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The decentralization of science, technology and innovation (STI) capacities in Colombia

La descentralización de las capacidades de ciencia, tecnología e innovación (CTi) en Colombia

Descentralização das capacidades de ciência, tecnologia e inovação (STI) na Colômbia

RESEARCH ARTICLE

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Abstract

Introduction: The resources for Science, Technology, and Innovation (STI) in Colombia have traditionally been allocated to universities and research centers in the country's largest cities, where the majority of highly qualified researchers are located. This represents a distortion in relation to public policy criteria for balanced growth and capacity-building. **Objective:** The article aims to present how this distribution has traditionally been carried out by the Ministry of Science, Technology, and Innovation (Minciencias) for STI projects in the country (2014-2018), and how, through a coordinated process, it is possible to decentralize capacities by leveraging the human resources associated with the Sociedad de Doctores e Investigadores de Colombia (SoPhIC). **Methodology:** To achieve this, geospatial analysis and correlation techniques of competitiveness indicators, departmental category, and the Gini index were used. **Results:** revealed the capacity and availability of human resources, based on the services that can be offered from and for these regions. **Conclusion:** These findings demonstrated the possibility and necessity of decentralizing resources to efficiently harness highly qualified human resources.

Keywords: Science, technological innovations, administrative decentralization, Colombia.

Resumen

Introducción: los recursos de Ciencia, Tecnología e Innovación (CTi) en Colombia han sido tradicionalmente destinados a las universidades y centros de investigación de las ciudades más grandes del país, en donde se encuentran la mayoría de los investigadores con formación de alto nivel. Dado que esto representa una distorsión frente a criterios de política pública de crecimiento armónico y la generación de capacidades. **Objetivo:** el artículo busca presentar cómo tradicionalmente se ha realizado dicha distribución desde el Ministerio de Ciencia Tecnología e Innovación (Minciencias) a proyectos de CTi en el país (2014-2018) y cómo en un proceso coordinado, es posible descentralizar capacidades aprovechando el recurso humano vinculado a la Sociedad de Doctores e Investigadores de Colombia (SoPhIC). **Metodología:** Para lograrlo se utilizaron técnicas de análisis geoespacial y de correlaciones de los indicadores de competitividad, categoría departamental e índice de Gini. **Resultados:** se evidenciaron las capacidades y disponibilidad de recurso humano, en función de los servicios que pueden ser ofrecidos desde y para dichas regiones. **Conclusión:** Estos hallazgos mostraron la posibilidad y necesidad de descentralizar los recursos para aprovechar eficientemente el recurso humano altamente calificado.

Palabras Clave: Capacidades regionales; Ciencia; Innovaciones tecnológicas; Descentralización administrativa; Colombia[1].

1 Los términos clave han sido recuperados a partir del Tesauro Universidad de Barcelona (THUB).

RESEARCH ARTICLE

Resumo

Introdução: Os recursos de ciência, tecnologia e inovação (CTI) na Colômbia têm sido tradicionalmente alocados para universidades e centros de pesquisa nas maiores cidades do país, onde está localizada a maioria dos pesquisadores altamente capacitados. Isso representa uma distorção dos critérios de política pública de crescimento harmônico e capacitação. **Objetivo:** o artigo busca apresentar como essa distribuição tem sido tradicionalmente realizada a partir do Ministério da Ciência, Tecnologia e Inovação (Minciencias) para projetos de CTI no país (2014-2018) e como, em um processo coordenado, é possível descentralizar capacidades aproveitando os recursos humanos vinculados à Sociedade de Doutores em Ciência, Tecnologia e Inovação (SCTI). ligados à Sociedade de Médicos e Pesquisadores da Colômbia (SoPhIC). **Metodologia:** Para Para isso, foram utilizadas técnicas de análise geoespacial, bem como correlações dos indicadores de competitividade, categoria departamental e índice de Gini. **Resultados:** as capacidades e a disponibilidade de Os resultados mostram as capacidades e a disponibilidade de recursos humanos, em termos dos serviços que podem ser oferecidos de e para essas regiões. oferecidos a partir dessas regiões e para elas. **Conclusão:** Esses resultados mostraram a possibilidade e a necessidade de descentralizar recursos para necessidade de descentralizar recursos para fazer uso eficiente de recursos humanos altamente qualificados.

Palabras-chave: Capacidades regionais; ciência, inovações tecnológicas, descentralização administrativa. descentralização, Colômbia .

Introduction

Knowledge, the product of research and technological development processes, which lead to innovations, are important elements for global competitiveness in a k n o w l e d g e - b a s e d economy (Foray & Lundvall, 1996; Lundvall, 1992; Solow, 2001). For such a process to be possible, three fundamental elements are required to be followed, human resources to develop science processes, infrastructure to support such exercises and financial resources (Escobar et al., 2016). However, Colombia, despite aspiring to it, is far from a knowledge-based economy, since its productive structure is supported by an extractive and primary system (Nieto et al., 2015). Moreover, investment in STI is low compared to other countries in the region (Quintero et al., 2021). In fact, a study of an econometric model of the determinants of industrial growth in Colombia showed that investment in STI activities is the only variable that is not significant in this model (Henao-Rodríguez et al., 2019).

The article is developed in three blocks, the first one oriented to understand the Colombian STI system, through a description of the institutional structure and the role of the Sophic association of doctors and researchers; the second block shows a set of analyses based on spatial mapping and the third one concludes that understanding how the resources of the Colombian STI system have been distributed at the regional level is fundamental to analyze the maturation processes of the Science, Technology and Innovation system.

