometimes informal or unconscious) of interconnection. According to Katz (2011), in this cohesion, the role of each individual or node depends on its inclusion in the network and its place in its structure.

An example of this are the research and development networks, which are used to transmit information, generate, and disseminate the knowledge at the global level, and which play an important role in the conception of public University immersed in a society where prevails the informational economy, which can be considered "global" to the extent that various actors participate in a network.

In this era, where the physical limits should not be a barrier to the satisfaction of social needs, networks, through direct exchange of information and knowledge in real-time remove the geographical distance, they become worldwide and dominant, reaching global recognition.

A great contribution of University networks of research and development to the satisfaction of a social need is displayed in the feature that distinguishes any system that operates under the premise of "real time" from other types of systems, which is the time of interaction of the nodes. It is understood that the proper functioning of a group of research or a network of collaborative work depends not only on the logical result of his work, but also the time in which it produces this result and the resulting benefits on providing it immediately. Deepen more in this aspect, it could also be inferred that not only the timeliness of the result of the research and development is important, but also the fact that the reaction of a network to external events should occur during its evolution, for example, that as a result the internal time of a network or a research group must be measured using the same scale which measures the external time or the time of the environment to which the network responds.

Approaches such as Katz (2011), might conceive that networks are the epicenter of the global economy and current capitalism. Information and knowledge have gained greater economic significance compared to the mere production of goods, flows through network interconnections. It is why the function of public

research and development networks becomes crucial. Several authors have pointed out that the use of data and knowledge organized, communicated and broadcasted through networks, in this case, of University origin, is fundamental for the evolution of society.

In the absence of the public, the use of information and knowledge depends only on their owners. The products of research and development are not public goods, and they are not provided free of charge. In fact, the main efforts of the private research and development focus on intellectual property mechanisms to protect their investment performance. From this field, the results of research and development are not available for any social agent, are self-imposed nor circulate automatically. The ownership of these resources determines their destination and its economic use, which depends on the decisions that take the owners of networks or the groups of developers. For this reason, Castells (1997) pointed out that the power of the information emanates from the power of capital.

However, public organizations, and more specifically to this case, the universities, have in their mission the approach of social actions that private entities would not assume given their characteristics. From the perspective of the public, networks have gained great importance given its potential of knowledge generation for free and its diffusion capacity.

2.4. The contribution of the public university: analysis of the research and development network externalities as a mechanism for the measurement of impact

The concept of externality in economics is important because it contemplates the impact on other agents of individual decision making. It is a comparative concept, which refers to how decision-making involves others without receiving any compensation or exchange (Katz and Shapiro, 1985).

This impact or "transfer of benefits", commonly occurs as a result of the public nature immersed in research agents, whose function is described by Houssey (1941), as a multiple effect of create and disseminate increasingly comprehensive knowledge to be achieved by research. It must prepare great professionals using expert and reasonably, techniques and methods useful to the present and future society.

The social expression of the public nature of the university research groups is observed in the transfer of benefits to different agents such as purchasers of cheaper products or improved goods as a consequence of the results of research, the companies without economic capacity that imitate a successful innovation and achieve benefits, and the entrepreneurs whose profits come from observation of the success or failure shown by the research efforts, are just some examples of the collection by third parties of benefits of externalities of research and development.

This situation illustrates that scientific, technical and economic/administrative analysis should be combined in order to analyze the phenomenon of research and development externalities. Jaffe (1996), points out that from a standard economic perspective there might be considered that the economic agents involved in research processes try to maximize their self-interest. In the context of the research and development in general, this would imply that there would be decisions about the level and focus of the research efforts for maximizing the benefits in the long term. Companies that would decide weather they will work or not a certain line of research or the amount of resources they would dedicate for a research project, try to balance, even in an unconscious way, the cost of the research against future profits that this effort can generate.

One of the main advantages that results in the fact of recognizing the market failure created by the research and development externalities is the important help or clarification that it offers for the construction of public policy in terms of the budgets allocated to the research activities and its likely impact or return to the society. This fact allows considering, in the research studies, this methodology as an innovative mechanism and a knowledge border line for the identification and measurement of impacts of the research and development.

