A model for measuring research capacity using an intellectual capital-based approach in a colombian higher education institution

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abstract

This article's main objective was to present a model for measuring research capacity from an intellectual capital-based approach for Colombian higher education institutions (Instituciones de Educación Superior – IES), forming part of the national science and technology system, in the sense that around 90% of Colombian research groups belong to it.

The model should lead to identifying IES capacity and competence and to strengthening these institutions' management ability with the aim of obtaining input facilitating designing and formulating science, technology and innovation policy. Likewise, it should contribute towards strengthening IES relationships within national and international public and private settings.

key words: innovation management, national innovation system, higher education, organisation, research system, intellectual capital, human capital, social capital, structural capital.

resumen

Modelo para la medición de las capacidades de investigación desde una aproximación basada en el capital intelectual en una institución de educación superior en Colombia

El principal objetivo de este artículo es presentar un modelo de medición de las capacidades de investigación desde una aproximación basada en el capital intelectual para las Instituciones de Educación Superior –IES- en Colombia, que hacen parte del Sistema Nacional de Ciencia y Tecnología, en la medida que a ella pertenecen cerca del 90% de los grupos de investigación del país.

A partir del modelo es posible identificar las capacidades y competencias de las IES y fortalecer las capacidades de gestión de estas instituciones con miras a obtener insumos que faciliten el proceso de diseño y formulación de políticas en Ciencia, Tecnología e Innovación. Asimismo, contribuir al fortalecimiento de las relaciones de las IES en el ámbito público y privado nacional e internacional.

palabras clave: gestión de la innovación, sistema nacional de innovación, educación superior, organizaciones, sistemas de investigación, capital intelectual, capital humano, capital social, capital estructural.

résumé

Modèle d'évaluation des capacités d'investigation à partir d'une approche basée sur le capital intellectuel dans une institution d'éducation supérieure en Colombie

Le principal objectif de cet article est de présenter un modèle de d'évaluation des capacités d'investigation à partir d'une approche basée sur le capital intellectuel pour les Institutions d'Éducation Supérieure - IES - en Colombie, faisant partie du Système National de Science et Technologie, près de 90 % des groupes d'investigation du pays lui appartenant.

À partir du modèle, il est possible d'identifier les capacités et compétences de l'IES et de fortifier les capacités de gestion de ces institutions afin d'obtenir des intrants, favorisant le processus de design et de formulation de politiques en Science, Technologie et Innovation, pour contribuer ainsi au renforcement des rapports des IES dans le domaine public et privé, national et international.

mots–clefs: gestion de l'innovation, système national d'innovation, éducation supérieure, organisations, systèmes d'investigation, capital intellectuel, capital humain, capital social, capital structurel.

resumo

Modelo para a medição das capacidades de pesquisa desde uma aproximação baseada no capital intelectual em uma instituição de educação superior na Colômbia

O principal objetivo deste artigo é apresentar um modelo de medição das capacidades de pesquisa desde uma aproximação baseada no capital intelectual para as Instituições de Educação Superior –IES- na Colômbia, que fazem parte do Sistema Nacional de Ciência e Tecnologia, na medida que a ela pertencem cerca de 90% dos grupos de pesquisa do país.

A partir do modelo é possível identificar as capacidades e competências das IES e fortalecer as capacidades de gestão destas instituições visando obter insumos que facilitem o processo de desenho e formulação de políticas em Ciência, Tecnologia e Inovação. Da mesma forma, contribuir ao fortalecimento das relações das IES no âmbito público e privado nacional e internacional.

palavras chave: gestão da inovação, sistema nacional de inovação educação superior, organizações, sistemas de pesquisa, capital intelectual, capital humano, capital social, capital estrutural.

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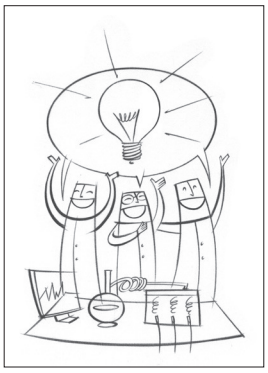
The authors are members of the GRIEGO research group (**Grupo de Investigación en Estrategia y Gestión de Organizaciones**) registered in Colciencias in A1 category.



Clasificación JEL: I20 e I21	Recibido: mayo de 2009	Aprobado: noviembre de 2009

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Sánchez-Torres, J.M. & Rivera Torres, S.C. (2009). A model for measuring research capacity using an intellectual capital-based approach in a colombian higher education institution. ***Innovar,* Especial en Educación, dic. 2009, 179-197.**

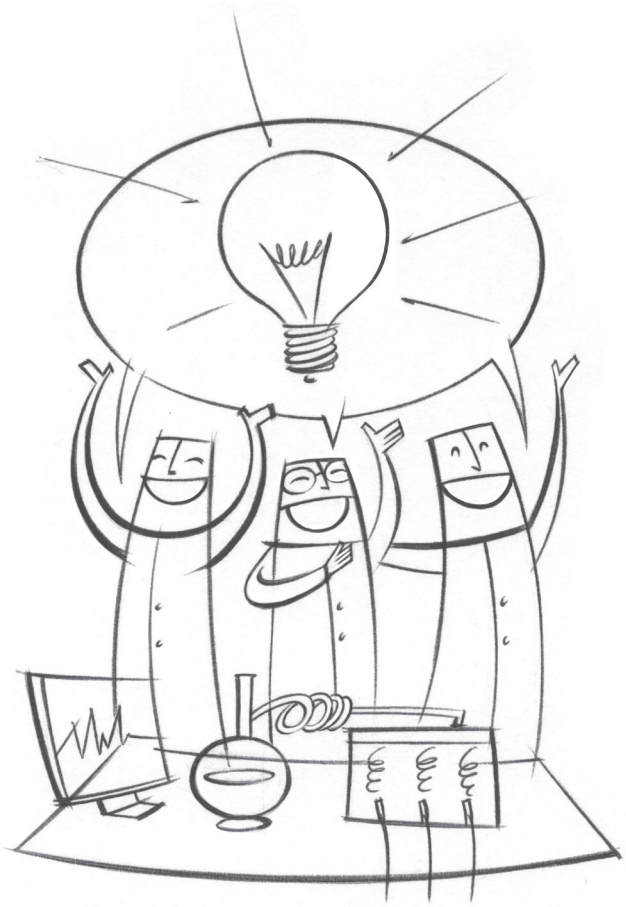
Introduction[1]

The Society of Knowledge's undeniable development, combined with an urgent need for raising Colombia's levels of competitiveness and productivity, requires profound productive and social transformation. This means that it is expected that Colombia have a dynamic economy with a supply of high added-value goods and services based on innovation, where science and technology become the fundamental basis for achieving this (Medina y Sánchez-Torres, 2008). As Haussman (2007) has pointed out, the foregoing leads to a significant acceleration in developing a population's capacity and promoting collective learning so that Colombia does new things and increases levels of knowledge regarding those activities, which it already knows how to do.

Colombian HEIs have become the fundamental support for achieving such productive transformation because these institutions take on two roles. Firstly, they adopt that of an actor who, given his particular nature, propitiates generating knowledge endowing added value to those goods and services which the country has opted for. Secondly, HEI are the main actor in the Colombian National Science Technology and Innovation System (NSTIS) (*Sistema Nacional de Ciencia, Tecnología e Innovación* –SNCyT), in terms of human capital (HC) forming part of the proposed intellectual capital (IC) model. There are registered 3,322 active research groups in the Colombian Science, Technology and Innovation (SCienTI) platform[2]: 3,090 correspond to HEI-backed research groups (1,416 groups belong to private HEI and 1,674 to public HEI (Colombian Observatory for Science and Technology–OCyT, 2008).

In line with the foregoing, several questions have arisen, which are orientated towards identifying HEIs' role in Colombia's development.

- Can HEIs contribute towards developing products and services having high added-values in determined economic sectors from the basis of those knowledge-generating processes that they are advancing?



- What does the HEIs' contribution amount to in terms of results associated with knowledge-generating processes?
- Do HEIs' contributions represent capacities in the National Innovation System?
- Other questions have risen in turn:
- What are Colombian HEIs' capacities in terms of generating knowledge?
- How can Colombian HEIs give an account of knowledge-generating and -transmitting processes?
- How should the Colombian government and other institutions allocate important sums of money towards consolidating the National Science, Technology and Innovation System (NSTIS)?

The model presented here tries to provide an answer to question "What are Colombian HEIs' capacities in terms of generating knowledge?" by applying it to a specific case, thereby leading to dealing with the concepts and components included in the model after obtaining some preliminary results.