THEORETICAL FRAMEWORK

Colombia, a diverse and unequal country

Colombia is a country with a great wealth of biodiversity, landscapes, reliefs and culture, administratively divided into 32 departments. However, geographically it is divided into six natural regions: Amazon, Andean, Caribbean, Insular, Orinoco and Pacific, which have different characteristics in terms of their economic base, population, culture, social relations, ethnicity, and physical and technological connectivity conditions. These differences impose differential possibilities for their inhabitants to articulate with the productive system and contribute to the social, economic and technological development of the country, according to the National Learning Service (SENA, 2018).

A study with regional data for Colombia from 1926 to 2018 evidences a greater economic development in the central part of the country compared to the other regions, which led to all regions not converging in terms of development during this period of time, as indicated by (Mei- sel Roca & Hahn, 2020). It is important to note that the generalities of each department in the country are heterogeneous, as can be seen in Table 1, which shows the large differences between the departments of Antioquia and Vichada in terms of investment from GDP and investment budget resources in 2012 and 2015, respectively. These differences should be considered when making decisions about each department, especially in policy formulation and execution. These differences are repeated throughout the national territory at the departmental and municipal levels, and between urban and rural areas.

Tabla 1.

Algunos datos de dos departamentos dispares en Colombia: Vichada y Antioquia

Variable	Antioquia	Vichada
Población	6.456.299	71.974
PIB 2012 (millones de pesos)	87.212.000	367.000
Índice de Necesidades Básicas Insatisfechas	23	67
Recursos Presupuesto de Inversión 2015	3.484.534	177.374
Categoría departamental	0	4

Nota: La categoría departamental se basa en la clasificación de tres grupos establecida a seguir: grandes municipios (categoría especial y de primera), municipios intermedios (segunda, tercera y cuarta categoría) y municipios básicos (quinta y sexta categoría) (Contaduría General de la Nación, 2022).

Fuente: (DNP, 2015).

STI policy in Colombia is led by the Ministry of Science, Technology and Innovation (Minciencias) (Law 1951, 2019) and is supported by a solid institutional framework called the National System of Competitiveness, Science, Technology and Innovation (SNCCTI, 2016). At the national level, an evolution and decentralization of STI policy has been achieved; however, at the regional level its application is discontinuous or nonexistent. An online survey of interested entities at the Colombian Observatory of Science and Technology (OCyT) revealed the need to apply methodological strategies that include disaggregated and geographically disaggregated data (Salazar et al., 2019) in order to gain an in-depth understanding of the real situation of STI policy and investment at the regional level. Furthermore, cases have been identified where the policy has been formulated but its implementation does not follow the proposed guidelines, as pointed out in a comparative study conducted by Escobar & Herrera (2015) in two Colombian departments in 2012.

The National STI Policy 2015-2025 identifies as the main problem that the country and its regions have not been able to boost economic and social development through STI. To address these specific problems, the strategic components of Knowledge Generation, Knowledge and Technology Transfer (KTT), Innovation and Entrepreneurship, and Governance have been developed. However, policy implementation requires the clear and consistent definition of policy instruments, as well as the development of STI capabilities. For example, cooperation between the public and private sectors needs to be fostered to identify, demand and appropriate knowledge and technology, and weaknesses in the current governance framework need to be addressed for an adequate development of the 2016-2025 STI policy. In addition, it is important to allocate human, technical and economic resources to implement the policy and consolidate an effective STI policy (see Table 2).

The Society of Doctors and Researchers of Colombia (SoPhIC), as a driving force in the democratization of the CTi in Colombia.

The Society of Doctors and Researchers of Colombia (SoPhIC; https://www.sophicol.org/) is a non-profit association constituted on August 7, 2020 and created by 13 researchers.

Tabla 2.
Marco conceptual CONPES borrador para una política de CTi

Componente	Definición	Estrategias
Generación de conocimiento	La formación de capital humano es determinante para la generación, absorción y difusión del conocimiento.	• Establecer fuentes de financiación sectoriales y estables en el tiempo para una I+D de excelencia y con propósito en cada una de las áreas y tecnologías focalizadas. • Consolidar los centros nacionales de I+D en las áreas y tecnologías. • Invertir en la formación de capital humano altamente calificado.
Transferencia de conocimiento y tecnología (TCT).	En este concepto se abordan dos tipos de TCT: Llevar a las firmas hacia la frontera de posibilidades de producción a través de conocimiento y tecnología existentes. Expandir la frontera del conocimiento, la cual se asocia a las instituciones generadoras de conocimiento.	• Implementar el Programa Nacional de Escalamiento de la Productividad. • Desarrollar un programa de vinculación de capital humano altamente calificado. • Implementar un Sistema para el Descubrimiento y Aprovechamiento de Tecnologías Aplicables (DATA). • Diseñar e implementar esquemas de apoyo a las instituciones generadoras de conocimiento.

Fuente: Elaboración propia con base en (CONPES, 2021)

Colombians, doctoral students and PhDs in different areas of knowledge. SoPhIC was created during the COVID-19 pandemic with the mission of contributing to the development of Colombia through science, technology and innovation, promoting and representing initiatives that contribute to the generation and consolidation of the scientific and research community, with a critical, interdisciplinary, inclusive and inter-institutional spirit. The association also aims to provide advice at all levels to public, private or mixed organizations, generating action plans and projects that can link doctors and future doctors in Colombia and abroad.

In this direction, from its constitution to date SoPhIC has more than 270 associates who have supported in different ways the development and growth of the association and have contributed to the realization of activities together with its founding members. Thus, during this first year of operation, eight webinars were held on different topics, including COVID-19, doctors at the service of society, entrepreneurship and technology development from science, the role of women in science, inclusion in science and academia, among others. In addition to the *I Symposium on Nutrition and Food Issues Update: Different Perspectives on Obesity* together with the University of Remington. This has facilitated the visibility of the association and its mission objective, as well as the generation of alliances, interconnection and networking with different institutions and researchers.