Reviewing all the approaches of Marshall (1920), one of the founders of the Orthodox microeconomics, and Jaffe's theory (1996), we come to an interesting description about the generation of externalities in the research and development activities through three channels or types: knowledge externalities, market externalities and network externalities. Adding that in order to observe their implications, it is useful to model and consider each one of them separately, and later analyze whether or not they also interact in a way that can increase their combined effect.

Marshall (1920) and Jaffe (1996), separately refer to the same phenomenon of externalities, but Jaffe deepens more in the concept of externalities related to public research and development. However, both authors explain what happens in a process when the knowledge created by a group can be used by another without compensation, or with a lower value to the real compensation. It is thus very likely that knowledge externalities occur in the public university as a result of basic research, when the groups begin to disseminate the results of their research among colleagues, groups (including networks) and faculties, and also it is possible that this phenomenon occurs through mechanisms of imitation or reverse engineering. Another way in which this externalities can be observed occurs when any group decides to leave or dismiss a line of research, showing to others that the line is unproductive or/and risky and therefore saves them the effort and risk to learn it by themselves (Adams, 1990).

At the public university level it is clear that the beneficiaries, referred in this article as "recipients of the externality" may or attempt to use the new knowledge to improve their products or services, or in the same way, they can use it as an input of another process of research conducing or leading to other new solutions, which creates a desirable effect of replication.

In the case of public organizations, in general, given their mission and also due to aspects of their organizational culture, the creation of knowledge spillovers is intentional and it has become an objective for the research groups and their networks; the publication of scientific articles is an example of this because it is intended to extend and disseminate, sometimes for free, the new knowledge, so that it may be used by many people as possible without geographical limitations. In fact, among the quality indicators in academic rates there are the citation and co-citation of the articles or the number of visits through the web throughout the world. Similarly, despite their low existence in our country, when invention patents are achieved, new knowledge is required by the society in order to facilitate new and different applications of it, and in return, the government approves the right of monopoly in the commercial use of knowledge.

It has also been established, that these knowledge externalities in research and development also occur when researchers leave a group and move to another one taking with them all the learning and valid knowledge generated by their original group of research.

Moreover, the market externalities occur when there is supply and demand, or in other words, when there is market operation of a new product or process resulting from university research and development processes causing that any of the benefits created flow to the receivers in the market other than the research group (Cohen and Levinthal, 1989). According to Jaffe (1998), is the spill of the benefits through the operation of the market forces, rather than the flow of knowledge itself, what differentiates market externalities from knowledge externalities. For Cohen and Levinthal (1989) this approach enriches the theory for impact measurement because it considers that when a company or organization creates a new product, or reduces the cost of production in an existing product or process, the natural operation of the market forces globally will cause that some of the benefits created are passed on to buyers.

According to this theory, the approaches of the General Accounting Office (1995) and authors as Levin, Klevorick, Richard and Winter (1987), if we analyze the case of selling at higher prices products and services improved or value-added, compared to other organizations, the products and innovative process, being or not protected from direct competition by the regulation of intellectual property in the specific case of patents, utility models, industrial designs, and trademarks, they will be sold to prices that do not capture all their superiority and added value in relation to what was available in the market before their introduction, taking in to a count the costs that would have been assumed in the research for the product and process development in the absence of the university research. As a result of this game in the global market, incremented by the remarkable effect of the CIT's (Communication and Information Technologies), the consumers of the global market will gain benefits in the introduction of a new product, because they are not paying or rewarding its real cost, and also gain benefits the producers or sellers who have achieved a greater market share at a global level without investing in research and development processes that were paid by the University. This increase in the consumer and producer welfare is a general social benefit not captured by the public university or the research group (Griliches, 1979).

The improvement in the productivity of companies throughout the world, recipients of the externalities resulting from the contributions of the university research and development, can also lead to the fact that by lowering their production cost, they also lower their selling prices, generating a benefit to customers and producers that is not captured by the research group. This type of externality with multiple benefits is one that typically occurs in the innovation process because innovation often results in better quality and performance, lower prices, benefiting more customers and producers (Goto and Suzuki, 1989).

The network externalities (where sometimes there is the combination of knowledge and market externalities) are those most common in the university. They occur when the organizations begin to consolidate their relational capital through the intervention of the university in their processes of generation of collaborative works or networks. This capital has been described as the value created to a company due to the relations and valuable interaction with other entities, the quality and sustainability of the amount of customers of a company and its potential to generate new market contacts in the future.

