Capacities of the Research Groups at UNICAUCA (Colombia) to Develop Spin-Off-type Undertakings

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Abstract: This paper aims to analyze the descriptive interpretations of the census applied to sixty-four research groups classified by the Administrative Department of Science, Technology and Innovation (COLCIENCIAS) for Universidad del Cauca (UNICAUCA) in the call 781 of 2017, submitting them to a quantitative evaluation using the Karl Person correlation model for pooled data, prior contextualization based on some of the conceptual referents applied by the state entity referred to classify and measure the quality and impact of the groups of I+D+i and their dynamics. From the results obtained in the crossing of variables among categories of groups and areas of knowledge compared to their aptitudes for the deployment of *spin-off-type* technology-based undertakings, it was possible to verify, among other relevant aspects, that the highest categorization is not a determining factor for groups that develop innovative products and have an entrepreneurial profile.

Keywords: research groups; capacities; technology-based undertakings; innovative products; Spin Off.

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Introduction

Since this work takes as a contextual reference the System of Science, Technology and Innovation that supports the dynamics of the research groups for the Colombian case, it has been considered pertinent, firstly, to refer to some contributions that from the specialized literature have approached the analysis of Science, Technology and Innovation Systems in other latitudes to characterize the research groups and researchers of the University of Cauca recognized by COLCIENCIAS in its call of 2017. The participation of Research Groups in knowledge transfer processes and their enhancement in the environment through the development of attractive Spin Off initiatives for investors from public universities internationally, but especially in the case of developing countries such as Colombia, It has been the subject of high interest for academics, but with limited scientific evidence, which makes this study a significant scientific contribution. In addition, it could play an important role in order to structure university strategies designed from this perspective. As well as its application to the development of public policies that facilitate and generate adequate conditions for this type of initiatives focused on the development of entrepreneur university in developing countries.

Aksnes et al., (2017) contrast official R&D statistics with socialized information in Web of Science for 18 OECD countries as input data and publications generated as output information, identifying methodological problems that affect the productivity measurements of the research of the National Research and Innovation Systems that need to be corrected, proposing a new methodology. Ghazinoory et al., (2017) suggest a new classification in order to evaluate the National Systems of Science, Technology and Innovation from local contexts, especially from countries not so advanced on this front, from five analytical categories, namely: The purpose of the System, the context, the structure of the model, the financing and the process of evaluation of. One of the methodological limitations of this study was related with the measurement model of COLCIENCIAS groups since this model lacks measures associated with the effective transfer of knowledge of the groups. However, the measurement bias is minimized giving it an important weight to the academic products associated with the previous stages of the transfer such as: patents, business secrets, software, etc.

Jiménez et al., (2011) in a study developed for the Inter-American Development Bank (IDB) analyze the importance given to Regional Innovation Systems (RIS) In eight countries of the region, based on a conceptual revision, identifying the differences between their subregions and the progress made in consolidating them. For (Navarro-Arancegui, 2009, p.53) the Regional Innovation Systems (RSI) materialized in networks are of the greatest importance when defining policies of economic and social development; however, they draw attention to various conceptual difficulties in the treatment and management of information that have generated gaps that need to be revised in order to obtain more reliable references when making decisions of the policy. The referred author says:

The review of the RIS literature shows that rather than referring to a theory, one could speak of a conceptual framework of the RIS, since many ambiguities and conceptual inconsistencies still persist: the constituent limits of the system are quite imprecise, the causal relationships between variables are not described rigorously, and well-established empirical regularities are still scarce. (Navarro-Arancegui, 2009, p.53)

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Lucio et al., (2015) in a recent publication, make a detailed contextualization of the Science and Technology System in Colombia, treating, among other considerations, topics such as investment in science activities, technology and innovation; scientific and technological training; national capacities in science and technology; bibliographic production; intellectual property titles; the role of COLCIENCIAS; the importance of information in the construction of indicators.

Palacio-Sierra (2017), critically analyzes the Colombian case and the processes of social appropriation of science, technology and innovation arguing that its conceptual foundation (a linear and market model) implies a reduced effectiveness in the face of the democratization of the social benefits of knowledge and proposes a more participatory model that will make it possible to fill these gaps. Becerra-Arévalo (2017), on the basis of a review of the implementation process of the Fund for Science, Technology and Innovation of the General System of Royalties in Colombia sees its implementation as a great opportunity to concretize the social appropriation of science, technology and innovation in the regions.

When it comes to the multidisciplinary research groups and teams that are part of these National and Regional Science, Technology and Innovation Systems and their results, the following contributions should be mentioned:

Castrillón et al., (2019), based on a review of specialized literature, show the role that the universities play in the processes of economic development from the promotion of the knowledge generated by their teachers and research groups through the creation of Spin Off with the support of capitals risk from the productive sector, considering appropriate policies based on State management. Alberts (2007) based on case studies on individual and collective dynamics and communication processes that operate among research teams in knowledge creation organizations, presents a conceptual framework that describes different categories and parameterizes the variables that explain a successful performance, concluding that an organization's ability to create and manage knowledge in its high performance teams makes a difference as a competitive advantage.

Rueda-Barrios & Rodenes-Adam (2016) from a sample of 223 Colombian research groups registered and categorized by COLCIENCIAS, through an empirical treatment (regression analysis and structural equation modeling) and conceptualizations that incorporate topics such as organizational culture, knowledge management and technological capital, collected in a structured survey applied to the leaders of the aforementioned groups against their perceptions on scientific production from motivating culture, the process of outsourcing in knowledge management and technological capital, concluding that these variables have a positive impact on the results obtained.

The structure of the National System of Science, Technology and Innovation in Colombia

This structure is supported by a rigorous process of organization, registration and evaluation of institutions, R&D&I groups and researchers from the public and private sectors, that from the academy and with the participation of the productive sector are inscribed in the Scienti platform as an international public network of sources of information and knowledge by COLCIENCIAS.

Each of the aforementioned actors takes on specific roles, corresponding to the institutions endorsing the groups that integrate them, which based on the dynamics of their researchers, develop projects that generate research products, which once evaluated and weighted, are socialized through the Scienti platform by COLCIENCIAS, prior recognition and categorization from a rigorous measurement model. According to the source, a Research, Technological Development or Innovation Group is:

A group of people who interact in order to investigate and generate knowledge products on one or more topics, according to a short, medium or long term work plan (aimed at solving a problem). A group is recognized as such, provided that it continuously demonstrates verifiable results, derived from projects and other activities arising from its work plan. (COLCIENCIAS, 2019, p.44)

Table 1 contains some of the criteria adopted by COLCIENCIAS for the classification of research groups in Colombia.