For this reason, in order to fulfill the mission objectives of SoPhIC, it is pertinent to develop a survey of human capital with high-level education in Colombia (database of SoPhIC associates and associates) and of the capabilities and services that doctors and researchers can provide. It is also necessary to establish the distribution of doctors and researchers in Colombia. In this way, it will be possible to identify which areas have lower concentrations of highly educated human capital and therefore tend to be more excluded from STI development.

METHODOLOGY

Approach: The objective of this research is to identify the relationship between an institutional program in STI and the generation of capabilities, expressed as the generation of equitably distributed benefits. Scope: The study is developed based on secondary information from the reports of the open databases of the National Government within the portal https://www.da- tos.gov.co/ and on the data resulting from a survey using the platform https://prospectiveworks- hops.com/ called Profiling of SoPhIC Associates carried out with associates of the Society of Doctors and Researchers of Colombia (SoPhIC); in which information was collected on the profile of the associates and their lines of action.

Stages: The study was developed in three stages, the first oriented to the collection of secondary information that would account for the capacities expressed in indicators of the departmental order. The second stage focused on the identification and collection of information through surveys and SoPhIC institutional reports. Finally, the third consisted of an analysis of the results using statistical and spatial geography tools.

The indicators were correlated using the competitiveness index, category and Gini index. Correlation is based on linear association, i.e., when the values of one variable increase, the values of the other variable may increase or decrease proportionally (Terrádez-Gurrea, 2006). For this exercise, the data of the continuous variables (Competitiveness Index and Gini Index) were analyzed for the 32 departments, and subjected to a Pearson correlation test (Terrádez-Gurrea, 2006), denoted as r. In addition, a test of significance was performed for the continuous variables (Competitiveness Index and Gini Index). In addition, a significance test was performed to indicate whether or not there is a relationship between two variables. When the p-value is less than 005 the correlation is significant. In addition, the correlation coefficient can range from -1 to +1. The further it moves away from 0, the stronger the relationship between the two variables, the sign indicates the direction of the correlation.

RESULTS

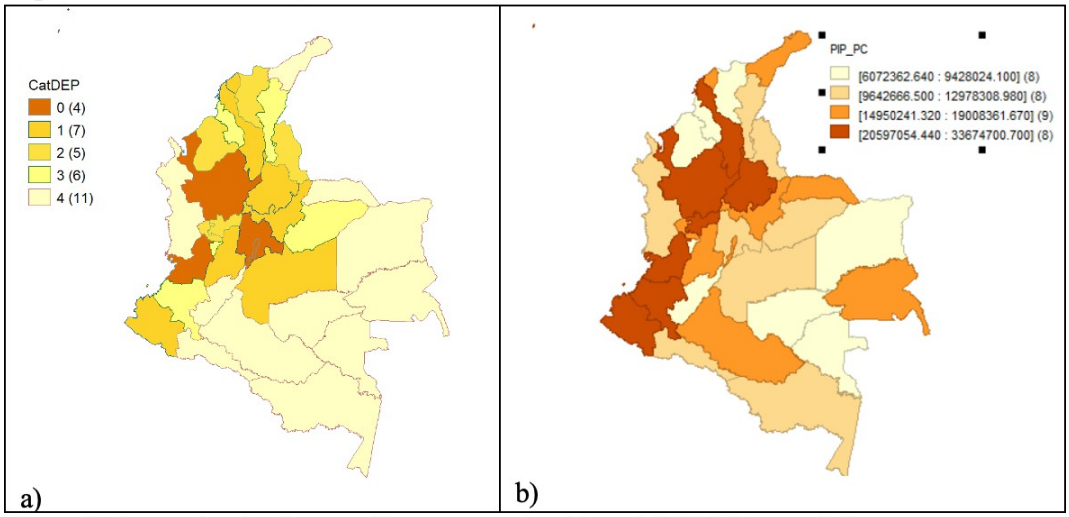
Department categories

According to the categorization of municipalities made by the General Accounting Office of the Nation (2022), 88% of the more than one thousand municipalities in the country are in category 6, that is, with less than 15,000 minimum salaries of free destination and/or population of less than 10,000 inhabitants, while municipalities in special category (zero) and category one (1) only represent 3% of the total. However, in terms of population, the same municipalities classified in special category (zero) and category one (1) account for 50% of the national total, as shown in Figure 1.

At the departmental level, the best economic and administrative operating and investment conditions in the territorial entities are concentrated in the middle of the country, specifically in the departments located in the Andean Zone, which are also the ones that are best positioned to make investments.

Figura 1.

Departamentos Colombia, 2018.



Nota: a) Categorías donde cero (0) corresponde a Especial; b) PIB per cápita.

Fuente: Elaboración propia con base en (Contaduría General de la Nación, 2022).

connected to each other, to the central part of the country and to the seaports. In turn, they coincide with the territories that are home to the largest proportion of Colombia's population.