The theory of Jaffe (1996), suggests that these network externalities occur when the market or economic global value of a new product or service is heavily dependent on the development of a team of actors producing related technologies. One example of this occurs when the University, in order to address a specific research problem, requires the participation or involvement of several research groups to make contributions from different disciplines to produce a result or combined or specialized outcome.

The author suggest that if the achievement of a certain project objectives, within a set of related research projects, or within a macro project is dependent on all or a significant fraction of the projects involved, then the private stakeholders, in the absence of the public university or without its commitment, would hesitate to undertake this projects, because they would fear that the rest of the projects (necessary for them) would be not successfully undertaken or may be abandoned.

Fortunately, due to the presence of the public university, with it's support reflected in the respective founds and the resulting commitment that comes with them, if any company decides to undertake a project of the network, it creates a positive externality for all the other projects or companies involved, increasing the possibility to create the necessary critical mass.

Jaffe (1996) expresses that this positive network externality might occur even in the absence of knowledge spillovers between firms (while noting that it is likely that knowledge spillovers were also occurring at the same time).

3. Methodology

The methodological research approach is mixed, it combines elements of the research mode 1 to establish the indicators and additionally it uses the research mode 2 to ensure the relevance and priority of the identification of network externalities. This descriptive study, incorporates secondary data with regard to the description of science and technology indicators emanating from the University, present in the specialized literature, clarifying and demonstrating which of these contributions correspond to externalities and which of them are primarily externalities of network, through the expert panel; supplemented by a qualitative and quantitative time.

In first place, the project develops the characterization of the investigative activity of the University, analyzing the contributions of the networks and research groups to the recipient community**.** Carrying out the research work to identify the variables of inputs and outcomes of the University research and development, arise a large amount of data requiring to be cleansed, analyzed and studied to be able to classify them according to their nature. In fact, the effort to characterize them is the main focus of this work.

The Table 1 displays the list of variables found in the research project "Construction of a System of Indicators to Measure the Research Capacity of the University of Cauca from the Knowledge Management Perspective" developed in year 2010 by the research group of Regional Models of Competitiveness, in which, the research made a first classification of these variables according to their nature, related to intellectual capital of the research and development of the university.

In a second part, the project makes a selection of science and technology indicators relating to research networks and their externalities, through the research technique known as panel of experts.

The expert panel focused in a system of indicators to identify research capabilities that allow the identification of the intellectual capital of the University of Cauca. The project has started the construction of a logical model in order to establish a list of variables and consequently develop a set of indicators to generate a protocol of inputs, incomes, outputs (products), outcomes (results), and impacts of the public university research and development, aiming to demonstrate, in a logical and organized way, the effect of the networks and research groups of the University on the society. It is important to clarify that the main effort of the project, in this stage, and subsequently of this paper, is concentrated on clarifying the impacts through the participation on the creation of externalities.

Following the methodology, the project identified panelist's keys from the list of researchers of the University of Cauca. The total number of participants was 10 researchers, with greater recognition in the consulted topics. The experts were selected regardless of their professional titles or hierarchical level, on the basis of the consulted subjects, some of the elected experts are chancellor members of the Research Affairs Office and/or act as directors of the most representative of the Cauca University research groups that are part of the first quartile of products of new knowledge, which means that they are among the first 15 groups of research with the highest production; key factors that facilitate a classification of the indicators of research capacities of the University of Cauca in the R&D variables. It is important to mention that the projects conducted a meeting with the panelists selected for the conceptualization about: indicators, logic modeling and externalities, with the objective of sharing the knowledge of each one of the participants and thus verify their expertise.

Subsequently, the expert panel technique is implemented: in a first stage, the authors of the project carried out an analysis of the

Table 1
List of indicators that measure the research capacity of the University of Cauca from the knowledge management perspective