Table 1: Criteria for the categorization of Research Groups. Call 781 of 2017 - COLCIENCIAS

Indicator	A1	A	B	C	Recognized
Group Indicator	Quartile 1 (25% superior)	Quartile 2 (50% superior)	Quartile 3 (75% superior)	> 0	To be recognized as a research group, it is necessary to have generated at least the equivalent of a product as a result of new-knowledge activities for each year of the group's existence, during the last five years
Indicator of Products	Top Quartile 1 (25% superior)	Top Products o A > 0	Top Products o A > 0	Top Products o A > 0	
Indicator of Products of Social Appropriation of Knowledge	> 0	> 0	> 0	> 0	
Indicator of products of activities related with the training of human talent	Type A > 0	Type A > 0	Type A > 0 o Type B that allow it to be on the same level or above Quartile 2 (50% superior)	Type A > 0 o Type B > 0	
# de Senior or Partner Researchers as members of the group	1 Senior or Partner Researcher	1 Senior or Partner Researcher	1 Senior or Partner or Junior Researcher with PhD	NA	
Cohesion indicator	> 0	> 0	> 0	NA	
Minimum years of existence	5	5	3	2	

Source: Adapted from the document Modelo de medición de Grupos de Investigación, Desarrollo Tecnológico o de Innovación y de Reconocimiento de Investigadores del Sistema Nacional de Ciencia, Tecnología e Innovación, COLCIENCIAS, (Model Measurement of Research Groups, Technological Development or Innovation and Recognition of Researchers of the National System of Science, Technology and Innovation), Development Division of Research–year 2017, pp. 92 to 95

According to the aforementioned state entity, the Group Indicator measures the quality of production with international standards of visibility and impact as a result of research processes. For the construction of each product indicator there are criteria such as requirement of existence, category and quality requirements, giving it a relative weight according to the type of product. New knowledge products generated by R&D&I groups are defined as:

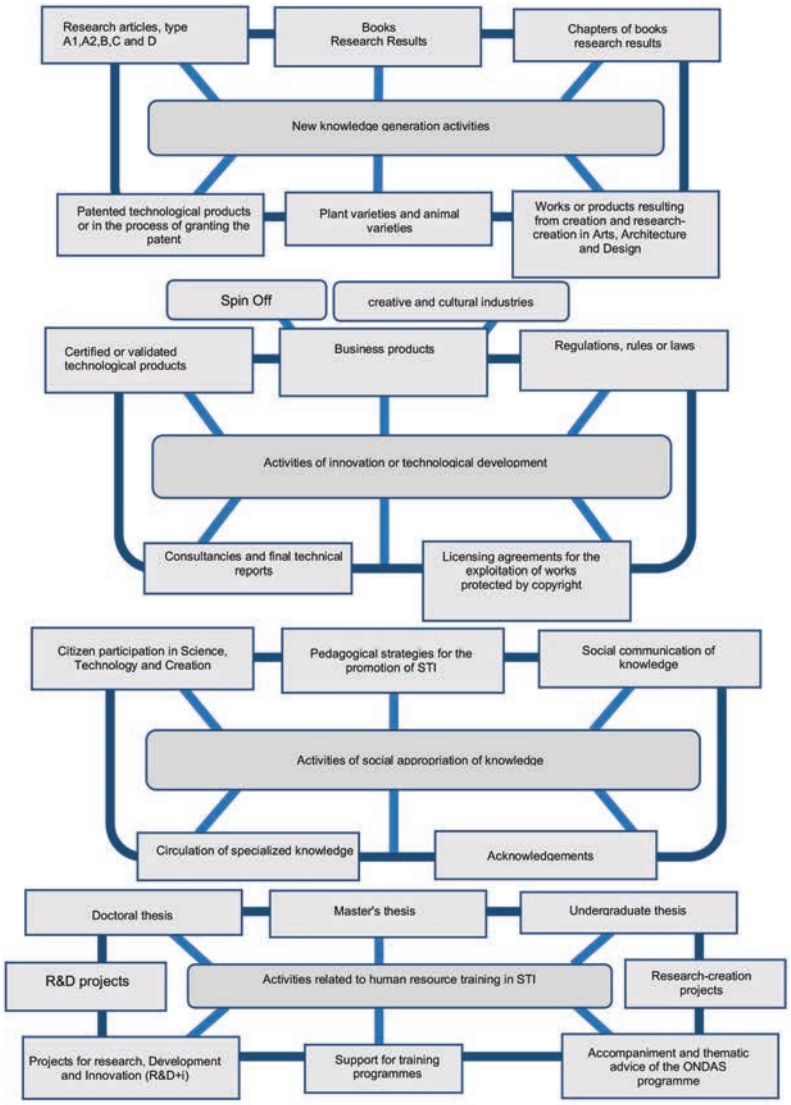
Those significant contributions to the state of the art of an area of knowledge, which have been discussed and validated in order to be incorporated into the scientific discussion, the development of research activities, development technology, and those who can be a source of innovation. This type of product is characterized by the involvement of standardization mechanisms that allow to corroborate the existence of an evaluation that verifies the generation of new knowledge. (COLCIENCIAS, 2019, p.57)

Typology of new knowledge products

These products are classified in four typologies, namely: Activities of new generation of knowledge; b) Activities of technological development and innovation; c) Activities of social appropriation of knowledge and, d) Activities related to the training of human talent. Figure 1 illustrates the specificities of each of the above typologies at a more disaggregated level.

When it comes to the articulation of the groups with the business sector, the aforementioned source also considers as products of new knowledge the companies of technological base (Spin-Off), understood as a company that emerged based on creativity, research and technological development whose origin is academic or business and in which the university has a participation. This conceptualization is treated with caution by authors such as Beraza-Garmendia (2012), who emphasizes its heterogeneity.