1 This paper is a result of an institutional initiative sponsored by UNAL Main Research office, and it is a component of the building research capacities program defined by the Global Development Planning 2007 -2009 of National University of Colombia. The authors would like to thank the Universidad Nacional de Colombia for its support, especially the team from the Vice-rector for Research's office led by Rafael Alberto Molina Gallego (the vice-rector) and for his wholehearted support during different stages of the project.

2 Administrative department for developing science and technology providing an information system in which HEIs have enrolled their research groups and respective members and products. This platform is nationally known as SCienTI.

Given the foregoing, this article's main aim is to present a proposal for a model measuring HEI research capacity from an intellectual capital-based approach and applying it to a specific case–Universidad Nacional de Colombia UNAL–. The model makes it possible to identify HEI research capacities and obtain input thereby facilitating designing and formulating science, technology and innovation policy.

The UNAL is the biggest Colombian public university with 35000 students and 2993 researchers with seven branches around the country. The problems and possible solutions detected at UNAL case can therefore be extrapolated to the general situation for other HEI.

This document is the result of the project "System of indicators of research" included in the Program Development 2007 to 2009 of the UNAL, which aims to achieve a joint perspective of R&D capacities and potential consolidated processes associated with research and knowledge of the IES. In order to build the model the team of Vice-Rector Research and other members of the academic community of the UNAL have participated and it has been socialized with other institutions of NSTIS, which are given to us a feedback of the model.

This article consists of the following sections: the first section shows the methodology to build the model; the second section explains the conceptual framework used to support the model; the third section explains each model´s component; the fourth section talks about how the model was applied at UNAL; the fifth section presents preliminary results related with the applying model stage. There are three types of results: the first ones are bound up with reporting the research capacity of the HEI in question, the second ones are associated with managing research within UNAL, which could become adapted to other HEI. The third ones are related to feedback for the model and learning from the process of applying the model and measuring research capacities in HEIs. The last section shows some conclusions of this project.

Methodology

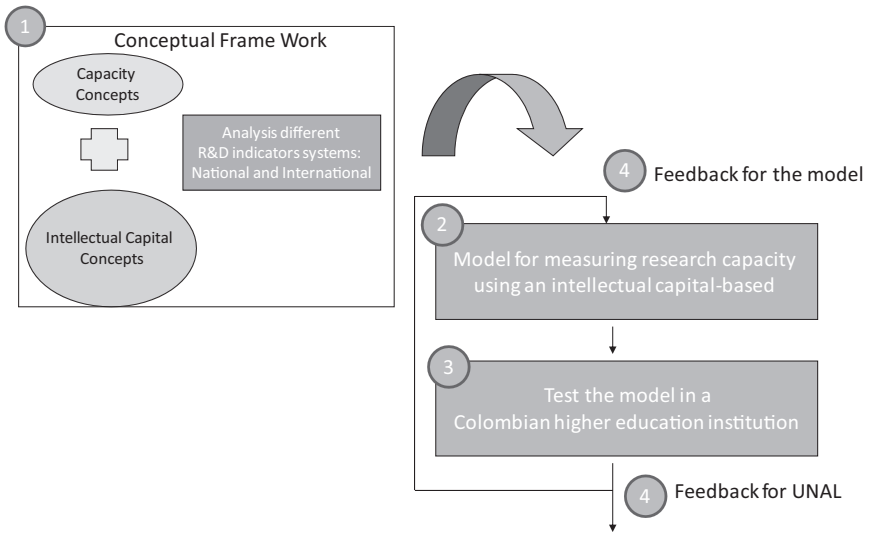
The performed analysis of the state of the art did not provide us with published works exactly matching the research question that could be used a reference, but there are some publications as we are going to mention at second and third sections, which support the model. The design of a model for measuring research capacity using an intellectual capital-based approach in a Colombian higher education institution required four phases (see Figure 1):

1. To build a conceptual framework
2. To design the model
3. To apply and test the model
4. To feedback the model

To build a conceptual framework

At first, we had to present the conceptual framework for designing the proposal for a model measuring HEI research capacities. This involved identifying the concept of capacity and its implications from an intellectual capital referent-based measurement proposal, its relationships with the Knowledge Society, processes for evaluating research using different approaches and exploring the indicator systems used in Colombia for evaluating research

FIGURE 1. Methodology.



Source: drawn up by the authors.

results (SUE, CNA),[3] as well as referents from international indicator systems (OEU[4], RiCyT, OECD).

To design the model

The model has two modules. One of the model's components, which is called **IC measuring module,** was established from the conceptual elements which could give an account of HEIs' research activities in different intellectual capital settings (once the HEIs had established the need for identifying their institutional capacities) providing input for constructing a collective and general scientific profile of HEIs.

However, the identification of aggregate capacities is not sufficient at the institutional level to account for the dynamics of research activities because, in several times, the decision-making process at the HEI requires to specialize in potential areas that have greater capacity or that it considers strategic for its development or they are identified as emerging research fields.

For going, the measurement model proposed capacities research advanced to a stage called **thematic IC measuring**, which supports the building of research thematic agendas that will serve as input to design R&D policies at HEI. This component involved designing a procedure for identifying research capacity in a particular area of knowledge or specific economic sector. This procedure goes beyond identifying an HEI's aggregate capacity and leads to constructing a specific scientific profile for one or more areas established by the HEIs.

To apply and test the model [T3]

We applied a pilot test to the most relevant public HEI in Colombia once we had formed the model. Section fifth gives a detailed account of how we have applied the model to the UNAL. The model applying went through phases of identifying, debugging and integrating the information from sources internal and external to the HEIs.

In general, for the first module we carried out the test in five steps:

1. Diagnosis of the system indicator used to report research
2. Define the indicator system based on intellectual capital approach
3. Collect and debug internal and external databases for each indicator
4. Identify time-series for each indicator
5. Analysis of findings

For the second module, the test was carried out in three steps:

1. Define thematic areas
2. Text mining on thematic areas using debugged internal and external databases
3. Analysis of findings

From applying the model to a specific case, the problems and possible solutions detected at UNAL case can therefore very possible be extrapolated to the general situation for other HEI. There are previous experiences that illustrate a case to apply a model and their results at HEI (Landeta, Rodriguez and Ranguelov, 2004; Sánchez and Elena, 2006; Bucheli and Villaveces, 2007, Rivera and Acevedo, 2007).

To feedback the model

The proposed model's strengths and weaknesses were detected by applying the model in the UNAL, as well as the preliminary results for the indicators and the general profile. The foregoing revealed the convenience of making advances in constructing the specific profiles leading to establishing whether HEIs' capacities responded to determined economic sectors' needs.

The preliminary results obtained for each proposed indicator, as well as the strengths and weaknesses detected when applying the model, became feedback input leading to adjusting the model. We supposed that it would

[3] The State University System (*Sistema Universitario Estatal* SUE) incorporates the set of public universities in Colombia consisting of HEIs representing around 30% of the total of HEIs in Colombia. Source: the Ministry of National Education (SNIES) 2008. The National Accreditation Council (*Consejo Nacional de Acreditación* –CNA) recognises high quality institutions and programmes in Colombia. These entities have proposed indicator systems accounting for HEI processes and results in Colombia, such systems encompassing specific public higher-education objectives and requirements for accreditation and recognition processes.

[4] The European Observatory of Universities is a European Unión initiative attempting to standardise how European universities account for their activities. The Latin-American Network for Science and Technology Indicators (*Red Iberoamericana de Indicadores de Ciencia y Tecnología* - RICyT) annually collecting statistics related to CTI activities and those of Latin-American countries.

be iteratively applied until all the indicators and profiles were obtained.

Conceptual framework

This section explains the most important aspects related to intellectual capital conceptual approaches, the concept of capacity and its implications from an intellectual capital referent-based measurement proposal, the intellectual capital's relationships with the Knowledge Society, processes for evaluating research using different approaches and exploring the indicator systems used.

Intellectual capital: The Main conceptual approaches

As Petty and Guthrie (2000), Kauffmann and Schneider (2004) and Tan, Plowman and Hancock (2008) have mentioned, intellectual capital (IC) has many definitions and given that it deals with a growing field, no consensus can be found in the literature about a single definition. Therefore, we present a brief review regarding the expression's evolution.[5] In effect, according to Sánchez (2008) the "intellectual capital" syntagma was first used in 1836, and several authors have used it since then.

The first formal definitions of intellectual capital appeared at the end of the 1990s, proposed by Edvinsson and Malone (1997) and reinforced by the Organisation for Cooperation and Economic Development –OECD (1999) in which intellectual capital is defined as the economic value of two categories of intangible assets in an organisation: human capital and structural capital (SC). As part of intellectual capital, human capital (HC) refers to intangible assets grouping people's knowledge (*know-how*), skills, abilities and competency leading (by dedicating a determined time), to developing knowledge being produced and scientific documents, technological objects and general objects of knowledge being obtained (Roos, Roos, Edvinsson, & Dragonetti, 1997; Sveiby, 2001; Jaramillo & Forero, 2001; MERITUM project, 2002).

