

Reflections on the future of research, development and innovation in Colombia

Reflexiones sobre el futuro de la investigación, el desarrollo y la innovación en Colombia

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Abstract

Colombia is going through a moment of historical change. After four years of formal peace negotiations and the signing of a peace agreement with the FARC in November 2016, the country is set to enter an era of increased stability. In this perspective, the Colombian government should concentrate its effort to respond to societal challenges by improving infrastructure, promoting social inclusion and a sustainable use of natural resources. However, while it is acknowledged that greater investments in science and technology could foster economic growth and development and respond to societal needs, Colombia is still lagging behind. Greater investment in science and technology with a long-term perspective should support the country's efforts for growth and development. Furthermore, considering Colombia's great diversity in terms of population, topography and societal needs, it appears reductive to apply a 'one size fits all' solution. This article presents some reflections on how strengthening the capacity of higher education institutions (HEIs) for research and internationalization and strengthening the link between knowledge, practice and policy would contribute to more and better research, development and innovation in Colombia.

Palabras clave: Government, higher education, science, industry, innovation, internationalization, Latin America and Caribbean, policy, societal challenges, and technology.

Resumen

Colombia está pasando por un momento de cambio histórico. Después de cuatro años de negociaciones formales de paz y la firma de un acuerdo de paz con las FARC en noviembre de 2016, el país está listo para entrar en una era de mayor estabilidad. En esta perspectiva, el gobierno colombiano debe concentrar sus esfuerzos para responder a los desafíos sociales mejorando la infraestructura, promoviendo la inclusión social y el uso sostenible de los recursos naturales. Sin embargo, si bien se reconoce que mayores inversiones en ciencia y tecnología podrían fomentar el crecimiento económico, el desarrollo y responder a las necesidades de la sociedad, Colombia sigue estando rezagado. Una mayor inversión en ciencia y tecnología con una perspectiva a largo plazo debería respaldar los esfuerzos del país por el crecimiento y el desarrollo. Además, teniendo en cuenta la gran diversidad de Colombia en términos de población, topografía y necesidades sociales,

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parece reductivo aplicar una solución de «talla única». Este artículo presenta algunas reflexiones sobre cómo fortalecer la capacidad de las instituciones de educación superior (IES) para la investigación e internacionalización y fortalecer el vínculo entre conocimiento, práctica y política, que contribuyen a una mayor y mejor investigación, desarrollo e innovación en Colombia.

Palabras clave: ciencia, educación superior, gobierno, industria, innovación, internacionalización, latinoamérica y el caribe, política, retos sociales y tecnología.

Introduction

Colombia is going through a moment of historical change. After four years of formal peace negotiations and the signing of a peace agreement with the FARC in November 2016, the country is set to enter an era of increased stability.

In this perspective, the Colombian government should concentrate its effort to respond to societal challenges by improving infrastructure, promoting social inclusion and a sustainable use of natural resources. A recent OECD study (OECD, 2017) shows that thanks to the profound reforms and sound macroeconomic framework, Colombia is already showing great resilience to economic crises and suggests that the peace agreement will boost economic growth and job creation. In this context, Colombia could benefit from appropriate measures to foster investments in research and development (R&D) and education.

However, while it is acknowledged that greater investments in science and technology could foster economic growth and development and respond to societal needs, Colombia is still lagging behind (Pardo Martínez, C, I., 2017). The most recent draft document of the national plan for science and technology (CONPES, 2016) briefly shows the evolution of the Colombian science, technology and innovation (STI) policies over the last fifty years pointing out its weaknesses and proposing 'more or less' ambitious policy measures to foster

research, development and innovation (R+D+I). The document reports the need for the Country to overcome its short-term vision in order to be able to develop more meaningful and ambitious research initiatives and create the enabling conditions to promote high-technology projects and results.

Traditionally, Latin American economies focus on low-tech goods and investments and the industrial sector, as well as higher education institutions (HEIs), and are far away from being the driver of technological breakthrough. (UNESCO, 2015)

Greater investment in science and technology with a long-term perspective should, therefore, support the country's efforts for growth and development. However, considering Colombia's great diversity in terms of population, topography and societal needs, it appears reductive to apply a 'one size fits all' solution. Colombia should look at how to develop appropriate solutions that strongly correlate to the country's needs rather than merely import existing technology from abroad. (Pardo Martínez, C, I., 2017) In this context, HEIs have an important role to play, together with industry and public institutions.