Figure 1: Typology of products from research activities for the measurement of R&D&I Groups - Colombia's National System of Science and Technology



Source: Developed from the tables inscribed from the document of COLCIENCIAS, Directorate of Research Promotion – Model of Measurement of Research Groups, Technological Development or Innovation and Recognition of Researchers of the National System of Science, Technology and Innovation, year 2017

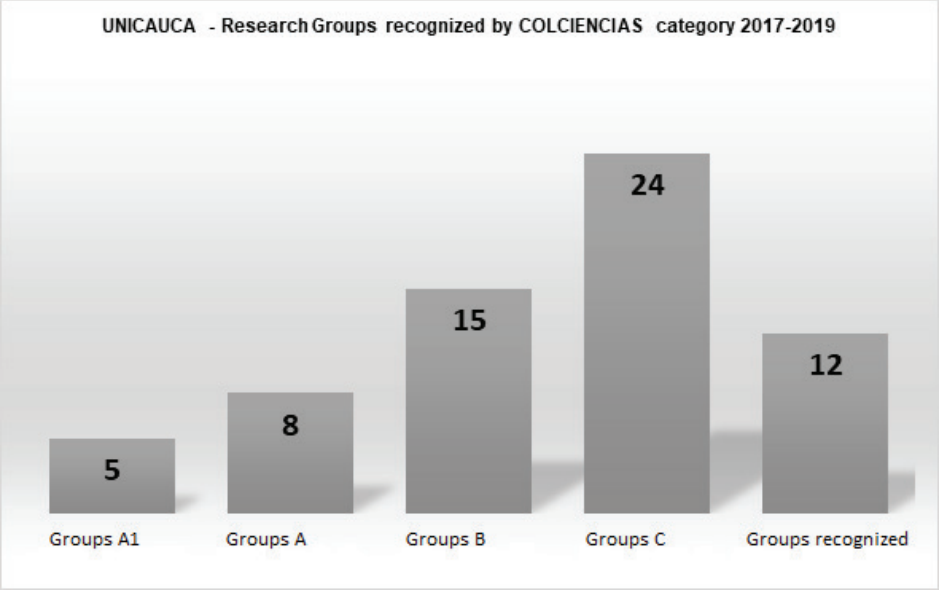
Law 1838 of 2017 (Congress of the Republic of Colombia, 2017), defines University Spin Off as a company based on knowledge and research results protected by intellectual property rights created in Higher Education Institutions (HEIs). This category includes creative and cultural industries, (Buitrago-Restrepo, F. & Duque Márquez, I. (2013), which are the basis of Law 1834 of 2017 also called "Orange Law" (In spanish, Ley Naranja) (Congress of the Republic of Colombia, 2017) for its development and consolidation it has an organizational structure of the first level as stipulated by Decree 1935 of 2018 (Presidency of the Republic of Colombia, 2018).

Innovations generated in business management and those derived from processes, procedures and services are also part of this type of new knowledge products.

Classification of the UNICAUCA Research Groups according to the results of the 781 call for proposals, 2017

Based on the results of the call 781 of 2017, and information provided by the Vice-rectory of Research, the Research System of the University of Cauca presents the following characterization: Of the sixty-four research groups recognized and categorized by COLCIENCIAS, 7.81%, 5 (5) correspond to category A1, 8 (8); 12.50% to category A; 15 (15), 23.44% of the total are groups B; 24 (24), 37.50% of the total, are groups C, and twelve (12), 18.75%, are recognized groups (Figure 2).

Figure 2



Source: Developed from information from COLCIENCIAS and the Research Vice-Rectory of UNICAUCA 2019

According to the information in Table 2, most of the groups in their different categories are attached to the Faculty of Natural Sciences, Exact and Education (FACNED), with twenty-two (22) of these, representing 34.88% of the total, followed, in their order, by the Faculty of Health Sciences with twelve (12) groups, corresponding to 12.50%. The Faculties of Accounting, Economic and Administrative Sciences (FCCEA) and Electronic Engineering and Telecommunications (FIET), with a relative weight of the order of 10.94%, each have seven (7) groups, while the Faculties of Agricultural Sciences and Human and Social Sciences, with six (6) groups, weigh each of them, in proportional terms, 9.38% of the total. For its part the Faculty of Law and Political Sciences (DCP) reports two (02) Groups with a relative participation of 3.13%, while the Faculty of Civil Engineering evidences one (01) group for a relative weight of 1.56% of the total.

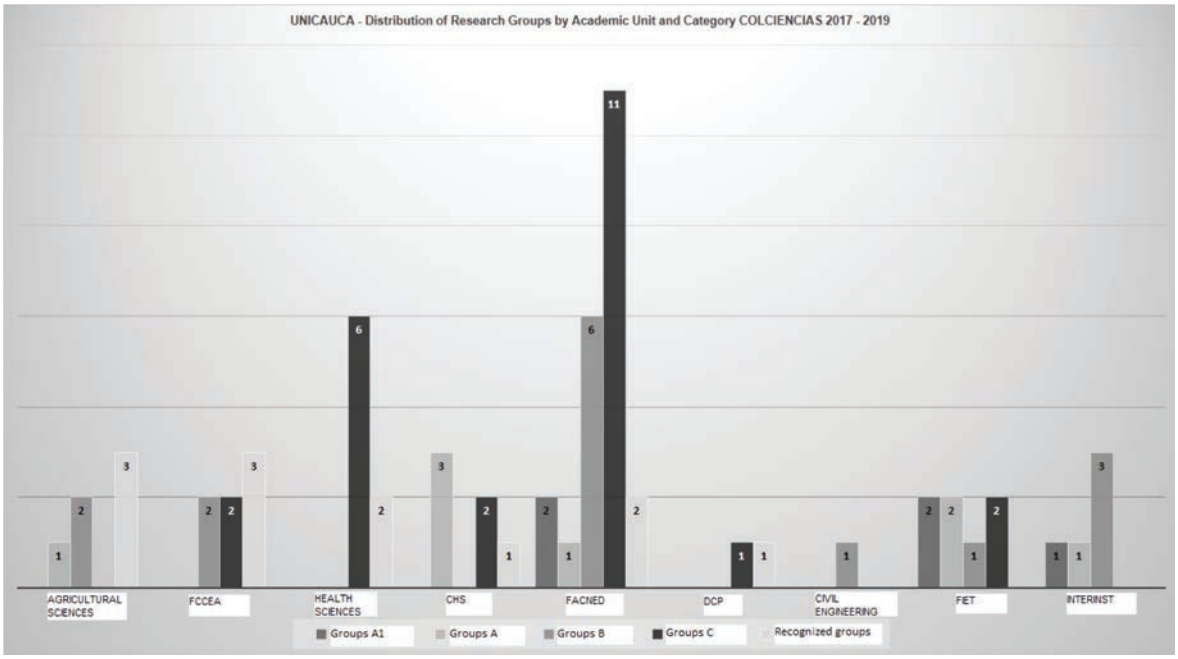
Table 2: UNICAUCA - Research Groups categorized and recognized by COLCIENCIAS according to Call 781 of 2017 according to academic unit

	Total	(%)	AGRICULTURAL SCIENCES	FCCEA	HEALTH SCIENCES	CHS	FACNED	DCP	CIVIL ENGINEERING	FIET	INTERINST
A1	5	7.81	0	0	0	0	2	0	0	2	1
A	8	12.50	1	0	0	3	1	0	0	2	1
B	15	23.44	2	2	0	0	6	0	1	1	3
C	24	37.50	0	2	6	2	11	1	0	2	0
R	12	18.75	2	3	2	1	2	1	0	0	0
Total	64	100%	6	7	8	6	22	2	1	7	5
	100%		9.38	10.94	12.50	9.38	34.38	3.13	1.56	10.94	7.81

Source: Developed from information from COLCIENCIAS and the Research Vice-Rectory of UNICAUCA 2019

Figure 3 shows the distribution of UNICAUCA research groups by category and academic unit as described in Table 2. This is the census universe to which the survey referred to above was applied.