Structural capital is understood as being intangible assets able to generate knowledge, forming part of the setting for an organisation's action (i.e. an organisation's own emergent knowledge in the sense that it is not the property of particular people or teams working for an entity). The organisation explicit, codified, systematised and interiorised it through a formal process creating a succession of organisational routines or guidelines being systematised and socialised by a particular organisation (CIC, 2003).

Consequently, structural capital refers to the infrastructure incorporating, preparing and sustaining human capital. This includes the set of knowledge, which is an organisation's property. It stays there in spite of people leaving it, the organisational capacity it has regarding physical aspects used for transmitting and storing intellectual material –e.g. information systems, the plant and equipment and all that contributing towards human capital feeling motivated and in constant creativity and contribution– (Edvinsson & Malone, 1997; the MERITUM project, 2002; CIC, 2003).

Subsequent conceptual developments suggested that intellectual capital consists of another category (as well as the already-mentioned ones): relational capital (RC) which covers clients' relationships and relationships with the external setting (Roos et al., 1997; Stewart, 1997; and Brooking, 1996, cited by Tan et al. (2008); Eurofo-rum, 1998; Sánchez, Chaminade, & Olea, 2000; MERITUM project, 2002).

[5] The review by Petty and Guthrie (2000) suggested that developing the intellectual capital concept could be divided into two overlapping and complementary stages: an awareness-raising and understanding stage regarding IC's importance and a consolidation and legitimisation one collecting evidence of measuring intangibles in organisations orientating future developments. Tan H. et al., (2008) thought that the latter could be divided into two phases, one related to conceptual developments for measuring intellectual capital by formally defining indicators and another related to applying intellectual capital concepts for increasing organisations' performance and competitiveness.
The awareness-raising and understanding stage regarding intellectual capital importance began in the 1980s with definitions about intangible assets, which could be considered as being forms of knowledge having differing degrees of specificity, codification and complexity (Sveiby, 1988 cited by Petty et al.; Kogut and Zander, 1992; Lado, Boyd, & Wright, 1992). Their knowledge intensity makes them scarce and valuable assets and hampers third-parties imitating them thereby facilitating income derived from cost and specialisation differentiation-focused strategies being generated (Barney, 1991; Grant, 1991; Peteraf, 1993) cited by Navas López (2002); from a strategic point of view, using knowledge allows differentiating elements and factors to become appropriated which can generate competitive advantages for an organisation (Strategor, 1995). It is worth mentioning Kaufmann and Schneider's review (2004) here, which observed how several authors, mainly Bukh et al., (2001), Gu and Lev (2001), Daum (2002), have used the "intangible assets" syntagm as a synonym for the intellectual capital concept and, at the same time, have distinguished several ways of using and applying it.
On the other hand, the consolidation stage began with its development in the 1990s with organisations proposing different intellectual capital measurement models, as mentioned by Sánchez and Elena (2006), the following work in particular being worth highlighting: Kaplan and Norton (1992) (the balanced score card), Celemi and Skandia (1995) and Edvinsson and Malone (1997) (the Skandia Navigator), Brooking, (1996) (broker technology), Bontis (1996) (West Ontario University) cited by Sánchez et al. (2006), Petrash (1996) (Dow Chemical Company), the Canadian Imperial Bank (Intellectual Asset Monitor), Eurofo-rum (1998) (the Intellectus model), intellectual capital, the value explorer and the MERITUM project (2002).

Notwithstanding the lack of consensus about how to define intellectual capital, there is relatively broad consensus in the literature regarding human, structural and relational capital categories.[6]

The relevance of intellectual capital to the Knowledge Society

It is increasingly accepted that we are involved in developing the Knowledge Society[7], which can be defined as the society producing, transmitting and appropriating knowledge for having a bearing on its reality as motor for economic development and social changes[8] (Chaparro, 1998; Sánchez, 2000; European Commission, 2000; Bianco, Lugones, Peirano, & Salazar, 2003; Medina, 2005).

It is also known that HEIs have evolved their missionary processes (since the 12th century), one of that is teaching, which (since the mid 20th century) has been accompanied by incorporating research and, recently, has included the so-called third mission,[9] which is no more than HEI assuming a more active role in the university–company-government relationship (Etzkowitz, 2003). So interaction between national innovation system agents is reinforced, leading to the emergence of the triple helix model (Etzkowitz & Leydesdorff, 2000) and Sabato's triangle (Sabato & Botana, 1968).

The role that HEI plays in Knowledge Society is reaffirmed through their three missions and society becoming more aware of HEIs' role being related to transmitting and generating knowledge through teaching, partly through forming regular students and partly through the hundreds of courses not included in academic programmes directed towards other actors in society.

Secondly, derived from research processes, HEIs' role is related to generating dynamic, inter- and trans-disciplinary knowledge through interaction between the academic world and industry having focalised and design-orientated solutions, a phenomenon known as knowledge-producing "mode 2" (Gibbons, 1994 cited by Leitner (2002)), making HEI an active part of innovation processes in the Knowledge Society (Etzkowitz & Leydessdorff, 2000). The European Commission (2003) has ratified such role when considering HEI as being the heart of the Knowledge Society in interacting with organisations and government actors.

Thirdly, inter and trans-disciplinary dynamics obliging HEI to establish cooperation agreements benefitting the production of knowledge generate processes and dynamics, which may have an effect on reducing the costs associated with carrying out research projects, and may reduce costs related to the time of developing research projects due to constant peer feedback.

Arising from the foregoing, as Leitner (2002) has pointed out, the HEIs' most valuable resource lies in their researchers and students with their implicit relationships as well as their own organisational routines from which knowledge is obtained, which, without doubt as pointed out by Sánchez & Elena (2006) is, at the same time, their main resource and result. The latter takes account of the pertinence of considering intellectual capital in developing HEIs' social role, as the main actor in the Knowledge Society.

Measuring intellectual capital within the context of evaluating research and higher education

Given the foregoing framework, we must establish whether HEIs are assuming their role in the Knowledge Society, especially because HEI carrying out research is not sufficient for considering that they are generating interaction with society and resolving different social sectors' problems from the results of such processes. It is thus necessary to evaluate such activities, thereby possibly implying reorientating policy aimed at designing, articulating and promoting research activities within organisations so involved, especially if it is considered that most science- and technology-orientated policies are supported by state resources, as in the case of some HEIs.

Measuring and evaluation processes must specially seek to identify the effects, impacts and efficiency of investing in developing specific projects or activities. Evaluation is considered to be a process permitting feedback. As rightly stated by the MERITUM project team (2002), "what is

6 Nevertheless, it should be stressed that there are other intellectual capital categories, as mentioned by Kauffman & Schneider (2004), in which other authors, such as the American Financial Accounting Standard Board and the Schmalenbach Society, have proposed categories such as innovation capital or process capital related to technological and organisational development in each institution, categories which could be included in structural capital or relational capital depending on how a case has been analysed, as pointed out by Edvinsson and Malone (1997).

7 According to Morcillo (2004), the Knowledge Society tries to, "manage tacit more than explicit knowledge given the major competitive implications which are associated with it."

8 As pointed out by Sánchez and Elena (2006), since the middle of the twentieth century different theories recognising the existence (to a greater or lesser degree) of factors constituting intangible resources for partly explaining economic growth (Arrow, 1962; Schultz, 1961; Freeman, 1982; Nonaka & Takeuchi, 1995; Gorey & Dobat, 1996; OCED, 1996; European Commission, 2000; Solow, 1957; Kendrick, 1974; Becker, 1975, and Deninson, 1962, cited by Sánchez and Elena (2006)).

9 At Colombian context, it is known as social projection or extension processes.

not measurable, is not manageable." If no evaluation is made, there is no feed-back, results are not known, weak points cannot be identified, or strong points, adjustments and connections for formulating policy and putting strategies into operation (Sánchez-Torres, 2006).

Nevertheless, recognising the need for evaluation, inconveniences may be identified in measuring research activities in different settings regarding their intangible nature. Bozeman & Dietz (2001) have thus reviewed the different approaches to evaluation, which have been used and have proposed moving from the "product paradigm" to the "capacities paradigm". The authors have described that the product paradigm centres on a numerical estimation of patents, publications, projects, citations, etc, whilst the capacities paradigm centres on determining the impact of financing the formation of scientific human capital incorporated in individuals and social aggregates including configuring academic research networks.