While the topic is very broad, this paper will concentrate on two main aspects that in our view are key to fostering Colombian STI development, namely strengthening the capacity of HEIs for research and internationalization and developing an R+D+I system in line with societal priorities and productivity needs.

Human resources and international cooperation for R+D+I

Universities are a fundamental component of innovation systems in that they provide human capital and the generation of knowledge necessary to strengthen countries' competitiveness and innovation. Thus, the quality of its research and the environment in which the new generation of researchers are trained are essential elements for national and regional development. (SELA, 2016)

In Colombia, about 70% (Informe annual Indicadores de Ciencia y Tecnología Colombia 2015, 2015) of the research is carried out in HEIs. However, the majority (El Espectador, 2016) of HEIs are focused on teaching, with very little time and infrastructure dedicated to research. The number of laureate Ph.D. students is still low, with an average of 8 doctorates per million inhabitants, while in Latin America (LA) this number increases to 41 Ph.D. laureates per million inhabitants, still low when compared to more developed countries (El Tiempo, 2017). There is a highly unequal distribution within the region with countries such as Brazil, Mexico, Argentina and Chile leading the way. Interestingly, those are the countries whose policies have prioritized investments in science, technology, and innovation and whose budget represent 90% of the region's total investment in STI. (SELA, 2016) Furthermore, those countries have signed bilateral agreements (The EU has formal Science and Technology Cooperation Agreements with four countries of the region: Argentina, Brazil, Chile and Mexico, 2017) with the European Union to play an active part in the EU research programme Horizon 2020 (Horizon 2020 is the biggest EU Research and Innovation program ever with nearly €80 billion of funding available over 7 years (2014 to 2020), 2017). This has strengthened the role of national scientific and technology councils and opened up opportunities for researchers to participate in high-level international projects and networks. In spite of internationalization being considered as an intrinsic component of research (Ministerio de Educación Nacional, 2015) as well as a condition for quality improvement, the participation of LA researchers in international scientific cooperation projects and networks is still limited. Likewise, the gap between LA and the EU or the USA in the publication of scientific articles in international journals is still wide and more so when considering the level of impact. This limits the presence and relevance of Latin American research on the global scene and the contribution to competitiveness and innovation in science and technology both at

the country level and internationally. Among the causes are the limited capacities, resources and research structures, coupled with a lack of leadership, adequate policies, strategies and an effective coordination between the public, private and academic sectors.

As a UNESCO report (UNESCO, 2017) points out, generating its own capacity for scientific and technological production is one of the greatest challenges for HEIs in LA. This cannot be achieved without the solid development of research institutions, a critical mass of scientists and young people trained at the doctoral level in international programs. In addition, because of its scale, this objective can hardly be achieved in an isolated way, so it is necessary to intensify international cooperation in the field of research and higher education.

A brief overview of initiatives across the LA region reveals the tendency to prioritize research and its internationalization through specific programs. In Ecuador, SENESCYT has promoted a scholarship program and created the Prometheus and Ateneo program, which aims at integrating foreign and Ecuadorian experts abroad in Ecuadorian HEIs for the development of research projects in priority sectors. In Chile, the internationalization of HEIs is part of the country's foreign policy and CONICYT promotes alliances with Mercosur, European and US countries, among others, to finance joint research projects, attract advanced human capital abroad and promote academic mobility. In Brazil, a mobility programme *Ciência sem Fronteiras* (Science without borders) was implemented for about 4 years with the aim of feeding trained researchers into the Brazilian R&D system. This program suddenly closed (CIENCIASSEMFRONTIERAS, 2017), (VALOR, 2017), due to the Brazilian economic and political crisis.

Colombia recently launched the Colombia Científica (Colombia Científica, 2017) program with the objective of fostering scientific cooperation in strategic areas and the training doctorate students abroad. Funded by the World Bank, and

co-managed by COLCIENCIAS, ICETEX, the Ministry of Education and the Ministry for Industry and trade (Colombia Científica, 2017), the 68 million dollar program (Colciencias, 2017) represents an interesting innovation for Colombian researchers. The 'scientific ecosystem' branch of the program requires the participation of research groups made up of multiple stakeholders including international partners and revolves around five priority areas: food, society, sustainable energy, health, and bio-economy. The higher budget for funded programs and the longer-term duration, enabling more ambitious research initiatives, are also new and welcome developments. If well implemented, this program could be an enabling platform to build research capacities and foster Colombian participation in international research programs such as Horizon 2020. However, while it is true that Colombian HEIs are transitioning towards more intense R+D+I activities, most still do not have the capacity to respond to these initiatives, thus losing opportunities and limiting scientific and technological development at country and regional level.