Number of active researchers working at the University of Cauca
Number of active research teachers working at the University of Cauca
Number of Young researchers at the University of Cauca
Number of teachers at the University of Cauca
Percentage of teachers according to the type of contract
Percentage of teachers of the University of Cauca according to their education level
Number of teachers of the University of Cauca according to type of contract by faculty
Number of teachers of the University of Cauca according to their level of education and by faculty
Number of Research Groups of the university of Cauca
Active Research Groups
Evolution of the Research Groups of the University of Cauca according to their year of creation
Dynamics of creation of research groups in the University of Cauca according to year of creation and faculty
Groups of research of the University of Cauca by faculty
Ranking of the research groups of the University of Cauca per year
Knowledge areas of the research groups of the University of the Cauca
Groups of research of the University of Cauca by National Program of Science and Technology (PNCYT)
Number of doctorate, masters and specialization students
Students of post degree by knowledge area
Number of graduated students in programs as doctorate, masters and specialization
Number of doctorate masters and specialization scholarship holders,
Products related to the production of new knowledge
Research capacities of the University of Cauca according their production registered in Colciencias
Production registered at SCIVERSE SCOPUS
Research founding
Number of indexed magazines
Number of current commissions for study
Teacher's mobility during the year 2010
Number of interinstitutional agreements
Number of affiliations in the data base of Scopus
Number of networks created at programs of post degree programs in national agreements
Number of teachers with doctorate title, classified according to the year of obtaining of the title and by country of formation
Number of Phd's in formation, classified according to the year of beginning, and country of formation
Number of teachers doctors waiting for their title, according to their country
Number of prizes given to the research work
Research groups with greater production registered in the category: production of new knowledge
Research groups with greater production registered in the category: formation of researchers
Research groups with greater production registered in the category: Spread of the research results

Source: made by the authors for the research project purposes.

logic model, the R&D variables and the profiles of network externalities in order to develop the matrix of R&D variables or indicators. The stage two is concentrated in the elaboration of a matrix containing the research and development variables, taking into account the previous modeling of the university's research system, the R&D externalities and the indicators provided by the project of research capacities and using the following scale: 0 corresponding to not effect, 1 to low effect, 2 to medium effect, 3 to strong effect, and 4 to very strong effect. The experts dialogued, talked and argued about the science and technology variables related to the networks and research groups from their particular point of view and specialization.

The consensus was analyzed and the results were processed to determine the level of consistency through the following expression:

$$Cc = [1 - Vn/ Vt]*100 \quad (1)$$

Where Cc is the consistency coefficient expressed as a percentage; VN corresponds to the number of experts against the predominant criteria; VT is the total number of experts. The consistency was considered acceptable if Cc > 70%, being eliminated those values of Cc < 70%, due to low consistency or little consensus among experts. In the third stage, the project makes a selection of each variable of input, output, outcome or impact as knowledge, market or network externalities. This process was made by every member of the panel.

Finally, in the stage fourth the project makes the elaboration of the list of variables in research and development related to networks and groups.

4. Results and findings

The profile of the experts is the following: from the 10 researchers invited to the panel, 90% are men; on average they are 48 years old and are dedicated to research processes in about 18 hours a week. The 50% of them has completed doctorate studies, 30% studies of master's degree and 20% pos doctorate studies, in universities such as the Universidad Autónoma de Madrid and The Universidad del Valle (20%); the University of Cambridge, the University of Manizales, John Hopkins University, The University of Cauca, los Andes University and The Universidad Politécnica de Madrid (10% each). The researchers expressed having average knowledge about the logical model in eight (8), eight seven (8,7) in R&D indicators and nine four (9,4) in knowledge about R&D, being ten variables (10) the maximum score.

The Table 2 shows the distribution of the profession of the panelists, according to which 30% of researchers are electronics engineers, and others have different professions, as biologist, chemist, lawyer, agro-industrial engineer, anthropologist, physicist, chemical engineer; whose individual share is 10%.

The higher percentage of participation by faculty was obtained by those researchers who belong to the Exact, Natural and Education Sciences Faculty (referred in this article as FACNED), and the Faculty of Electronic and Telecommunications Engineering (also called FIET) with a percentage of 30% each, followed by the Agricultural Sciences Faculty (20%); the faculties with less participation were Health and The Faculty of Social and Human Sciences with a 10% representation each one, such distribution is shown in table 3.

Table 2
Profession of the panelists

	Frequency	Percentage	Valid Percentage	Accumulated Percentage
Biologist	1	10	10	10
Chemist	1	10	10	20
Licentiate	1	10	10	30
Agro-industrial engineer	1	10	10	40
Anthropologist	1	10	10	50
Physicist	1	10	10	60
Electronics engineer	3	30	30	90
Chemical engineer	1	10	10	100
Total	10	100	100	

Source: made by the authors.