The same authors have grouped models for measuring research activity into two large categories. The first consists of individualistic models measuring productivity, leaving aside science's social fluidity. The second one consists of social models analysing interactions between actors, regarding the potential of such networks.

In spite of existing developments regarding models for measuring intellectual capital[10], we should recognise that most of them are designed for private organisations (Leitner, 2002). This situation demands adapting or designing alternative models for other types of organisation, such as HEIs.

From an intellectual capital approach, knowledge is the key factor or strategic resource in creating an organisation's value. It leads to identify which is its available knowledge. It is understood as acquiring it, applying it, storing it and classifying it (Grant, 1996 and Spender, 1996; Tsoukas, 1996 cited by Navas López (2002)), maintaining a perspective regarding creating or acquiring new knowledge (Nonaka, 1991 cited by Navas López (2002); Nonaka and Takeuchi, 1995) which is applicable to a particular organisation. However, from interactions which may arise between different intellectual capital categories (López, Martín, and &Navas, 2004), this knowledge's value is comparable to the concept of capacity understood as being that which it is known how to do, including personnel, organisational and technological capacity (Bueno, 2002).

Even though it is true that models for measuring HEIs' intellectual capital do account for their research activities and constitute the starting point for this document, it is necessary we to go further. So, HEIs' constructed capacity can be identified from measuring intellectual capital (i.e. identifying what they know how to do, in terms of research's interaction with teaching, formation and third mission. The foregoing tries to obtain an associated scientific profile, whether this is with a thematic area or with an economic sector.

A model for measuring hei research capacity from an intellectual capital–based approach

Constructing a model for measuring HEI research capacity from an intellectual capital-based approach springs from two premises. One considers, as mentioned before, intellectual capital to be a working framework that allows HEI to confront the new challenges that the Knowled-

[10] The RICARDIS report (European Commission, 2006) is a recent example of accounting for intellectual capital in small- and medium-sized companies (SME) can be highlighted. Sánchez & Elena (2006) have mentioned some initiatives for measuring intellectual capital in public entities, and have stressed the experience of the Austrian Research Centre (ARC). This centre had been working for nine years on presenting its intellectual capital report. It also had suggested that the Austrian government should design a law obliging Austrian HEI to produce such report since 2006, the same as the European Observatory of Universities' initiative (EOU) created in 2004, one of whose objectives is contributing towards understanding managing intangibles in public European HEI for improving higher education quality and competitiveness. Rodríguez-Castellanos, Landeta, & Ranguelov (2004) explained that a way to measure intellectual capital at universities is related with direct or indirect social value, it means that the value of the intellectual capital is based on the generate and transfer capacity to the social environment (companies, governmental agencies and so on).
At Colombian context there are some experiences: Ballesteros & Ballesteros (2004) proposed a model for measuring intellectual capital for public sector entities consisting of four components: internal organisation, external relationships, human capital and social/environmental commitment. Each component is accompanied by key or intangible aspects. The concepts are quantified by using a set of indicators; each entity must incorporate those which it considers opportune, according to its stated objectives. Medina et al. (2007) proposed a model to measure capacities in terms of research, education and invention of strategic production sectors of Colombia using indicators related to human and structural capital. Human capital indicators are based on research teams and structural capital are related to the training programs and patents. Bucheli & Villaveces (2007) have proposed a model for measuring returns on capital from investing in R&D in a private HEI from an intellectual capital approach. The same authors applied the model to the Universidad de los Andes in 2008. It accounted for the topicality of discussing and applying intellectual capital referents when measuring HEIs' activity in Colombia. In the case of UNAL, the vice-rector of research's office formulated some elements (2006) serving as guidelines for reviewing research policy for research groups' topic areas, as well as proposing some preliminary measurements for research groups' interaction by analyzing its social networks (Rivera & Acevedo, 2007).

ge Society imposes on them and taking account of their activities. A second considers that resources dedicated to research activities do not represent an expense; on the contrary, it means an investment insofar as resources destined to research activities become capacities imparting dynamics to processes associated with generating knowledge and providing HEI with added value.

The model was constructed from the following conceptual referents (see Figure 2):

i. In line with the foregoing at conceptual framework, and for the effects of the model proposed for measuring HEI capacities, it has been considered that intellectual capital will be the set of an organisation's intangible assets generating value for it or having the potential for generating it in the future.

ii. Consensus found in the literature about intellectual capital categories (i.e. human capital, relational capital and structural capital);

iii. For effects of the model, human capital integrates the abilities, the experience, formation and knowledge of the people forming part of a particular organisation.

iv. Structural capital refers (as stated above) to the infrastructure incorporating, training and sustaining human and relational capital.

v. Relational capital is integrating relationships with an organisation's the external setting.

vi. Generating capacities understood as being that which it is known how to do, including personnel, organisational, technological and structural capacities providing an organisation's activities with value;

vii. The paradigm of generating capacities as a way of evaluating research being centred on the impact of financing R&D projects, forming scientific human capital in their social aggregates and generating new uses of knowledge (Bozeman and Dietz, 2001) (in other words, the impact of financing on human, relational and structural capital, respectively, being observed;

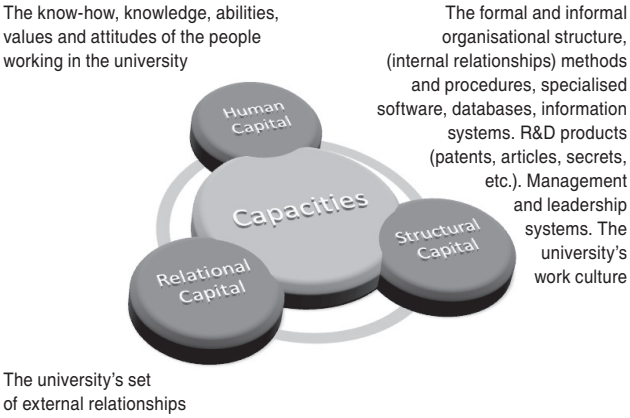
viii. The interaction between different intellectual capital categories leads to developing institutional capacities. Bozeman and Dietz (2001) have pointed out that the interaction between relational capital and human capital is so fundamental, intimate and dynamic that none of the concepts acquire full significance by themselves alone, making it almost impossible at the end to identify where one ends and the other begins. It can be added, in line with Lopez *et al.,* (2004), that relational and human capital cannot be developed if HEIs do not have a suitable structural capital level;

ix. Constructing institutional capacities reflects accumulative dynamics on which knowledge is based and its intangible nature, due to the set of intellectual capital components (i.e. research capacities become increased and growth in intellectual capital components is generally observed as a result;

x. Evaluating research capacity is a process which, depending on the availability of information, will be applied in phases; and

xi. Models for measuring HEIs' intellectual capital form the basis and are the springboard for seeking to identify and propose a suitable alternative for measuring HEI capacity regarding research through thematic areas or economic sectors.

FIGURE 2: The conceptual basis for the model of HEI research capacity.



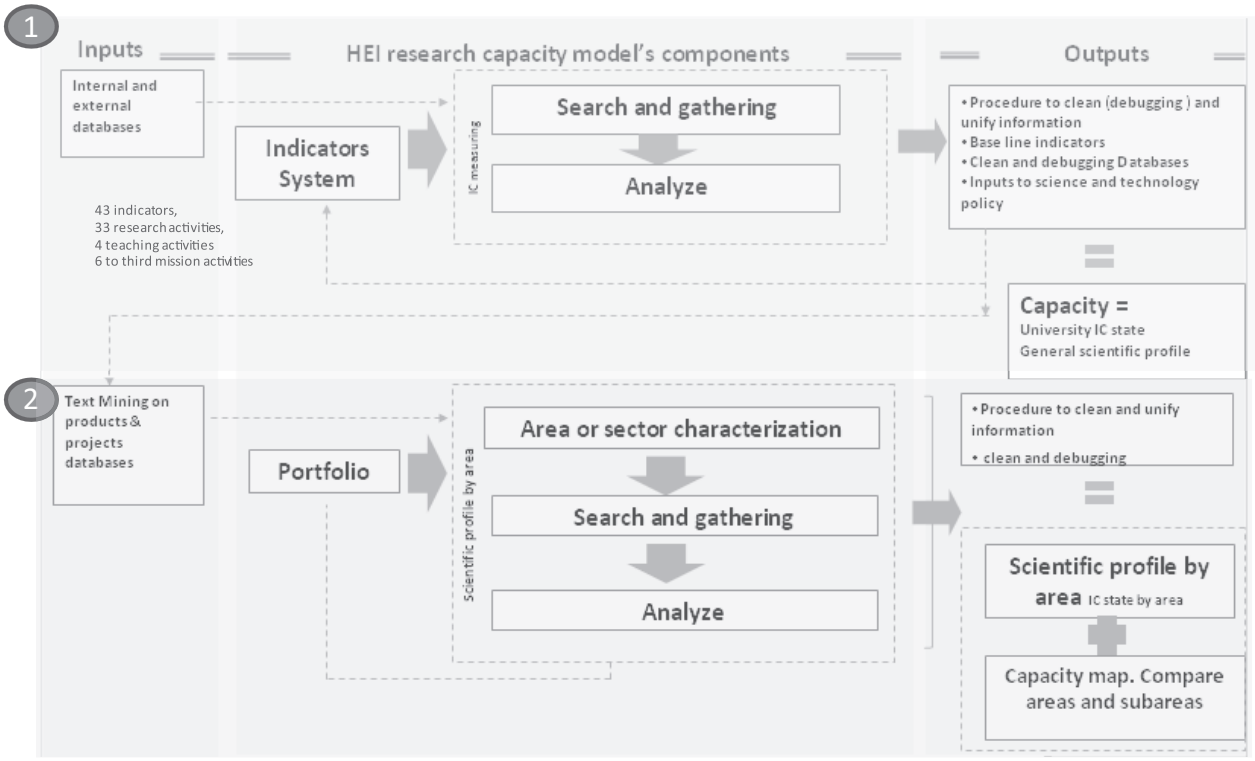
Source: drawn up by the authors, based on Edvinsson & Malone (1997), Roos et al., (1997), Jaramillo & Forero (2001), Bozeman & Dietz (2001), the MERITUM project (2002), CIC (2003), Sánchez (2008).