Figure 3



Source: Developed from information from COLCIENCIAS and the Research Vice-Rectory of UNICAUCA 2019

UNICAUCA has a hundred and six researchers recognized by COLCIENCIAS in the 2017 call several times mentioned, whose typology is illustrated in Table 3. Most of them are Junior Researchers with 53.77% of the total, followed by Associated Researchers with 16.98%; in their order, there are 18 Senior researchers that equal 16.98% of the total of the classified and an Emeritus Researcher with 0.94%.

Table 3: Total of UNICAUCA Researchers categorized by COLCIENCIAS 2017

Researcher classification	Final result	(%)
Emeritus researcher (IE)	1	0,94%
Senior Researcher (IS)	18	16,98%
Associated Researcher (I)	30	28,30%
Junior Researcher (IJ)	57	53,77%
Total	106	100%

Source: Research Vice-Rectory of UNICAUCA 2019

The problem to be solved

In this context, the following research questions were raised: Could the University of Cauca be classified as a national higher education institution, as an entrepreneurial university in the light of new legislation and global perspectives on science, technology and innovation? Is it possible for the institution to have clear policies in the medium term because of its autonomy; to have appropriate internal rules on intellectual property and an efficient organizational architecture that enables it to transfer through flexibly and highlight it in the society, in partnership with world class investors, the knowledge generated by their research groups, managing and participating as a partner in sustainable technology based companies in regional, national and global emerging markets, through a rigorous prospective process, supported by an appropriate road map?

Methodology

The following procedure was followed to address the analysis covered by this work (Figure 4): From a census applied to the 64 research groups recognized by COLCIENCIAS to the University of Cauca in its call for measures 781 of 2017, results are obtained descriptively on the capacities that the institution would have, in the medium term, to properly articulate with State agencies and external enterprises by

creating and subsequently consolidating a model for the development of technology-based initiatives that would enable it to act as a an entrepreneurial university within an appropriate ecosystem.

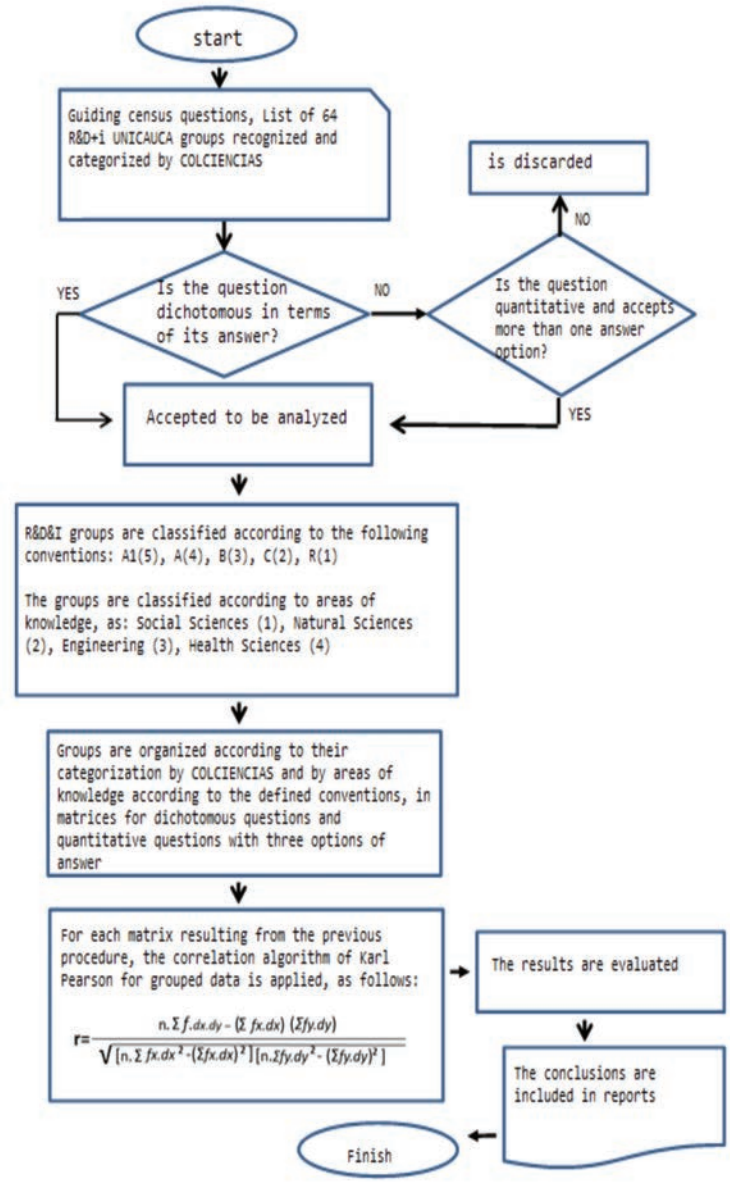
Taking the questionnaire used for the census, structured in eighteen guiding questions, a filter is made to focus on those variables of a quantitative order that can be managed using Pearson's correlation coefficient model for grouped data, Camarero (2002).

Research Groups are classified according to the results of the COLCIENCIAS measurement protocol by means of appropriate conventions to structure the information in a matrix organization, according to Pearson's correlation coefficient, as follows: For groups A1 the convention (5), for groups A, (4), for groups classified in category B, (3), for groups typified as C (2), for recognized groups it was used as a convention (1). Similarly, the information of the groups was organized considering four areas of knowledge to adapt them to the Pearson procedure, as: Social Sciences (1); Natural Sciences (2); Engineering (3) and Health Sciences (4).

Taking into account these results, the information was systematized in order to generate the benchmarks that will make it possible to propose, through a Strategic Prospect exercise and with the participation of the main actors that have been identified, a roadmap to a University Ecosystem of Entrepreneurship and Innovation based on the capabilities demonstrated by the UNICAUCA Research Groups.