Table 3
Faculty of the panelists

	Frequency	Percentage	Valid Percentage	Accumulated Percentage
Health	1	10	10	10
FACENED	3	30	30	40
Agricultural Sciences	2	20	20	60
Social and Human Sciences	1	10	10	70
FIET	3	30	30	100
Total	10	100	100	

Source: made by the authors.

Table 4
Research areas of the panelist

Research areas	Frequency	Percentage	Valid Percentage	Accumulated Percentage
Molecular Epidemiology	1	10	10	10
Food and environment	1	10	10	20
Body, youth and imaginaries	1	10	10	30
Starches and bio polymers	1	10	10	40
Anthropology	1	10	10	50
Science of material-ceramic	1	10	10	60
Systems of innovation	1	10	10	70
Management of Knowledge	1	10	10	80
Telematics	1	10	10	90
Biotechnology	1	10	10	100
Total	10	100	100	

Source: made by the authors.

The 20% of the panelists belong to the research Group I+D in *Tecnologías de la Información*; the others belong to the Applied Human Genetics Group, *Biotecnología, Calidad Medioambiental y Seguridad Agroalimentaria*, Warp, *Ciencia y Tecnología de Biomoléculas de Interés Agroindustrial*, Comparative Social Studies, *Ciencia y Tecnología de Materiales Cerámicos*, Regional Models of Competitiveness, and *Aprovechamiento de Subproductos, Residuos y Desechos Agroindustriales*, with a share of 10 % each one. The Table 4 shows the research areas to which the panelist belong: molecular epidemiology, food and environment, body young people and imaginaries, starches and biopolymers, anthropology, ceramic material sciences, systems of innovation, knowledge management, telematics and biotechnology; whose participation is of 10% each.

The panel of experts was focused on the generation of externalities in its three categories identified as externalities of knowledge, market and networks, in the system of indicators for the measurement of the research capacities of the University of Cauca from the knowledge management perspective, this is shown in table 5. Besides, trhough this mechanism the project got to establish the profile of the spillover effect, especially regarding to the network externalities. This profile is composed by the next two characteristics:

- Variables related to science products and services that require complementary facts.
- Variables related to actions regarding social interaction.

The Table 5 and Figure 1 show the consensus of the experts. They show that the indicators "Products related to the production of new knowledge" (21), "Number of networks derived from the post-graduate programs in national agreements" (33) and "Number of graduates in doctoral, masters and specialization programs" (19), are variables that measure the network externalities

In addition, the Table 5 shows in the indicators "Areas of knowledge of the research groups of the University of Cauca" (15), "Number of Ph.d, master's and specialization degree students", (17) and "Products related to the production of new knowledge" (21), the level of concordance of the experts about the measurement of generation of knowledge externalities was 80%.

The indicators "Number of active teachers researchers working at the University of Cauca" (2), "Number of young researchers at the University of Cauca" (3), "Number of research groups of the University of Cauca (9), "Active research groups" (10), "Dynamics of creation of research groups at the University of Cauca according to year of establishment and faculty" (12), "Research groups of the University of Cauca by faculty" (13), "Graduate students by knowledge area" (18), "Research capacities of the University of Cauca according to production registered at Colciencias" (22), "Production registered in SCIVERSE SCOPUS" (23), "Number of indexed journals" (25), and "Number of existing study committees" (29), refers to the level of concordance of the experts regarding these indicators in relation to the measurement of knowledge externalities was 70%.

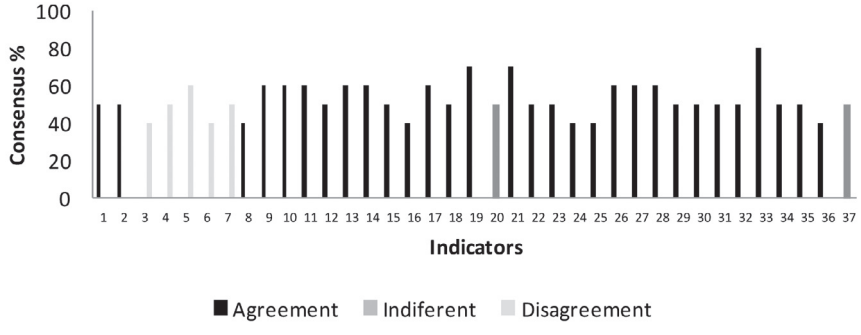

Figure 1 Network externality consensus.
Source: Made by the authors.