The proposed model has the followings components: an intellectual capital measuring module and a thematic intellectual capital measuring module. Figure 3 shows the model with its components–inputs and outputs.

IC measurement module [T3]

The intellectual capital measurement module is aimed at identifying HEIs' accumulated capacity expressed through their general scientific profile from the results obtained from constructing the indicator system. The module tries to integrate observing human, structural and relational capital into a system of indicators accounting for the activities arising from HEIs knowledge generating processes.

FIGURE 3: The HEI research capacity model's components.



Source: prepared by the authors.

External and Internal databases and the indicator system provide entry to the intellectual capital measurement module. The indicator system is defined from making a systematic review of the indicator systems used for measuring research activity in HEIs in a national and international setting (SUE, OCyT and CNA indicators and EOU, OECD and RiCyT international indicators). The indicator system proposed for HEI in Colombia consists of 43 indicators[11], 33 of which are directly related to research activities, 4 to formation activities, and 6 to third mission activities, recognised within the national setting as social projection or extension. Table 1 describes the indicators included in the proposed model related to research activities.

In turn, this is subdivided into 5 indicators for human capital, 10 indicators for relational capital, and 18 indicators for structural capital (categories selected from the intellectual capital approach applied to the model). We should point out that structural capital indicators included the investment in R&D indicator, which is catalogued in the literature as financial capital.

The reasons for being included in the structural capital category are that (from our point of view) investment in R&D forms part of the infrastructure, similar to plant and equipment which are necessary for human capital to become developed. On the other hand, investment in R&D has an intangible nature regarding its management (i.e. abilities and experience must be developed in HEI for levering external resources from both R&D financing agencies and from selling services implicit in the third mission.

[11] At the same time, each indicator must deal with the following aspects suggested by the MERITUM project and which are considered to be an accepted international referent and, thus, applicable to the indicators proposed in the intellectual capital approach-based model for HEI research capacity (MERITUM project, 2002):

- The indicator must contribute useful, relevant and significant information regarding the different aspects to be studied;
- The indicator must be understandable if calculated and presented with clarity, using rational procedures which can be easily understood by its potential users;
- The indicator must be opportune;
- The indicator must be comparable, so that comparisons can be made in both time and national and international settings;
- The indicator must be reliable, given that the information provided is reliable (i.e. truthful, objective and verifiable);
- The indicator must easily give a rapid idea of the state of a particular HEI's research capacities, synthetically offering characteristic features;
- The indicator must include whether it is relatively easy to obtain the necessary information for establishing its value; and
- The indicator must have a clear, unambiguous definition which avoids different interpretations being given, especially at the moment of the information being captured. Such indicators having a highly subjective nature must thus have a respective definition of a scale.

TABLE 1: System of indicators proposed for measuring HEI research activity from an intellectual capital viewpoint.

Human capital	Relational capital	Structural capital
Number of active researchers involved in HEI	Number of HEI teachers in other institutions	Number of projects presented to state financing entities discriminated by institution (Colciencias-MADR, Ministries, Banco de la República, etc.). Approved *cf* non-approved
Number of active researchers / Number of full-time teachers	Number of teachers not belonging to HEI / visitors	Number of research projects leading to support from national and international processes for drawing up norms' commissions, participating in formulating long-term programmes, public policy studies
Teachers' time dedicated to research	Number of teachers-researchers participating in networks / number of teachers-researchers	Total economic resources for research (own+public+private) discriminated by items.
Number of administrative personnel involved in research groups or research projects	Number of external recognitions, prizes and distinctions awarded for an institution's research work	Total budget appropriated-executed (expenses for personnel is not included)
Number of HEI research groups classified by Colciencias	Number of spin-off companies	Total economic resources destined for teachers' PhD formation
Number of research group members (researchers, students)	Number of networks in which HEI researchers participate	Economic resources awarded *cf* economic resources requested for financing projects
Total economic resources for research/ number of active researchers	Number of graduate works involved with the production sector	Private and public sector economic resources supporting research and extension projects (value of contracts with private and public sectors)
Number of undergraduate and postgraduate research assistant students	Number of intellectual property requests registered with other institutions	Public sector economic resources supporting research projects/ total economic resources for research
Number of PhD-MSC/MA- specialisation-specialty and undergraduate students	Number of research projects discriminated by beneficiary	Private sector economic resources supporting research projects/ total economic resources for research
Entry rate for PhD, MSC/MA, specialisation, specialty and undergraduate programmes		Number of research projects.
Number of postgraduate study-grants / Number of postgraduate students		Products or results generating new knowledge
		Number of products arising from a group's research activities related to forming researchers
		Number of products related to extending a group's research activities and their results: social appropriation of knowledge
		Number of articles published per institution in indexed journals
		Number of articles from an HEI in expanded ISI
		Number of citations of articles by an HEI
		Number of citations of articles from an HEI in ISI
		Number of requests for registering HEI intellectual property

Once the system of indicators had been completely structured, an information search and collection stage was carried out for establishing base-lines for the defined indicators using internal and external HEI databases. The following stage concerned analysing the indicators so obtained. This result gives the overview of intellectual capital in HEIs in such a way that an account of their research activity could be given and so become the scientific profile for the HEIs.[12] As showed in Figure 3 there are others outputs like a procedure to debug and unify information, a clean and debug databases set and base lines for the defined indicators.

The proposed indicators are applicable to the different levels of an HEI's organic structure (i.e. applying to a school or faculty or for the aggregate level of the whole organisation).

Thematic IC measurement module

As mentioned before, the identification of aggregate capacities is not sufficient at the institutional level to account for the dynamics of research activities because in several times, the decision-making process at the HEI requires specialize in potential areas, which have greater capacity or that it considerers strategic for its development or are identified as emerging research fields.

The thematic intellectual capital measurement module was aimed at constructing specific thematic profiles that would lead to establishing whether HEIs' capacities really did respond to determined economic sectors' needs or detailed demands.

This module involved a process of identifying HEIs' specific capacities so that the HEIs' specific thematic or scientific profiles could be recognised and constructed.

This component of the model became a way for HEIs to account for their potential and research activity for determined areas of knowledge or regarding certain production sectors.

This component was constructed in three stages: an initial one for defining thematic areas and characterising them–each thematic area were composed by at least 4 or 5 subthematic areas. A second one seeking and collecting information for establishing capacities using the clean and debug set of databases and text-mining techniques to identify indicators of human, structural and relational capital for each area. A third stage for analysing the information so obtained. This stage involved a process of normalising some of the intellectual capital indicators–for example, the number of investigators was normalised regarding human capital. The number of institutions with which research projects were being carried out was normalised in relational capital and the number of products arising from new knowledge and the number of research projects was normalised in structural capital.

A profile was obtained for a thematic area from the foregoing, which could then be compared to other profiles, in the sense that each thematic profile could be represented. It was established that the "x" axis reflected normalised human capital on the map and the "y" axis the sum of normalised relational and structural capital. Figure 4 presents a preliminary map of scientific profiles in different subthematic areas related to the environment area and indicates the compared capacities of the researchers so involved and the products arising from new knowledge.