Figure 4

Methodological process followed in the investigation



Parameterized questions of the applied census, using Pearson's correlation coeficient for grouped data

Table 4 contains five binaries and one multiple option questions that were extracted from the questionnaire applied in the aforementioned census.

Table 4: Quantitative questions taken from the Census for calculation of correlations between variables according to the Pearson model for grouped data

#	Guiding question	Variables defined for correlation analysis
1	Do you think that some of the research carried out or to be carried out in your research group may result in a product (good or service) aimed at solving some local or national problem?	Has potential innovative products
2	Do you consider that your research group has developed or can develop and/or take part in projects with technology based R&D guidelines?	Has technological R&D projects
3	Do you consider that your profile as a researcher or that of your research group can lead to initiatives related to technology based enterprise management?	Has an entrepreneurial profile
4	Have you had institutional barriers that have prevented or prevent the articulation of the University with external actors interested in contributing resources and/or venture capital for the development of technology based initiatives from the production of research groups? (If your answer is yes, type which one or which in other)	There are institutional barriers
5	Have you or the research group participated in agreements outside the university in project management? (If your answer is yes, write which or which ones in other)	Participates in international entrepreneurship networks
6	Being 1 the lowest score and 5 the maximum, Your interest in participating personally or with your research group in interinstitutional agreements of the University to manage technologically based enterprises is:	Interest in interinstitutional agreements (1) to (5)

Source: Questionnaire structured. Census applied to 64 research groups of the University of Cauca recognized by COLCIENCIAS, Call 2017

Treatment of the variables

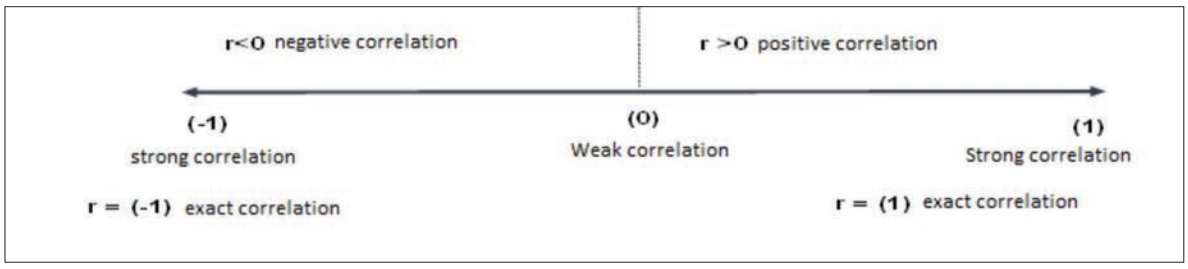
In order to calculate the relationship or dependence between the quantitative variables subscribed in the census, the correlation coefficient of Karl Pearson for the two dimensional grouped variables was used. It is obtained from the ratio between the covariance of the variables involved for each specific case and the standard deviation of one of them, multiplied by the standard deviation of the other according to the following expression:

$$r = \frac{n\sum fdx.dy - \sum(fx.dx)(\sum fy.dy)}{\sqrt{[n\sum fx.dx^2 - (\sum fx.dx)^2][n\sum fy.dy^2 - (\sum fy.dy)^2]}}$$

Where: n = number of data; f = frequency of cell; fx = frequency of the variable X; fy = frequency of the variable Y; dx = values encoded according to the ranges of variable X, making sure that the central interval corresponds to dx=0, to facilitate the calculations; dy = values coded according to the intervals of the variable Y, ensuring that the central interval corresponds to dy=0, to facilitate the calculations. According to Figure 5, if r is greater than zero, the dependence between the two variables is positive or direct; when one increases the other also increases and, similarly, when one decreases the other also decreases.

Figure 5

Interpretation of correlation coefficient results



If the coefficient is negative the dependency is also negative or inverse, so that when one variable increases the other decreases by the same proportion.

If the result of r is equal to -1 or 1, it means that the dependency is exact. It can be exact positive, so that the two variables increase in the same way, or it can be exact negative, so as one variable increases, the

other decreases, but always in the same proportion. Whenever the result of r is close to zero the dependency between the two variables is said to be weak (the points are further away from the regression line). If the result of r is equal to -1 or 1, it means that the dependency is stronger; that is, the points are located very close to the regression line.

Results

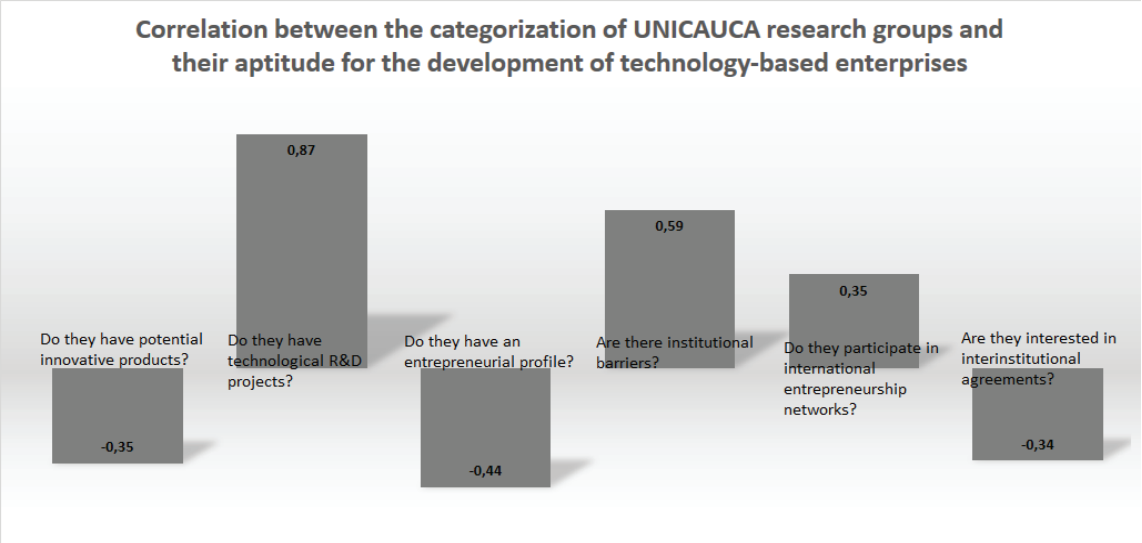
The information in Table 6 and Figure 6 shows the arithmetic average of the affirmative responses that the 64 research groups recognized and organized according to their categorization before COLCIENCIAS assigned to each of the quantitative variables derived from the questions asked in the census and the average of the variable associated with the multiple selection question related to the interest of signing interinstitutional conventions, through the following conventions: (5) for A1, (4) for A, (3) for B, (2) for C and (1) for the ones recognized. Column r of the table corresponds to the correlation coefficient, which interprets the capabilities of the evaluated groups to develop technology-based Spin Off enterprises from the above variables (Groups according to their category and Questions answered affirmatively).