The regions in terms of competitiveness

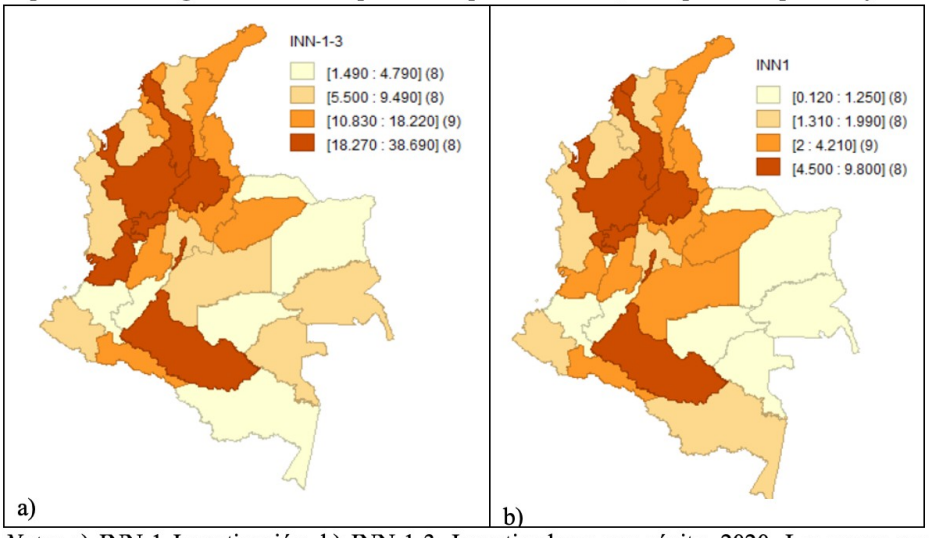
In Colombia, regions and departments have been developing at very different rates. While some have shown an improvement in their economy and social welfare, others have remained static or even lagged behind. This indicates that territorial disparities are reproduced, as Ramírez et al. (2013) state.

The results of the competitiveness study by Ramírez et al. (2013) indicate that in the period 2000 - 2012 the departments that have traditionally led these rankings in Colombia have consolidated their position, while those that have historically been in the lowest positions hardly show progress above the others, a condition that has been consolidated until 2023.

One of the conclusions of an ECLAC study (2017), points out that the persistent stagnation of the country in basic requirements of its competitiveness is nothing more than the expression of visible lags in most of its regions in pillars such as institutions, infrastructure, education, health, environmental sustainability and market size, which end up becoming fundamental obstacles towards Colombia's goal of being one of the three most competitive economies in Latin America. Accordingly, it is reaffirmed that it is essential to strengthen the regions in the aspects that contribute to growth and social and economic development, given that there are still large differences between them, so they are not comparable, to the point of not including seven departments in these measurements, not only because they are the most backward but also the most disconnected, in terms of road infrastructure, information and communication technologies, as well as for the formulation and management of policies and resources, from the so-called center of the country and other regions, as shown in Figure 2.

Figura 2.

Departamentos según índice de competitividad para Colombia, en el pilar CTi para los factores



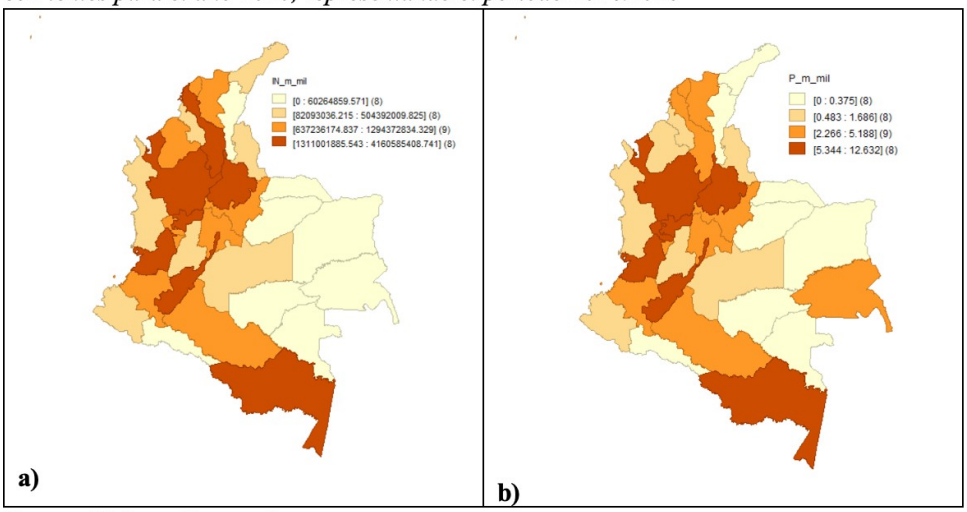
Nota: a) INN-1 Investigación, b) INN-1-3. Investigadores per cápita, 2020. Las zonas con la tonalidad más clara son las más competitivas.

Fuente: Elaboración propia.

Among the pillars that support competitiveness is pillar 7 and 12, which is related to investment in STI (Private Competitiveness Council, 2022), Figure 3 shows the behavior of the consolidated data on investment (a) and projects (b) by Minciencias, per thousand inhabitants in the period 2014-2018.

Figura 3.

Mapas de la inversión (a) y número de proyectos por departamento (b). en miles de pesos corrientes para el año 2020, representando el periodo 2014.2018