In addition, this module has others outputs (showed in Figure 3) as a procedure to debug and unify information to build a portfolio, a clean and debug databases set for each thematic portfolios and base-lines for the defined indicators.

Applying the model in the Universidad Nacional de Colombia–UNAL

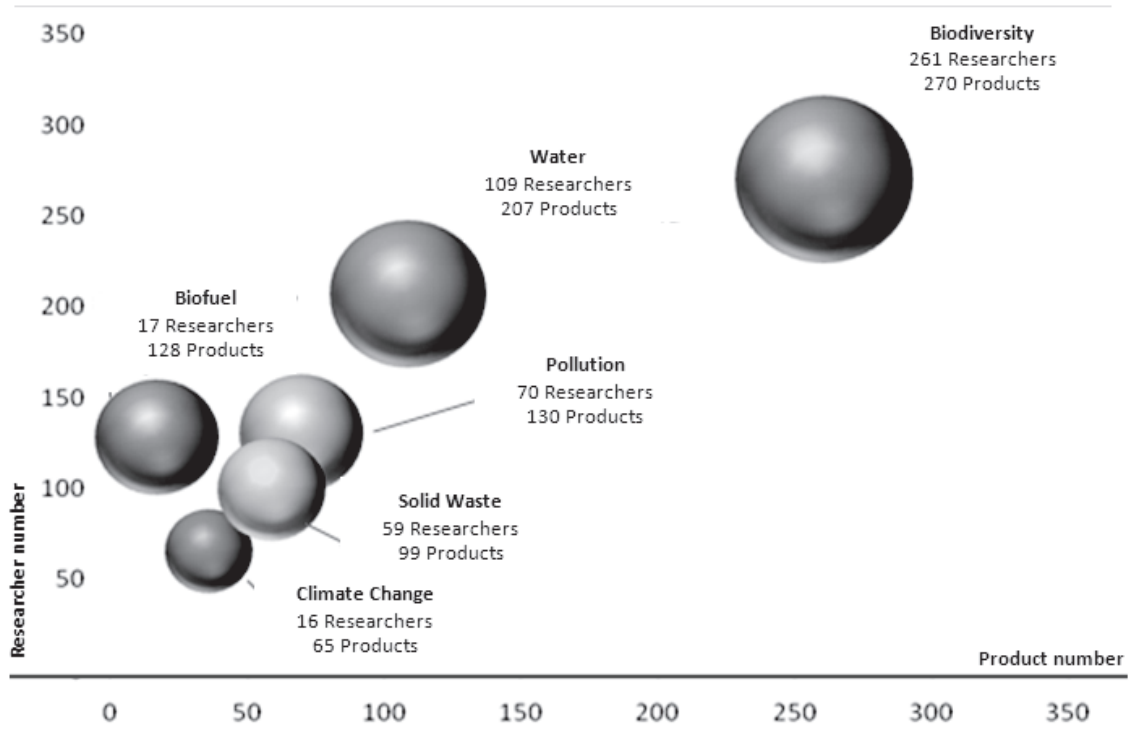
UNAL is a point of reference for Colombian HEI, as it is the public university offering fulltime courses. It has the largest student population (around 40,000 undergraduate and postgraduate students), the largest amount of fulltime teachers (about 3,000), as well as seven sites in different parts of Colombia. According to OCyT (2008), UNAL has around 45% of the research groups registered in the SCienTI platform, thereby making it the main actor in the Colombian SNCT. As well, UNAL has 19% of the research groups of the country, and is the publisher of 14% of national scientific journal. It offers 40% of doctoral programs in the country, and has 24% of the Colombian ISI publications. For these reasons, we think that applying the proposed model in UNAL became a pilot case leading to large-scale feed-back. Therefore, other Colombian HEI can use the results and take advantages of the lessons we have learnt.

Additionally, the model is important to the UNAL because it could be used to support the great efforts that the UNAL has been making towards becoming a research university (i.e. an HEI whose efforts are orientated towards:

1. Developing research-based infrastructure;

[12] This result is obtained using and adapting the models for measuring intellectual capital as mentioned before.

FIGURE 4: A map comparing capacities.



Source: the authors' own work, taken from information provided by the Vice-Rector for Research's Office, Universidad Nacional de Colombia.

2. Offering PhD programmes (having most of its students at this level);

3. Supporting a large number of investigators as being generators of new knowledge forming part of interdisciplinary teams, having international partners seeking to resolve real world problems through university-state-company integration (as far as possible);

4. Consolidating a broad network of international relationships stimulating collaborative research;

5. Ensuring international visibility for research results and artistic creation;

6. Allocating important R+D+ resources through different sources of financing; and

7. Ensuring its research takes place within a global setting (Aziz, 2006; Mohrman, Mab and Bakerc, 2008; Balan, 2008).

It is thus relevant to measure that institutional capacity after applying the proposed model in UNAL.

Applying the model to UNAL involved two large stages: a phase to identify an intellectual capital overview–applied between August 2008 and September 2009, and a phase to identify thematic intellectual capital capacities. This phase began with a prototype portfolio in January 2009 for the environment, housing and territorial development area, as the result of approaching the government entities involved in these topics.

An intellectual capital overview

As we mentioned before, for the first module the test was carried out in five steps: i) diagnosis of the system indicator used at research area; ii) define the indicator system based on intellectual capital approach; iii) collect and debug internal and external databases for each indicator; iv) identify time-series for each indicator; and, v) analysis of findings.

Diagnosis of the system indicator used at research area and define the indicator system based on intellectual capital approach

A search was made within the organisation for indicators reporting research activity from 1990 to 2008 as the background for constructing the system of indicators. Institutional documents were thus consulted (Brigalbo & Campos, 2001) and UNAL's annual journals of statistics and indicators (2000-2007). In effect, for some of the years during the period being observed, UNAL had previously reported six indicators from the indicator system proposed in the model presented in this article. They are the number of research groups according to Colciencias' classification, the number of HEI teachers by formation level, the number of journals listed in the national jour-

nal index (PUBLINDEX), spending on R&D, the number of museums and research centres, and the number of students supported by UNAL in mobility programmes.

These six aforementioned indicators presented at least four limitations (even though they fulfilled the requirements proposed by the MERITUM project for being indicators). Firstly, they did not account for research activity in their set; they especially did not present measurements related to structural capital, as they did not highlight researchers' academic production. They also did not measure UNAL's relational capital, as its researchers' institutional or personal links with members of other academic or scientific communities could not be determined from the six indicators. In turn, they did not measure the complete set of human capital, as they did not account for the number of researchers forming research groups or the role of their members: teachers, students, support personnel, etc.

The second limitation was related to measurement continuity (i.e. indicators having some level of disintegration were reported during some years but not in line with the same protocol in other years). The third revealed that some indicators had definitions that occasionally varied over a period, thereby hampering constructing time series. The fourth lay in the availability of information, which is a source external to UNAL for constructing most of the indicators.

A system of indicators, which overcame the above limitations, was thus adopted, given the abovementioned inconveniences and by analysing national and international referent indicator systems. This was in line with national and international standards and accounted for activities involved in generating new knowledge from an intellectual capital-based approach, resulting in a system having the 43 previously mentioned indicators.

Collect and debug internal and external databases, time series for each indicator

Time-series for the proposed indicators were then constructed by applying the model to UNAL. An information search and collection stage was thus begun. This phase implied establishing the origin of the data for each proposed indicator and identifying the external or internal information system containing the expected data. Human capital data were obtained from the HEI academic personnel information system (SARA in the case of UNAL) and the NSTIS platform, called SCienTI.

Regarding structural capital information related to research projects, financial system information (QUIPU in the case of UNAL) was used and cross-referred to information available from external R&D activity-financing agencies. Academic production information was extracted from the SCienTI platform, the SARA system for data concerning the score assigned to teachers involved with HEI for their academic production and arbitrated publications registered in the ISI Web of Knowledge. Regarding relational capital, information was extracted from the Inter-institutional Relationships Office (*Oficina de Relaciones Interinstitucionales*–ORI in the case of UNAL) and from matrices constructed from external links from the aforementioned information systems' input.

The dispersion of information in different sources constituted a limiting factor for quantifying the indicators, thus making it necessary to centralise such data in a special information system and establish its suitableness by getting researchers to validate it, particularly regarding external information from the SCienTI platform. An information system was designed in WEB format for the first phase and presented to the researchers and research groups. This was a collection/validation instrument containing data concerning research groups, projects, products, etc. Researchers, thereby automatically confirmed the information so presented.