Table 6: averages and correlations derived from the Research Groups surveyed from their categorization by COLCIENCIAS to validate their aptitude Towards the development of technology based companies Spin Off

COLCIENCIAS Categories	A1	A	B	C	R	
Conventions defined to estimate the correlations between research group categories and their ability to develop Spin Off	5	4	3	2	1	Correlation coefficient
Binary and multiple selection questions (Percentage of positive responses) YES (1) to (5) multiple selection questions	(%)	(%)	(%)	(%)	(%)	r
Do they have potential innovative products?	100%	87.5%	92,86%	100%	100%	-0,35
Do they have technological R&D projects?	100%	100%	92,86%	76,90%	83,30%	0,87
Do they have an entrepreneurial profile?	80%	87,50%	92,86%	80,80%	91,70%	-0,44
Are there institutional barriers?	40%	25%	20%	34,60%	16,70%	0,59
Do they participate in international entrepreneurship networks?	40%	50%	46,70%	26,90%	41,70%	0,35
Are they interested in interinstitutional agreements?	3,60	4,50	4,10	3,70	4,40	-0,34

Source: Calculations from census applied to 64 research groups of the University of Cauca recognized and categorized by COLCIENCIAS, Call 781 of 2017

Figure 6
Pearson correlation coefficient between categories of UNICAUCA research groups and their skills for developing technology-based enterprises



Source: Calculations from census applied to 64 research groups of the University of Cauca recognized and categorized by COLCIENCIAS, Call 781 of 2017

All the high recognition groups (A1); 100% of the groups categorized in (C) and the total of the groups categorized as recognized (R) in the census,

consider that their dynamics point to the development of innovative products. Groups (B) on average responded positively to this question by 92.86 %, while groups (A) did so by 87 %. The correlation coefficient for this question yielded an indicator of (-0,34), which indicates that it does not necessarily have to be classified in the largest categories by COLCIENCIAS to generate products of technological knowledge.

In regards to the second question on Technological R&D Projects, all of the groups with the highest categorization by COLCIENCIAS (A1) and (A) responded positively; for their part, those categorized in (B) responded positively in 92.86; while groups (C) did so in 76.90%; finally, recognized groups (R) responded positively to this concern on average by 83.30%. The correlation coefficient for this variable was 0,87, which implies that there is a very high causal relationship between the categorization of the group and the development of R&D projects classified as technological.

In regards to the entrepreneurial profile, the results of the averages reflect that a high categorization by COLCIENCIAS is not necessarily required to have this capacity. Indeed, only 80% of groups (A1) responded positively to this question; 87.5% of groups (A) responded positively to the question; 92.86% of groups (B) claim to have an entrepreneurial profile; 80.80% of groups (C) claim to have this aptitude, while 91.70% of recognized groups feel related with the entrepreneurial profile. The correlation coefficient for this variable is (-0,44), realizing that it is not essential to have a high categorization in the scale of COLCIENCIAS in order to have entrepreneurial abilities as a group.

Concerning the existence of institutional barriers that have prevented or prevent the articulation of the University with external actors interested in contributing resources and/or venture capital for the development of technology based initiatives from the production of research groups, the opinion of most groups according to their categorization by COLCIENCIAS, although positive, is not very high. Indeed, the groups categorized with (A1), on average, stated that they had not been affected by institutional barriers in the development of their dynamics by 40%; on the other hand, the groups (A) say they were not affected by this phenomenon by 25%; groups (B) by 20%, groups (C) by 34.6% and recognized groups (R) by 16.7%. The correlation coefficient for this variable, of the order of 0,59, indicates that research groups with a lower category feel mainly affected by the existence of institutional barriers to their dynamics of articulation with external actors than those with greater categorization by COLCIENCIAS.

In terms of group participation in international entrepreneurship networks, 40% of those categorized in (A1) responded, on average, positively; 50% of the groups (A) demonstrated this capacity; 46.7% of those categorized in (B) responded positively to the concern; 26.9% of the category groups (C) say they participate in international entrepreneurship networks and 47.5% of those recognized, say they are participating. The correlation coefficient of 0.35 for this variable implies that the group category has some impact on its articulation with international networks of entrepreneurship, which suggests making priority institutional efforts to strengthen relational capital at this level.

In regards to the interest in assigning it to interinstitutional agreements for the management of technology-based enterprises, considering a response of 1 of no interest and 5 of great interest, the groups categorized in (A1) on average, show moderate interest (3.6); groups categorized in (A) show high interest (4.50); groups (B) show a relatively moderate interest (3.70), while recognized groups show high interest (4.40). The correlation coefficient for this variable (-0.34) shows that there is no direct correlation between the category of the group and the interest in interinstitutional agreements for the management of technology-based enterprises. In other words, a high categorization is not a necessary condition for a group to show interest in signing interinstitutional agreements to manage technology-based enterprises.

The numbers in Table 7 and Figure 7 correspond to the arithmetic average of the affirmative responses that the 64 research groups organized according to the following areas of knowledge, (1) Social Sciences, (2) Natural Sciences, (3) Engineering and (4) Health Sciences, assigned to the quantitative questions derived from the applied census and the average of the variable related to the multiple choice question on the interest of signing interinstitutional conventions. Column r corresponds to the correlation coefficient calculated from the variables referred.