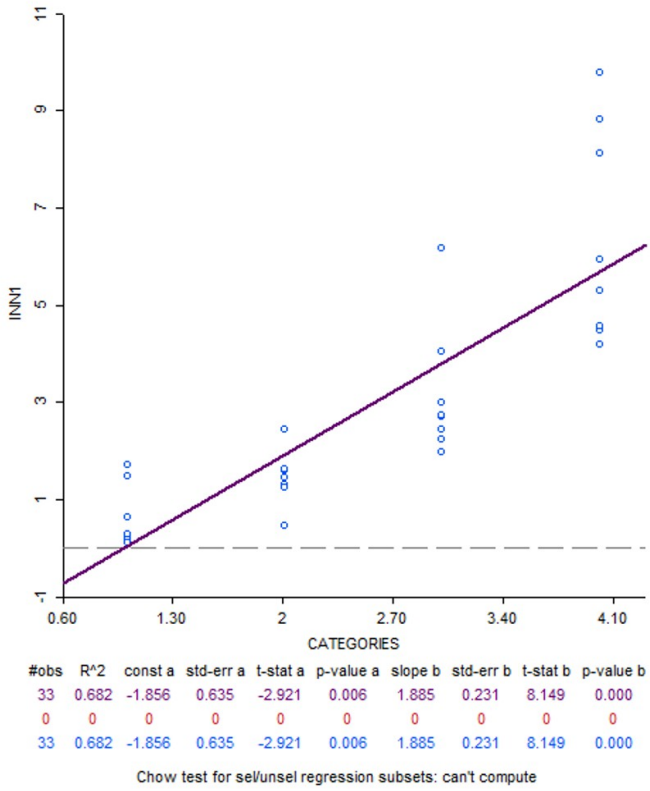


Fuente: Elaboración propia.

To understand the relationship between the variables, graphs and evaluations were carried out linking the INN1 research index with the departmental categories. The values previously reported for each of the departments were represented in Figure 4, in order to determine the behavior between the variables.

Figura 4.

Diagrama de dispersión para las variables *Índice de competitividad en investigación INN1* y *Categorías departamentales*.



Fuente: Elaboración propia

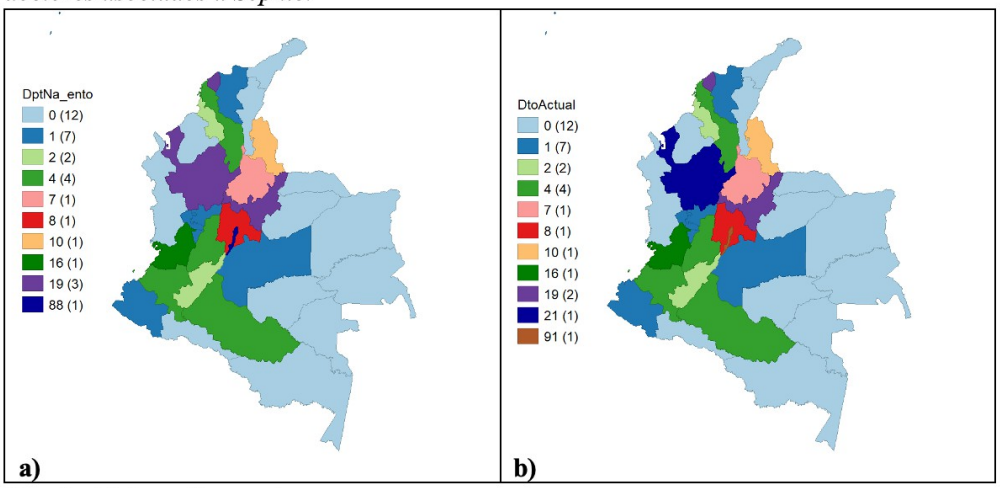
It is identified that there is a directly proportional relationship with an r2= 0.682, and a p-value of 0.0000 between INN1 research and departmental categories. This shows that investing in STI has some type of response associated with the competitiveness of the regions.

STI actions from the Society of Doctors and Researchers of Colombia (SoPhIC) and the provision of services from the association.

Based on the survey of SoPhIC associates, the number of doctors who belong to the different departments, either by birth (Figure 5a) or by current residence (Figure 5b), stands out; and one of the most striking results is that most of the doctors return to their department of origin. Similarly, 12 departments were identified in which there is no presence of doctors from the group associated with SoPhIC.

Figura 5.

Mapas donde se indica el departamento de nacimiento (a) y el de residencia actual (b). de los doctores asociados a Sophic.



Fuente: Elaboración propia

It is found that the research capabilities associated with highly educated personnel are concentrated in five departments.

Based on the survey in which the associates were consulted about the possible services to be provided, identifying interest, experience, relationships and knowledge, 19 services or actions that SoPhIC associates can support in the different regions were identified (Table 3).

Tabla 3.

Servicios identificados por los asociados de SoPhIC para fortalecer las capacidades regionales en CTi.

Servicios o apoyo posible desde SoPhIC	Servicio
1 - Formulación de política CTi	S1
2 - Participación en desarrollo de política pública	S2
3 - Crear alianzas con organizaciones fuera de Colombia	S3
4 - Crear alianzas con organizaciones en Colombia	S4
5 - Bases de datos de SoPhIC de empresas o universidades (nacionales e internacionales)	S5
6 - Redes Sociales SoPhIC	S6
7 - Apropiación social del conocimiento	S7
8 - Servicios de innovación abierta en empresas	S8
9 - Consultorías especializadas	S9
10 - Gestión para la creación de las oficinas de i+d+i en las empresas	S10
11 - Servicio editorial	S11
12 - Apoyo para el acceso laboratorios especializados, inicialmente a través de convenios	S12
13 - Presentación a convocatorias de proyectos CTi	S13
14 - Ofertar capacitaciones a empresas e instituciones públicas	S14
15 - Asesorías a empresas públicas y privadas	S15
16 - Desarrollo de unidades empresariales	S16
17 - Emprendimiento e intraemprendimiento	S17
18 - Participación en proyectos públicos	S18
19 - Portafolio de doctores e investigadores	S19

Fuente: Elaboración propia.

To characterize each service, the maturity level of the service was identified through a process of identifying interest, relationships, experience and knowledge (Table 4).

Tabla 4.

Mapa de calor de la madurez de los servicios con potencial de ser ofrecidos por SoPhIC en el país.