As a result, HEIs need to consolidate the institutional commitment for research and internationalization and better coordinate the work of research institutes, international relations offices as well as the transfer of results to support and encourage the participation of HEIs in high-profile national and international research initiatives. Research capacities should be strengthened and researchers should be increasingly involved in international networks and projects.

At the national level, relevant policy instruments should be supportive of R+D+I to foster growth and competitiveness as well as raise Colombia's profile internationally. Yet the approach should be sustainable in time and relate to the capacity of the country to absorb skilled researchers in key sectors and institutions. This would contribute to gradually creating generations of highly skilled scientists while avoiding the risk of embarking on ambitious initiatives that may generate a sudden boom of internationally trained staff without having put in

place appropriate measures to reabsorb them into the system (As in the case of the *Ciência sem Fronteiras* program in Brazil, 2017).

Science and Society: connecting knowledge, practice, and policy

Another relevant aspect to consider is the need to firmly relate Colombian R+D+I to the country's production system and societal needs; to date, Colombia ranks 61st in the global competitiveness index 2016-2017 of the world economic forum (Schwab K., 2017), second only to Chile (33) within South America, and 5th in Latin America and Caribbean (LAC).

In spite of economic growth, LA still presents the highest level of disparity between urban and rural areas, being the most urbanized region amongst developing countries (Inter-American Development Bank, 2017). The 80% of its population lives in cities of which approximately 25% to 50% lives in informal settlements. This limits the capacity of mega-cities such as Bogota, Buenos Aires, Sao Paulo (cities with more than 5 million inhabitants) to absorb and integrate its citizens and to respond to big challenges such as urban development, mobility, transport, water management and sanitation, health, education, and employment.

As for Colombia, growth is still stymied by inadequate infrastructure, volatility of the market for exported goods (i.e. oil prices), social inequality and high poverty rate (More than a third of the population lives below the poverty line, 2017). Yet, in the midst of a demographic and economic transition, Colombia is considered an emerging economy (Yuk, P.K., 2017) (upper-middle income according to The Global Innovation Index (The Global Competitiveness Report 2016–2017, 2016)).

The country holds a demographic distribution that falls between that of the more established economies and emerging ones; it has a relatively young population with almost 60% of the population in the core working ages (15-24 years: 17.54% 25-54 years: 41.82%) but with a steady decline in

its fertility, mortality, and population growth rates (The World Factbook-Colombia, 2017) that will eventually result in an ageing society similar to that of many wealthier countries. OECD (2008).

Geographically Colombia is also very diverse, partially because it sits at the point where the Andes mountain range splits into three branches. This challenging landscape of tall mountains and deep valleys exacerbates the divide between urban and rural areas, making it harder to provide adequate services, security, and infrastructure to local populations. Also in line with international priorities and the UN Sustainable Development Goals for 2030 (United Nations, 2015), there is the need to move towards 'sustainable cities and communities' which are more inclusive, resilient, safer and sustainable, promoting a better use of resources and by doing so contributing to a reduction of poverty and environmental impact. In countries like Colombia where agriculture is an important source of income, rural areas should not be neglected.

As an example, the topography and population distribution across the country highly affect the issue of access and distribution of electricity. On one side, there is the need to provide services to urban areas such as Bogotá with about 8 million inhabitants (capital city area only) and smaller cities such as Medellín and Cali that hold a population comparable to that of Paris. On the other side, there is a vast countryside with people scattered throughout. In comparative terms, Bogotá has a density of approximately 4.310 inhabitants per square kilometer while it is 0.68 in the Colombian Amazon region.

Furthermore, the electricity sector in Colombia is dominated by large hydropower generation (68.5% of total installed capacity) and thermal-fossil fuel generation (28.4%) (The World Factbook-Colombia, 2017), but the continued growth in energy consumption should be accompanied by higher investments in advanced renewable energy technologies (mainly wind, solar and biomass), that so far have not been exploited yet.