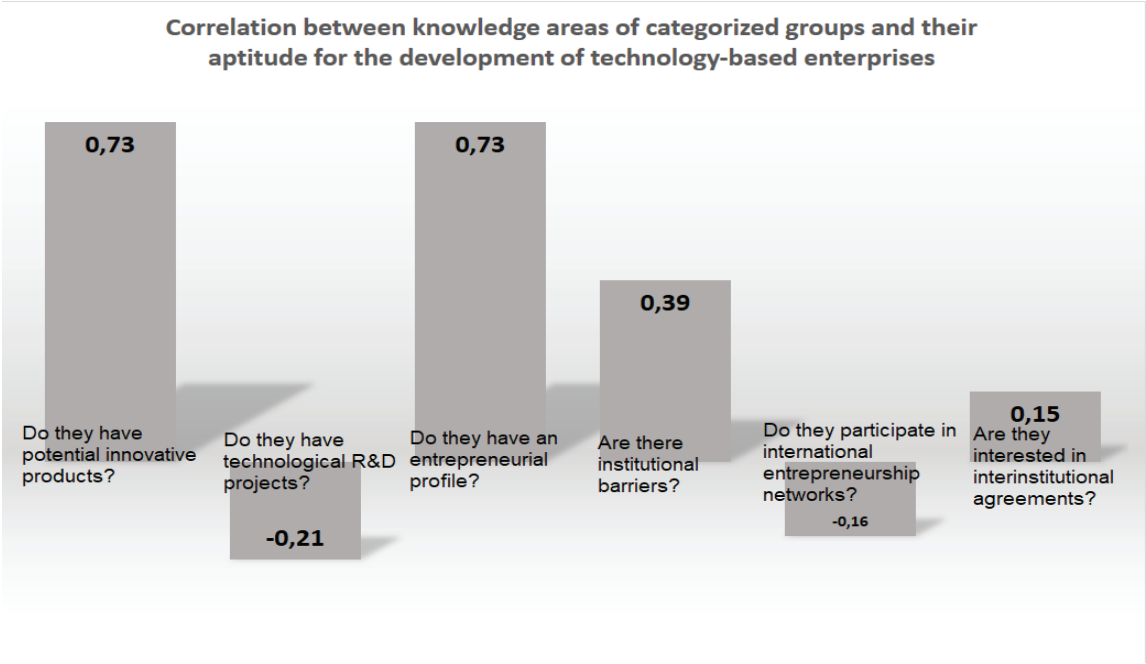
Table 7: Averages and correlations derived from the Research Groups surveyed from the adscription to four areas of knowledge to validate their aptitude towards the development of technology-based companies Spin Off

Area of knowledge to which the Research Group belongs	**social sciences**	**Natural sciences**	**Engineering**	**Helath sciences**	
Conventions defined to estimate correlations between areas of knowledge to which the groups belong and their aptitude for the development of Spin Off	1	2	3	4	correlation coefficient
Binary and multiple selection questions (Percentage of positive responses) YES (1) to (5) multiple selection questions	(%)	(%)	(%)	(%)	R
Do they have potential innovative products?	95,50%	92,30%	100%	100%	0,73
Do they have technological R&D projects?	77,30%	92,30%	100%	66,70%	-0,21
Do they have an entrepreneurial profile?	77,30%	92,30%	88,90%	91,70%	0,73
Are there institutional barriers?	13,60%	46,20%	27,80%	33,30%	0,39
Do they participate in international entrepreneurship networks?	45,50%	30,80%	33,30%	41,70%	-0,16
Are they interested in interinstitutional agreements?	3,80	4,20	4,20	3,90	0,15

Source: Calculations from census applied to 64 research groups of the University of Cauca

Figure 7

Pearson correlation coefficient between areas of knowledge of UNICAUCA research groups and their skills for developing technology-based enterprises



Source: Calculations from census applied to 64 research groups of the University of Cauca

The analysis of this information shows the following: The perception of most of the research groups surveyed is that their dynamics generate innovative products aimed at solving national or regional problems, depending on the area of knowledge to which they are attached; in fact, 95.5% of the groups attached to the Social Sciences, confirm it; 92.30% of the groups of Natural Sciences consider it; all of the groups surveyed from the engineering sector consider it too and 100% of the groups attached to Health Sciences do it too. The correlation coefficient of 0.73 for this variable corroborates this.

In terms of R&D product management, groups in the areas of Social Sciences and Health Sciences have the lowest averages at 77.30% and 66%, respectively, whereas the engineering groups consider 100% that their projects are in line with this type of product management; the groups attached to the area of the Natural Sciences believe that, on average, their developments have this profile at 92.3%. However, a negative correlation coefficient of (-0.21) indicates that it is not necessary to belong to groups related to engineering or basic sciences to be able to develop projects that generate products of technological knowledge.

In terms of the entrepreneurial profile, Natural Science Groups claim to have this capability with an average of 92,3% positive responses, those related to health sciences with a positive perception of 91.7%; those related to engineering responded affirmatively on average to this concern in 88.9% and those of Health Sciences in 77.3%. The correlation coefficient of 0.73 for this variable gives account of a direct relationship between the entrepreneurial profile and the area of knowledge to which the groups are attached, according to the conventions used in this document.

In regards to the effect or perception of the existence of institutional barriers that prevent the articulation of groups with external agents that give resources for the development of technology-based initiatives according to the area of knowledge, those coming from the Natural Sciences are the ones that most perceive this influx with an average of 46.20%, followed by the groups of Health Sciences, followed by those of engineering with 27.8% on average, and finally the Social Science groups with 13.6%. The correlation coefficient for this variable is 0.39, indicating a moderate direct relationship between the areas of knowledge and the perception of existence of institutional barriers to get involved with external actors who contribute to the development of technology based initiatives proposed by the groups.

In terms of participation in international entrepreneurship networks, social science groups respond positively on average by 45.5%, followed by health sciences in 41.7%; on average, the engineers responded to this concern by 33.3%, while the natural sciences did so, on average, by 30.8%. The correlation coefficient for this variable (-0.16) shows an inverse, though slight, relationship between the areas of knowledge and participation in international networks.

Finally, in regards to the interest in participating in interinstitutional agreements for technology-based enterprises, the groups most concerned are those of engineering and natural sciences, followed by Health Sciences and Social Sciences. The correlation coefficient

for this variable of 0.15 shows a direct relationship, although slight, among the areas of knowledge against the interest in participating in interinstitutional agreements to carry out technology-based enterprises.

Conclusions

1) The classification of the group according to the parameters of COLCIENCIAS is not decisive in order to generate products of technological knowledge that promote the structuring and putting into effect of Spin Off enterprises. 2) Research groups with more status develop to a greater degree than those with less categorization, R&D projects classified as technological ones. 3) It is not necessary to have a high ranking in the ranks of COLCIENCIAS for a research group to be considered with entrepreneurial skills for the development of technology-based Spin Off enterprises. 4) UNICAUCA's research groups, in all categories, feel moderately affected by their dynamics of articulation with actors due to institutional barriers, this means that the efforts to be made by UNICAUCA to bring them closer to entrepreneurial dynamics do not present any major drawbacks. 5) Somehow, although the correlation is not very strong, the category of the group affects its articulation with international networks of entrepreneurship. 6) When it comes to the relationship between the areas of knowledge and the skills of research groups for the development of technology-based enterprises such as Spin Off, Figure 7 shows the following: a) the perception of most of the research groups surveyed that their dynamics generate innovative products aimed at solving national or regional problems, depending on the area of knowledge to which they are attached is b) Coming from areas related to engineering or basic sciences is not a necessary condition for an institutional research group to be able to undertake projects with technological knowledge products. C) There is a clear relationship between the entrepreneurial profile and the area of knowledge to which the institutional research groups are attached. D) There is a direct, though moderate relationship between the areas of knowledge and the perception of the existence of institutional barriers to associate with external actors that contribute to the development of technological initiatives proposed by the groups. E) In the area of knowledge in which research groups operate is not determinative of their ability to link up with international entrepreneurship networks. F) The area of knowledge has, though slightly, an impact on the interest in participating in interinstitutional agreements for technology-based enterprises that support the initiatives of research groups.