Servicio	Interés	Relaciones	Experiencia	Conocimiento
S1	117	42	42	71
S2	112	41	41	58
S3	116	52	49	70
S4	100	65	59	71
S5	108	32	37	57
S6	64	36	63	76
S7	108	44	78	103
S8	92	33	44	58
S9	128	53	97	119
S10	104	30	35	53
S11	107	42	67	88
S12	87	40	36	62
S13	131	55	91	121
S14	133	63	75	103
S15	128	58	90	102
S16	90	36	51	61
S17	104	39	54	63
S18	123	53	75	86
S19	123	53	64	88

Fuente: Elaboración propia.

Categorization of SoPhIC services

After the characterization of the possible services and the identification of interest, relationships, experience and knowledge, a capabilities matrix was constructed, associating the evaluated criteria as follows:

Support services: these are all those services in which there is interest on the part of the associates and some type of relationships that allow them to materialize. In this group, the following stand out: 9 - Specialized consultancies; 13 - Presentation to calls for STI projects; 14 - Offering training to companies and public institutions; 15 - Consultancy to public and private companies; 18 - Participation in public projects; 19 - Portfolio of doctors and researchers.

Services with potential: all those services in which there is experience and know-how.

by the associates, which allow them to materialize in a project, consultancy or advisory service. Of this group, the following stand out: 7 - Social appropriation of knowledge; 9 - Specialized consultancies; 13 - Submission to calls for STI projects; 14 - Offering training to companies and public institutions; 15 - Consultancy to public and private companies; 18 - Participation in public projects; 19 - Portfolio of doctors and researchers; 20 - Participation in public projects; 21 - Participation in public projects; 22 - Participation in public projects; 23 - Participation in public projects; 24 - Participation in public projects; 25 - Participation in public projects.

Support services: these are all those services in which there are relationships, experience and knowledge on the part of the associates, which become the initial pillars of the process of interaction and support from the different areas of SoPhIC to the regions in a dimension equal to or less than the number of doctors in each department, as shown in Table 5.

Tabla 5.

Mapa de calor de la madurez de los servicios que harían parte de la estrategia SoPhIC.

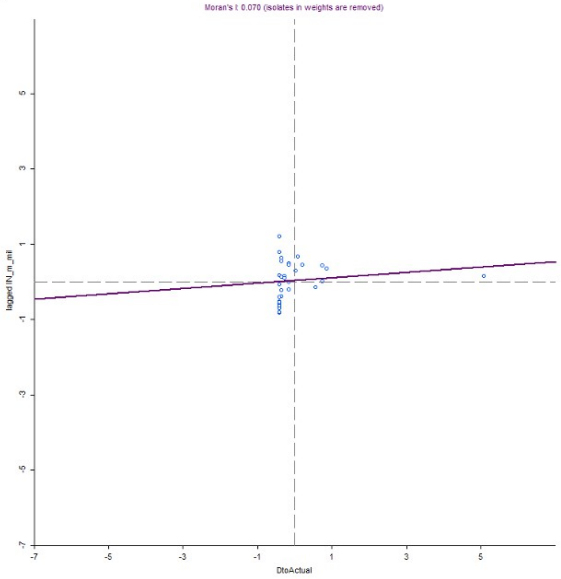
Variable	Apoyo	Potencial	Soporte
S1	120	146	353
S2	125	121	283
S3	142	171	402
S4	142	193	406
S5	114	139	472
S6	97	190	333
S7	150	251	493
S8	122	134	355
S9	202	350	838
S10	111	101	280
S11	134	194	337
S12	150	98	205
S13	222	321	713
S14	257	280	853
S15	248	313	839
S16	124	145	452
S17	139	163	437
S18	196	289	734
S19	175	250	630

Fuente: Elaboración propia.

Based on the data on the services provided by SoPhIC, which link the number of doctors per department with the investment of Minciencias per hundred thousand inhabitants, it is revealed that, although t h e impact of doctors in the regions is not statistically significant, it is positive. This implies that the actions of the doctors have a tangible presence, as shown in Figure 6. Although a statistically significant relationship is not reached, the existence of such a connection suggests the need to delve deeper into the subject for a complete understanding of its scope and effectiveness.

Figura 6.

Relación espacial entre la inversión de Minciencias en proyectos por millón en los diferentes departamentos de Colombia y el número de doctores por departamento.



Fuente: Elaboración propia.

DISCUSSION

Colombia presents a marked inequality between its different regions and departments in terms of development and wealth generation, as shown in Figure 1. However, this disparity is not only limited to the territorial level, as significant inequality is also evident within each region. This is manifested by a high concentration of wealth and land, which underscores the challenges facing the country in its quest to achieve a more equitable distribution of resources and opportunities for all its citizens. This phenomenon of inequality and concentration of capabilities and resources is not unique to Colombia, but is also applicable in a similar way to other countries in the Latin American region. In many Latin American countries, there is a significant concentration of capabilities and resources in certain areas, while other regions are marginalized and do not fully enjoy the benefits of development. This situation poses a common challenge for the region as a whole, in terms of fostering more inclusive and equitable growth to reduce socioeconomic gaps between different geographic areas and ensure sustainable and equitable development for all citizens (ECLAC, 2018; Jimé- nez, 2015; RIMISP, 2017). On the other hand, Ezcurra (2019) reports lower levels of inequality in the richest countries of the European Union and with better levels of governance. This implies that the development policy, which has so far been implemented in countries such as Colombia, tends to strengthen and finance the strongest groups or institutions with the most developed capacities, thus deepening such imbalances, as reviewed by Sánchez-Torres (2017) for Colombia. The author indicated that departments with lower income levels tend to be the most unequal. In the same sense Capello et al. (2013) point out that regional public policies in Argentina do not always have the expected effects with respect to human development indicators. Something similar

Quintana et al. (2019) found when evaluating at the sub-national level the conditions of equity in income and employment for the regions of Mexico, Ecuador and Brazil, where, despite being under different economic policy regimes and having shown a general improvement in the indicators, some regions still lag behind in the aspects evaluated.