Developing an information system supporting the system of indicators has been vital in the sense that the information was validated by the researchers and has also led to collecting the data regarding such indicators which was not available through it, especially that of regarding relational capital.

The information analysis stage began once the model of indicators had been constructed and the information was available in the forms and in the databases. This led to obtaining the chronological series for the established indicators. The databases used for constructing each indicator were then debugged and normalised; for example, the name of the institution in the articles was normalised for the number of articles published in ISI, the name of the journal was normalised for the number of articles in indexed journals listed in the PUBLINDEX index[13]. Once this stage was finalised, a document presenting the indicators' behaviour and the set of the HEIs' scientific profiles was constructed. It should be pointed out that to implement this model, HEIs should be aware that it implies arduous, time-consuming work due to the need for centralising and debugging the information.

[13] PUBLINDEX is the Colombian system for indexing serial publications that emerged as a response to the need for accounting for the quality of national journals in line with the implementation of Decree 1279/2002, which assigned a point-score to articles published in indexed journals.

Thematic intellectual capital capacities

For the second module, the test was carried out in three steps: i) define thematic areas; ii) text mining on thematic areas using debugged internal and external databases; and, iii) analysis of findings.

The second module to identify thematic intellectual capital capacities was begun once most of the indicators had been constructed and databases debugged. Constructing a prototype had been proposed for this phase, aimed at identifying institutional capacity in one of the sectors considered to be strategic.[14] Thus, human capital indicators were presented for a thematic area or a production sector such as the number of research groups and their classification according to Colciencias, the number of investigators belonging to such groups, the respective investigators' characterisation in terms of dedication, jobs and formation. Structural capital indicators were presented such as the number of products arising from the new knowledge generated and the number of research projects. Relational capital indicators were presented as a sociogram of links with external entities in carrying out research activities. All the above accounted for the density of a specific area in the set of HEIs' institutional capacities. The following areas have been considered as being preliminary thematic areas in the case of UNAL: the environment, biodiversity and territory; art and culture; biotechnology; health sciences; constructing citizenship and social inclusion; organisational, economic and industrial development; the state and political system; energy; habitat and city; resources, minerals and materials; information and communication technologies.

The results of applying the model to the Universidad Nacional de Colombia

Applying this exercise suggested three types of preliminary results. The first one was related to reporting research capacity (intellectual capital overview and thematic intellectual capital) of the HEI in question. The second one was associated with managing research within UNAL which could become adapted to other HEI and the third one was related to feed-back for the model and learning from the process of applying the model and measuring research capacities in HEIs. At the end of the section, we will explain some limitation in the model.

Reporting research capacity through intellectual capital

Concerning reporting UNAL's research capacity, applying the model led to:

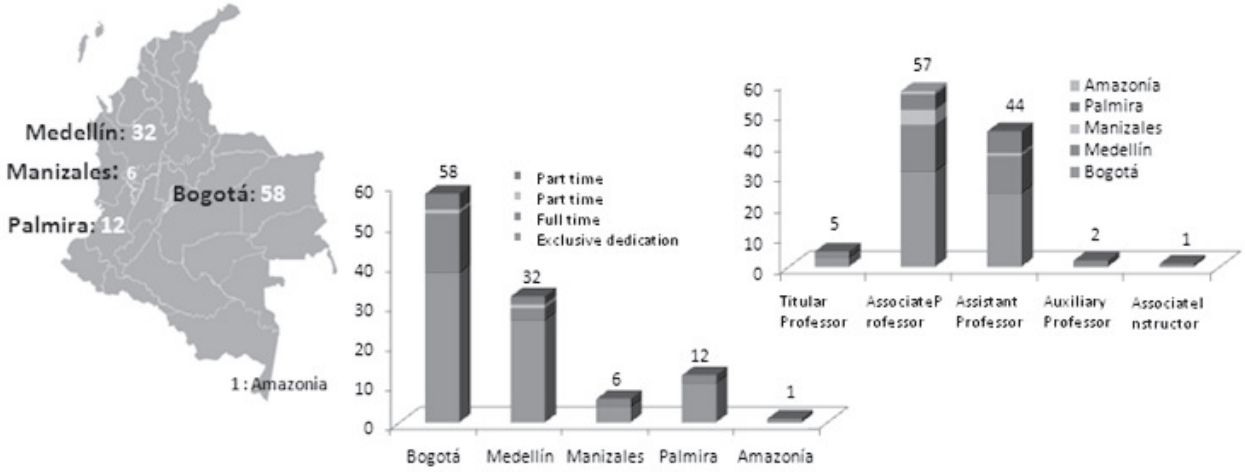
- *Results for intellectual capital overview:* Constructing base-lines for years in the present decade from most of the indicators from the proposed battery. Some of the most relevant indicators were those concerning relational capital that presented UNAL's interactions with other institutions arising from co-authoring/co-responsibility processes, inter-institutional work teams' share in research projects and extension courses. These relational capital results show strong or weak links with different institutions, so they could be used to design mechanism to strong and support HEI–companies relationship. (it should be pointed out that specific results regarding the indicators will be published in a book which were printed during November 2009);

- *Results for thematic intellectual capital:* Identifying UNAL's scientific profile as a whole and in each of its sites, without the detriment of possibly having to descend to faculty or basic academic unit level. Figure 5 gives an example of capacities in a specific area (i.e. water and hydric resources). Human capital indicators are presented as being the number of research groups with their respective SCienTI platform classification and geographical location, the number of investigators ascribed to these research groups. Regarding structural capital indicators, the number of products arising from new knowledge per year and by geographical location is presented.

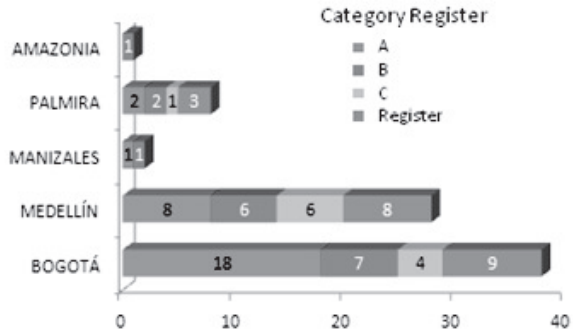
Constructing an initial map of capacities for specific areas of knowledge from national and regional referents and break the data down according to the composition of the HEI structure. This map provided an answer for one of the initial questions (Are Colombian HEI able to respond to an economic sector or a thematic area?) in the sense that thematic profiles could be compared on the map, as can be observed in Figure 4. There was greater capacity for some topics than for others; for example, there was greater capacity in the Universidad Nacional de Colombia for developing investigations related to biodiversity then for carrying out research related to climate change. A map like that presented here (whether in a university's higher levels or in its basic units) will lead to decision-makers (on the one hand) favouring those areas which are weak and (on the other hand) designing

[14] It should be clarified here that defining strategic sectors is an ongoing process having two types of input: policy guidelines, such as the law of Science and Technology and Innovation (DNP, 2009), regional and national development plans–Visión Colombia II Centenario: 2019–a discussion proposal (DNP, 2005), National Competitiveness and Productivity Policy (DNP, 2008), the Ministry of Agriculture and Rural Development's export supply and, on the other hand, institutional guidelines, including those described in PhDs and research: trends, perspectives and strategic guidelines in the Universidad Nacional de Colombia in *Doctorados e investigación: tendencias, perspectivas y lineamientos estratégicos en UNAL* (2006).

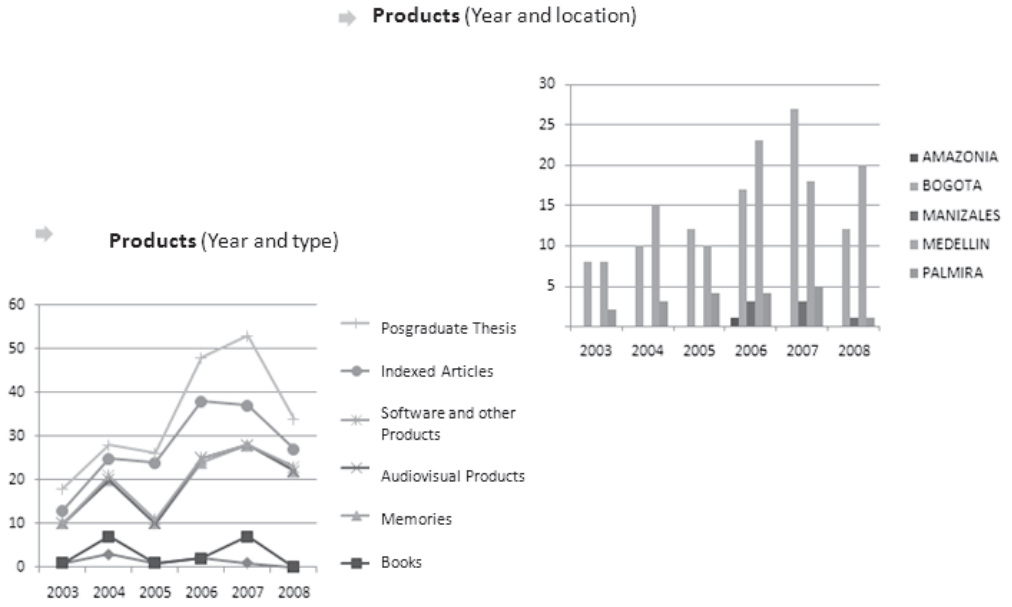
FIGURE 5: Research capacity compared in a specific area of knowledge (water and hydric resources).