Discussion and implications

Discussions from the literature show how difficult it is to propose models and ecosystems of science, technology and innovation that apply in a standard way to all countries and regions. However, the responsibility of universities and higher education institutions, technology centres and R&D&I groups through appropriate structures and consistent processes is clear, to generate synergies and collective building processes for the future that ensure the social appropriation and value of knowledge from Spin Off enterprises that contribute to economic growth and the social development of in a balanced manner, in a highly complex global environment.

References

Alberts, D. J. (2007). A model of multidiscipline teams in knowledge-creating organizations. Team Performance Management: *An International Journal*, 13(5/6), 172-183. DOI: https://doi.org/10.1108/13527590710831873

Aksnes, D. W., Sivertsen, G., Van-Leeuwen, T. N. & Wendt, K. K. (2017). Measuring the productivity of national R&D systems: Challenges in cross-national comparisons of R&D input and publication output indicators. *Science and Public Policy*, 44(2), 246–258. DOI: https://doi.org/10.1093/scipol/scw058

Becerra-Arévalo, Y. M. (2017). Sistema general de regalías: nuevos recursos para la ciencia, tecnología e innovación en Colombia. *Revista* CEA, 1(1), 75. DOI: https://doi.org/10.22430/24223182.65

Beraza-Garmendia y Rodriguez-Castellanos (2012). Tipología de las Spin-Off en un contexto universitario: una propuesta de clasificación. *Cuadernos de Gestión,* 12(1), 39-57

Buitrago-Restrepo, F. & Duque Márquez, I. (2013). *La Economía Naranja*. *Banco Interamericano de Desarrollo* (Vol. 1, p. 244). Banco Interamericano de Desarrollo, División de Educación. Retreived from http://search.ebscohost.com/login.aspx?direct=true&db=asn&AN=95486465&lang=es&site=ehost-live

Camarero, L. (2002). Acerca de las medidas de asociación en investigación social: un viejo problema que conviene no olvidar. In J. M. Arribas y M. Barbut (Eds.), *Estadística y Sociedad* (pp. 377–397). UNED y L´ecole des Hautes Etudes en Sciences Sociales. Retrieved from https://www2.uned.es/dpto-sociologia-I/departamento_sociologia/luis_camarero/asociacion.pdf

Castrillón-Muñoz., A.J., Infante, A., Zuñiga-Collazos, A. & Martínez, F.C. (2019) University Spin-Off: A Literature Review for Their Application in Colombia*, Journal of Environmental Management and Tourism***,** 10.1(33), 73-86. DOI: https://doi.org/10.14505//jemt.v10.7(33).08

COLCIENCIAS. (2016). Actores del Sistema Nacional de ciencia, Tecnología e Innovación. *Documento 1602*. Retrieved from http://www.colciencias.gov.co/sites/default/files/ckeditor_files/politicia-deactores-snctei.pdf

COLCIENCIAS. (2019). Modelo de medición de grupos de investigación, desarrollo tecnológico o de innovación y de reconocimiento de investigadores del Sistema Nacional de Ciencia, Tecnología e Innovación, año 2018, retrieved from https://colciencias.gov.co/sites/default/files/upload/convocatoria/4._anexo_1._documento_conceptual_del_modelo_de_reconocimiento_y_medicion_de_grupos_de_investigacion_2018.pdf, consultado en 8 de junio de 2019

Congreso de Colombia. (2017). LEY 1826 DE 2017. Recuperado de http://www.imprenta.gov.co/gacetap/gaceta.mostrar_documento?p_tipo=06&p_numero=1826&p_consec=47228

Congreso de Colombia. (2017). Ley 1834 de 2017, Presidencia de la República § (2017). Retrieved from http://es.presidencia.gov.co/normativa/normativa/LEY%201834%20DEL%2023%20DE%20MAYO%20DE%202017.pdf

Ghazinoory, S., Farazkish, M., Montazer, G. A., & Soltani, B. (2017). Designing a national science and technology evaluation system based on a new typology of international practices. *Technological Forecasting and Social Change*, *122*, 119–127. DOI:https://doi.org/10.1016/j.techfore.2017.04.012

Jiménez, F., Fernández de Lucio, I., & Menéndez, A. (2011). Los sistemas regionales de innovación: Revisión conceptual e implicaciones en América Latina. In J. J. Llisterri, C. Pietrobelli, & M. Larsson (Eds.), *Los sistemas regionales de innovación en América Latina* (pp. 8–27). Whashington, D.C.: Banco Interamericano de Desarrollo.

Lucio, J., Rivera, S., Tique, J., Lucio-Arias, D. (2015). *Indicadores de ciencia y tecnología Colombia 2015*. (E. Á. Ltda., Ed.), *OCyT, Observatorio Colombiano de Ciencia y Tecnología* (1era Edici, p. 206). Bogotá, Colombia. Retrieved from http://ocyt.org.co/es-es/InformeAnualIndicadores/ArtMID/542/ArticleID/273/Indicadores-de-Ciencia-y-Tecnolog237a-Colombia-2015

Navarro-Arancegui, M. (2009). Los sistemas regionales de innovación. Una revisión crítica. *Ekonomiaz*, *70*(1), 24–59.

Palacio-Sierra, M. C. (2017). La construcción de la sociedad del conocimiento y las políticas públicas de apropiación social de la ciencia, la tecnología y la innovación. *Trilogía Ciencia Tecnología Sociedad*, *3*(5), 17. https://doi.org/10.22430/21457778.166

Presidencia de la República de Colombia (2019). Decreto 1935 de 2018, Retrieved from https://dapre.presidencia.gov.co/normativa/normativa/DECRETO%201935%20DEL%2018%20DE%20OCTUBRE%20DE%202018.pdf

Rueda-Barrios, G. & Rodenes-Adam, M. (2016). Factores determinantes en la producción científica de los grupos de investigación en Colombia. *Revista Española de Documentación Científica*, *39*(1), e118. https://doi.org/10.3989/redc.2016.1.1198