Regarding the correlation between the development indicators presented in Figure 4, it has been identified that the capacity of a region to develop has a direct relationship with the capacity to generate wealth and, with it, the consolidation of its bureaucratic apparatus or municipality (Angeelli & Llisterri, 2003).

Since 2003, the Economic Commission for Latin America and the Caribbean (ECLAC) has pointed out that regional disparities are based more on the implementation and design of policies than on local limiting conditions, given that "any territory can be good for developing very diverse economic activities, as long as it complies with certain requirements that are indispensable for improving the competitive conditions of territorial economic units" (Silva, 2003, p. 7). This is why the formulation of adequate policies should change the direction of development and equality indicators. Authors such as Leydesdorff et al. (2019), Porto-Gómez et al. (2019) and Tho- mas & Maine (2019), indicate that many of the policies and mechanisms of innovation systems work very well at the national level in the Mexican case, or at the State level for the second, but cease to be operational and efficient at the regional scale.

From Table 3 it can be inferred that the generation of capabilities for STI is an incremental process, which depends on the continuity of policies aimed at solving structural problems. This is consistent with Escobar et al. (2022), Escobar et al. (2016), who indicate that the first allocation of resources is configured as expenditure in immature innovation systems. However, when the system is mature, it is configured as an investment.

CONCLUSIONS

Colombia is a country with notable inequalities, but in terms of scientific and technological policy it is possible to close these gaps through adequate planning, continuity of processes and scalability of actions. Public policies implemented with equity criteria can help generate capacities and offer opportunities to lagging societies that are trapped in the vicious circle of not having access to resources because they are not well categorized and cannot improve their performance due to lack of resources.

PhDs in Colombia, and especially those who are part of societies and associations, are an important group that can generate regional development capabilities through the provision of technology-based or knowledge-intensive services, although they are concentrated in some departments. In the medium and long term, this may allow for growth in different indicators of STI development in different areas of Colombia. The generation of capacities in science, technology and innovation is possible thanks to the training of human resources, the provision of technological infrastructure and the establishment of permanent sources of financing. Therefore, it is important to support the development and consolidation of research groups.

Consequently, a fundamental axis of government policy must be the resolution of structural problems. Furthermore, this study demonstrates that, whether at the institutional, regional or national level, the development of STI policies must be continuous and coherent, not only in terms of resources, but also in terms of instruments that promote social and economic inclusion.

Colombia can reduce its inequalities through adequate planning and equitable scientific and technological policies. This will make it possible to close gaps and provide opportunities to lagging societies.

The participation of PhDs and associations can generate regional development capabilities in science and technology. This can lead to sustained growth in different development indicators in different areas of Colombia, especially those farther away from the so-called centralities.

To strengthen state policy in STI, it is crucial to address structural problems, establish permanent sources of financing and promote social and economic inclusion through continuous and coherent policies at the institutional, regional and national levels, and to achieve this in a harmonious manner, it is essential to have oriented decentralization processes through capacity transfers.

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Conflicts of interest

The authors declare that there is no possible conflict of interest related to the article submitted for publication.

References

Angelelli, P. & Llisterri, J. J. (2003). *El BID y la promoción de la empresarialidad: Lecciones aprendidas y recomendaciones para nuevos programas.* 21.

Capello, M., Figueras, A., Freille, S. & Moncarz, P. (2013). Efectos de las transferencias federales sobre la convergencia regional en indicadores de desarrollo humano en Argentina. *Investigaciones Regionales, 27,* 33–63.

CEPAL. (2017). *Escalafón de la competitividad de los departamentos de Colombia 2017.* https://hdl.handle.net/11362/43156

CEPAL. (2018). *La ineficiencia de la desigualdad. Síntesis.* (LC/SES.37/4). https://repositorio.cepal.org/bitstream/handle/11362/43566/4/S1800302_es.pdf

CONPES 4069. (2021). *Política nacional de Ciencia tecnología e innovación 2022-2031.* https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/4069.pdf

Consejo Privado de Competitividad. (2022). *Índice departamental de competitividad 2022.* https://compite.com.co/wp-content/uploads/2022/04/CPC_IDC_2022.pdf

Contaduría General de la Nación. (2022). Resolución 314 de noviembre de 2022, *Categorías departamentos, distritos y municipios de Colombia*.

Departamento Nacional de Planeación. DNP. (2015). *Documento Borrador de POLÍTICA NACIONAL DE DESARROLLO PRODUCTIVO. Vichada.* (Documento COMPES). https://colaboracion.dnp.gov.co/CDT/Inversiones%20y%20finanzas%20pblicas/Vichada%2015.pdf

Escobar, J. F. & Herrera, J. F. (2015). Los planes estratégicos para el desarrollo de la ciencia, la tecnológica y la innovación como herramienta hacia la competitividad regional y su real impacto. Altec 2015. http://altec2015.nitec.co/altec/papers/981.pdf

Escobar, J. F., Anderson, J., Zuluaga, F., Castañeda, D., Londoño, A. A., Alfonso, G. & Martínez, G. (2022). Science, Technology, And Innovation Capabilities As Main Determinants Of Economic Performance In Aerospace Companies. *Journal of Language and Linguistic Studies, 18*(4), 1065–1083. http://jlls.org/index.php/jlls/article/view/5098/1763

Escobar, J. F., Jardón, C. M., Bedoya, I. B., & Mosquera, J. (2016). Ciencia, tecnología e innovación y su impacto en la generación de riqueza: análisis del PIB per cápita en 13 países Iberoamericanos. *Revista Espacios, 37*(35), 16. https://www.revistaespacios.com/a16v37n35/16373517.html

Ezcurra, R. (2019). Regional disparities and within-country inequality in the European union. *Revista de Economia Mundial* (51), 139–162. https://doi.org/10.33776/rem.v0i51.3907

Foray, D., & Lundvall, B.-A. (1996). The Knowledge - based Economy: From the Economics of Knowledge to the lea*rning Economy* (O. Documents (ed.)). Employment and Growth in the Knowledge-based Economy.