Table 5
Generation of externalities from the Cauca University

Indicator	Externalities								
	Knowledge			Market			Network		
	VSA/A	I	VSD/D	VSA/A	I	VSD/D	VSA/A	I	VSD/D
1	60%			40%			50%		
2	70%			40%			50%		
3	70%					50%			40%
4			50%			50%			50%
5			60%			70%			60%
6	60%					50%			40%
7			50%			60%			50%
8	60%			40%			40%		
9	70%			50%			60%		
10	70%			50%			60%		
11	60%			40%			60%		
12	70%			50%			50%		
13	70%			50%			60%		
14	60%			40%			60%		
15	80%			50%			50%		
16	60%			40%			40%		
17	80%			40%			60%		
18	70%				40%		50%		
19	50%			50%			70%		
20	50%				50%			50%	
21	80%			70%			70%		
22	70%			50%			50%		
23	70%					40%	50%		
24			40%			40%	40%		
25	70%					50%	40%		
26	50%					50%	60%		
27	60%					50%	60%		
28	50%					40%	60%		
29	70%					50%	50%		
30	40%					50%	50%		
31	40%					50%	50%		
32	50%				50%		50%		
33	60%					50%	80%		
34	50%			40%			50%		
35	50%			40%			50%		
36			70%		40%		40%		
37	60%				50%			50%	

I: indifferent; VSA/A: very strong agreement/agreement; VSD/D: very strong disagreement/disagreement.
Source: made by the authors.

There is concordance in the experts about the fact that the indicator "Production of new knowledge products" (21) is useful to measure the market externality creation. In opposite, the indicator "Number of Ph.D. teachers expecting their title according to the country of the study" (36) and the indicator "Percentage of teachers according to type of contract with the University of Cauca" (5), are not useful to measure the knowledge and market externalities respectively, with a coefficient of concordance of 70%.

5. Conclusions

Regarding to the generation of network externalities, this study does not coincide fully with the aspects mentioned by Marshall (1920) and Jaffe (1996) about the general concept of externality. There is no reference to the research groups and to the dynamics of their creation, neither to the number of internal agreements, as generators of network externalities. In this study, aspects such as the

number of graduates in doctoral, masters and specialization programs and products related to the production of new knowledge, are considered as generators of network externalities.

This study coincides with the theory of Jaffe (1996), who mentions that it is very likely that knowledge externalities occur as a result of basic research, when the groups begin to disseminate the results of research among colleagues, groups (including networks) and faculties, and is also likely to happen or occur through mechanisms of imitation or reverse engineering.

However, this study considers other aspects within the University that measure externalities of knowledge, which are not covered by these authors as: number of research groups, the dynamics of creation of these groups, the number of indexed journals and number of existing study committees. In absence of a direct relationship, it is likely that the more research teachers there are, the more knowledge externalities there will be.

The spillover effect, also called externalities, occurred and could be seen in three categories, knowledge, market and networks. There are also situations where it occurs as a combined effect increasing the economic benefit transferred to the society.

The spillover effect in research and development activities with regard to the generation of externalities occurs and can be seen in the category of networks through the products related to the production of new knowledge, the number of networks due to the post-graduate programs in national agreements and the number of graduates in doctoral, masters and specialization programs.

Mapping the spillover effect is a standard for ranking the behavior of the research and development variables at the public university which allows to start the process of measurement, evaluation and further assessment of the impact on the global economy. The observation of this effect can be a way of communication to the stakeholders about how the University moves the benefits to the society and not appropriates them for itself.

The modeling of impacts created by the research in terms of externalities might create a common vocabulary among the stakeholders and the design and establishment of system of indicators to measure the research variables is becomes a tool to achieve transparency. In fact, the University, through their modeling processes welcomes independent voices to examine, criticize and help improve their metrics.

The method of mapping the impacts through the network spillover effect is not the only valid criteria for decision-making. The observation and the judgment may also influence this process.

The model, its operational mechanisms and its metrics are not unchangeable. Further research and more refined calculations, will validate this work. There is not an universal answer for measurement, evaluation and assessment of the impact of these networks on the global economy. The work carried out so far, is the first approximation to this effort.

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