In the energy sector, Colombia should go beyond exploiting the current energy resources and existing distribution grids and develop alternative ways to generate energy at the local level in "mini-grids" or "off-grid". This configuration would be particularly useful in remote areas that are not connected to the main grid. (International Renewable Energy Agency (IRENA), 2015.)

When it comes to transport and mobility, there is a difference in needs between big urban areas and rural low-density areas. While for urban areas innovative solutions might be in line with other major cities worldwide, embracing the concepts of heavily digitalized smart cities, rural areas may require different solutions.

These examples suggest that the technological solutions needed for Colombia may vary within the country and that standardized solutions may not fit the needs of the population. Case-by-case solutions and related R+D+I is to be expected, developed and applied.

The global economy is currently entering an important transition phase. Recovering from the great economic crisis that started in 2007, new opportunities are opening up to exploit and build on technological achievements that only a decade ago were considered prototypical ones. Worldwide, the most successful nations are implementing a series of policies focused on innovation and the pursuit of economic growth, investing efforts in fostering academic-public-private partnership. (Salazar J.F., (2014))

In this context, HEIs have a double role to play. On the one hand, they are in charge of training skilled human capital capable of responding to the needs of society and the productive sectors; on the other hand, they promote high-level R+D+I initiatives. Frontiers between academia and society should become looser and the creation of new partnerships between the productive sector, public institutions, and civil society organizations has the potential to drive the transformation towards a more sustainable society.

It should be a goal for Colombia's policies in higher education, science, and technology to generate the knowledge for a sustainable use of its natural resources while encountering societal needs, thus generating a strong link between knowledge-driven technology, implementation, and policy. Also defined as the "golden triangle" (With the phrase the "Golden Triangle, 2017), the connection of knowledge, practice, and policy is a well-known practice occurring traditionally in the United States, but also in the EU member states (OECD, 2017).

Conclusions

As argued in this article, linking academia, industry and government institutions would boost productivity and create new jobs, while avoiding the risk that skilled scientists face a lack of professional opportunities and consequently leave Colombia, resulting in a 'brain drain'. At the same time, investing in both the transfer and implementation of research results will lead to job creation and ensure funding for further research from the private sector. (Guarino A. and De Martinis D., 2016)

Fostering the internationalization of research is a current and urgent challenge in LA countries in order to improve their insertion in the dynamics of global science and innovation, and Colombia makes no exception. Internationalization of research, both between LA countries and with other relevant players outside the region, could strengthen Colombian ties with its neighbors and enable its national scientific and technological programs to keep pace with those of the most competitive countries.

Today scientific research is more dispersed than it used to be. The growth of BRICS, the technological advances of many Asian countries and the consistency of the EU and the USA in R+D+I have generated a more variegated and competitive scenario. Acknowledging this trend, analysts suggest that promoting scientific networks, mobility, and

inter-institutional collaborations is the way forward in order to create novel and beneficial opportunities and relations (Colglazier E. W. and Lyons, E. E., 2014).

Thus, building up capacities and the internationalization of R+D+I and strengthening the link between knowledge, practice and policy should be among the main drivers of Colombia's research and development actions in key sectors such as agriculture and biodiversity, energy, transport, and society, to name a few of the most compelling areas within Colombia.

While governance measures to achieve those goals might be already available in Colombia (Miranda, J.B., 2016), their implementation supported by adequate resources will be key issues for a successful knowledge-based development of Colombia's economy and society. Almost all (Achenbach, J. and L.H. Sun, 2017) governance or policy programs agree on the importance of R&D, yet when it comes to (public) funding and (national) budget allocations they frequently receive less attention. Colombia is no exception. Despite the perspective of external support (Gillespie P., 2015) (Totten, M.J., 2016), R+D+I investment was a mere 0.24% of GDP in 2015 and recent news shows that further cuts can be expected (Wade, L., 2017). At this historical point in time when Colombia is entering into a post-conflict era, this decision is particularly controversial and goes against the need to increase investments and set up a long-term plan for more sustainable R+D+I.

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With the phrase the "Golden Triangle, (2017). The Dutch Ministry of Economic Affairs, Agriculture and

Innovation is referring to the successful collaboration of (agricultural) research/education, industry, and government

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