Henao-Rodríguez, C., Lis-Gutiérrez, J. P., Bouza, C., Gaitán-Angulo, M., & Viloria, A. (2019). Citescore of publications indexed in Scopus: An implementation of panel data. *Communications in Computer and Information Science, 1071,* 53–60. https://doi.org/10.1007/978-981-32-9563-6_6

Jiménez, J. P. (2015). Desigualdad, concentración del ingreso y tributación sobre las altas rentas en América Latina. *In Libros de la CEPAL* (Vol. 134). https://www.cepal.org/sites/default/files/publication/files/37881/S1420855_es.pdfhttps://doi.org/10.15446/cuad.econ.v35n67.52441

Ley 1951 de 2019. (2019, 24 de enero). Congreso de la República de Colombia. Diario Oficial No. 50.846. http://www.secretariasenado.gov.co/senado/basedoc/ley_1951_2019.html

Leydesdorff, L., Wagner, C. S., Porto-Gomez, I., Comins, J. A. & Phillips, F. (2019). Synergy in the knowledge base of U.S. innovation systems at national, state, and regional

levels: The contributions of high-tech manufacturing and knowledge-intensive services. *Journal of the Association for Information Science and Technology, 70*(10), 1108–1123. https://doi.org/10.1002/asi.24182

Lundvall, B.-Å. (1992). *National System of Innovation. Towards a Theory of Innovation and Interactive Learning.* Pinter Publishers.

Meisel Roca, A., & Hahn, L. (2020). R*egional Economic Inequality in Colombia, 1926–2018.* 183–210. Palgrave Macmillan. DOI: 10.1007/978-3-030-47553-6_8

Nieto, V. M., Timoté, J. A., Sánchez, A. F., & Villareal, S. (2015). Clasificación por tamaño empresarial en Colombia: Historia y limitaciones para una propuesta. *Archivos de Economía - Departamento Nacional de Planeación, 434*(C14 L11 L52), 1–34. https://colaboracion.dnp.gov.co/CDT/Estudios Econmicos/434.pdf

Porto-Gomez, I., Zabala-Iturriagagoitia, J. M. & Leydesdorff, L. (2019). Innovation systems in México: A matter of missing synergies. *Technological Forecasting and Social Change, 148.* https://doi.org/10.1016/j.techfore.2019.119721

Quintana, L., Salas, C. & Correa-Quezada, R. (2019). Crisis, employment and inequality in Latin America: A national and regional analysis between Mexico, Brazil and Ecuador. *Investigaciones Regionales,* (43), 129–147.

Quintero, I. C., Ospina, Y., Quiroga, D. J., & Cubillos-González, R. A. (2021). Relación entre Capacidad de Innovación e Índice de Innovación en América Latina. *Journal of technology management & innovation, 16(3),* 47-56. https://dx.doi.org/10.4067/S0718-27242021000300047

Ramírez J., J. C., Parra-Peña S., R. I., Ramírez, J. & Parra-peña, R. I. (2013). Variaciones en torno al escalafón de competitividad departamental en Colombia. *CEPAL-Serie Estudios y Perspectivas, 26.*

RIMISP - Centro Latinoamericano para el Desarrollo Rural. (2017). Pobreza y desigualdad. *Informe Latinoamericano 2017* (F. Grez (ed.)).

Salazar, M., Guillard, C., & Crespi, G. (2019). *The Colombian Observatory of Science and Technology.* Between Relevant Context and Internationally Comparable Indicators. https://doi.org/10.18235/0001556

Sánchez-Torres, R. M. (2017). Desigualdad del ingreso en Colombia: Un estudio por departamentos. *Cuadernos de Economía, 36*(72), 139–178. https://doi.org/10.1016/S0210-0266(11)70011-5

SENA. (2018). *Plan de acción 2018 Lineamientos operativos V.2.*

Silva, I. (2003). Disparidades, competitividad territorial y desarrollo local y regional en América Latina. In Serie Gestión Pública (Issue 33). http://repositorio.cepal.org/bitstream/handle/11362/7286/S034200_es.pdf?sequence=1&isAllowed=y

Sistema Nacional de Competitividad, Ciencia, Tecnología e Innovación. SNCCTI. (2016). *Gobernanza Sistema Nacional de Competitividad, Ciencia, Tecnología e Innovación.* https://compite.com.co/el-cpc/snccti/

Solow, R. M. (2001). After "Technical Progress and the Aggregate Production Function." *New Developments in Productivity Analysis, January,* 173–178.

Terrádez-Gurrea, M. (2006). Análisis de Componentes Principales. *Revista Chilena de Obstetricia y Ginecolog, 71*(1), 1–11. https://doi.org/10.4067/S0717-75262006000100004

Thomas, V. J. & Maine, E. (2019). Impact of regional systems of innovation on the formation of university spin-offs by biomedical star scientists. International Journal of *Entrepreneurship and Small Business, 37*(2), 271–287. https://doi.org/10.1504/IJESB.2019.100108

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