109 researcher belong to 77 research groups which have related with Water and Hydric Resources



207 products (articles, books and so on) related with Water and Hydric Resources



Source: the authors' own work, taken from information provided by the Vice-Rector for Research's Office, Universidad Nacional de Colombia.

mechanisms for coordinating this capacity with external actors interested in this topic.

Additionally, defining the role of the actors involved in research activities, technological development and innovation from the research projects and extension courses, the results of academic production and links with the set's environment at UNAL level and that for each of its sites.

Research management

Regarding the results related to research management, it can be said that:

- The proposed model had an evaluation mechanism that was applicable to both UNAL and HEI. It was able to give an account of their research activities; however, the model proposed a system of indicators including national and international referents. It had the necessary procedures available for constructing and debugging each proposed indicator. These two contributions were relevant in the national context as however UNAL and public HEIs might apply the model they could give an account of their activities to the National Higher Education Information System (*Sistema Nacional de Información de la Educación Superior* - SNIES) and insertion into the NSTIS.

- One of the main contributions from our point of view was that, by applying the model, the process of designing and implementing research policy led to input was obtained for supporting decision-making processes. On the one hand, measuring human capital defined policy guidelines in areas of knowledge (whether linked to production sectors or not) in which they had consolidated capacities, in construction or which were still growing, and inputs (including indicators and maps of general and specific capacities) were obtained for initiating processes for defining long-term research agendas. On the other hand, measuring relational capital led to strengthening formation and internationalisation strategies considering guidelines for orientating the teachers and students' mobility strategy within HEI. It also strengthened management processes for promoting research activities with external resources, on constructing spaces in national and international scale networks and research projects and strengthened links between the university and other social actors, between industry and the state. Likewise, measuring structural capital led to obtaining policy input orientated towards consolidating the academic community in terms of strengthening production having national and international visibility and defining guidelines orientating research-promoting programmes. This is important, however the trajectory might be followed; it allows HEIs to have a heritage of knowledge and consolidate their research capacities, advance their research processes and lead to technological development and innovation having greater complexity.

- The foregoing results coincided with Altenburger and Schaffhause-Lizatti's findings (2006), cited by Sánchez (2008b), as they pointed out that a intellectual capital report led to identifying both structural or individual weaknesses and strengths. At the same time, they constituted a state of the art in each HEI mission, understood as formation, research and extension, and thus being a control and monitoring mechanism achieving added-value in this type of organisation in constructing institutional capacities.

- Applying the model led to reporting the university's capacities in terms of different intellectual capital categories' interaction. This meant that by identifying structural capital in terms of products from articles published in the Science Citation Index, then researchers' positioning was identified compared to that of the international academic community (human capital) as well as identifying with which communities cooperation links had been established (relational capital. In others words, the model supported the proposal by López et al. (2004), stating that developing relational capital and human capital requires that HEIs have the necessary conditions regarding structural capital. It has also been observed that constructing institutional capacities is an accumulative and incremental process over a period, especially in consolidating capacities regarding research. This must present as the result of developing intellectual capital components in HEIs.

- This was a first step in measuring those capacities which could eventually be linked together for measuring the institution's financial efficiency and evaluating intangibles, not in the same way as is done in industry but, on the contrary, with HEIs' own nuances.

Feedback and learning processes

Regarding results related to feed-back and learning processes, it was observed the following topics:

- Applying a model reporting HEI research capacities from an intellectual capital approach implied recognising that reporting indicators was a cyclical process. The procedures for obtaining and debugging the information from each of the different sources of information had to be refined to homogenise the protocol for constructing each indicator during successive periods.

- The learning process must be stimulated within the University for understanding the measuring process' importance and scope (i.e. designing a strategy for disseminating the culture of measuring the organisation's intangible assets).

- It should be stressed that the procedure for constructing capacities for thematic areas becomes improved and receives feed-back in the sense that the databases for the indicators were debugged and the actors involved in the measuring process acquired abilities for suitably developing the process. Figure 5 shows an example of identifying capacities for a specific area.

- Identifying research capacities from the proposed model constitutes a gradual process for those HEI that might adopt it, because they must overcome technical limitations associated with the processes of securing, debugging and validating internal and external sources of information. It means an organisation that wants to use this model must be aware that, at least in the first stage, applying the model is a long-term process in which a diagnosis of the organisation–in terms of information systems–must first be made, followed by designing procedures for facilitating reporting different levels in HEIs when the indicators must be consolidated.

- At the same time, the model requires involving actors working in the HEIs forming part of the academic community and contributing towards processes of constructing capacities as dynamising agents for knowledge-generating processes in Colombia, fostering HEI contributions to the National Innovation System in terms of institutional capacities.

Limitations

Because of the reporting indicators was a cyclical process, there were some indicators from which baselines could not be obtained for the whole observation period for its first iteration and, thus, it was expected that measuring the set of proposed indicators would be completed in following iterations.

As an effect of the foregoing, the university was seen to have been obliged in some cases to homogenise its information systems to give an account of the proposed indicators and in others to prepare both procedures and information systems for collecting information regarding some indicators.

To build the thematic areas is necessary to have an expert team to validate the results in order to obtain an approach-measure accurate.

Conclusions

We can observe that intellectual capital offers a working framework from which it is possible to give an account of the research activities of an organisation whose main product and input is knowledge. The value of knowledge is comparable with the concept of capacity within the context of this work, taken from a human, relational and structural perspective. Knowledge as an intangible asset poses the challenge for HEIs of considering managing these intangibles as part of its action (i.e. configuring them as an HEI strategic resource and differentiating factor).

From such formulation and, especially, from applying the model proposed for HEI in Colombia, we can affirm that the model for measuring research capacities coordinates intellectual capital components and leads to accounting for capacities providing an organisation with value. Constructing institutional capacities through intellectual capital as an alternative for measuring research in HEI is centred on the impact of R&D processes on forming scientific human capital, on their social aggregates and on generating new uses of knowledge.

From applying the model, it is important for UNAL recognizes that this kind of systematic exercise let to obtain information as an input to design R&D and academic policies. In other words, there are two major results. The first one is related to the overview of the research capacities and the second one is related to specific research capacities. From the first results can be input to design R&D policies that cover the generality of the research effort and are especially valuable to increase the visibility of such activity. However, the second results are the most important because they show the thematic areas where the HEI has really the research capacities, and consequently the design of policies in R&D is more accurate.

From the results obtained during the first module, it was identified that the role of the HEIs was orientated towards generating capacities through formation and research processes and forming links with the production sector arising from processes of qualifying human resources and cooperation within the framework of programmes and projects. Consequently, it can be stated that HEIs are able to contribute towards developing products and services having high added-value in determined economic sectors from the knowledge-generating processes that they are advancing.

From the results obtained during the second module, it was identified that there are thematic areas with strengths and other areas with weaknesses. As well,

each thematic area has its own behaviour, i.e. each subarea can be consolidated or emergent. It was noted that some thematic areas have similarly strong subareas, while other thematic areas are formed by one or two subareas with high potential, and the other subareas are very fragile.

These results give a thematic map of research capacities of the HEI, which could compare with the economic sectors that the country has defined to increase its competitiveness. It let to know, on the one hand, how real is the potential of the HEI to help in the building of those sectors, and on the other hand, how the level of correlation of the knowledge generated by the HEI and the challenges of the public policies is.

From the results obtained and shared with other HEI, it has been possible applying the model in other cases of studio, which contributes to the model´s validation and feedback. Besides, using the Colombian model HEIs can give an account of processes for generating and transmitting knowledge, because they can recognise the potential of the science and technology activities they are carrying out, from the perspective that knowledge constitutes an asset and, in the long-term, a referent for formulating policy and generating spaces for interaction with different actors. An example of this would be the processes accrediting the quality of higher education in Colombia, which could see as benefitting them from a look at the set of relationships amongst the functions forming HEIs' mission: formation, research and mission relationships.

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